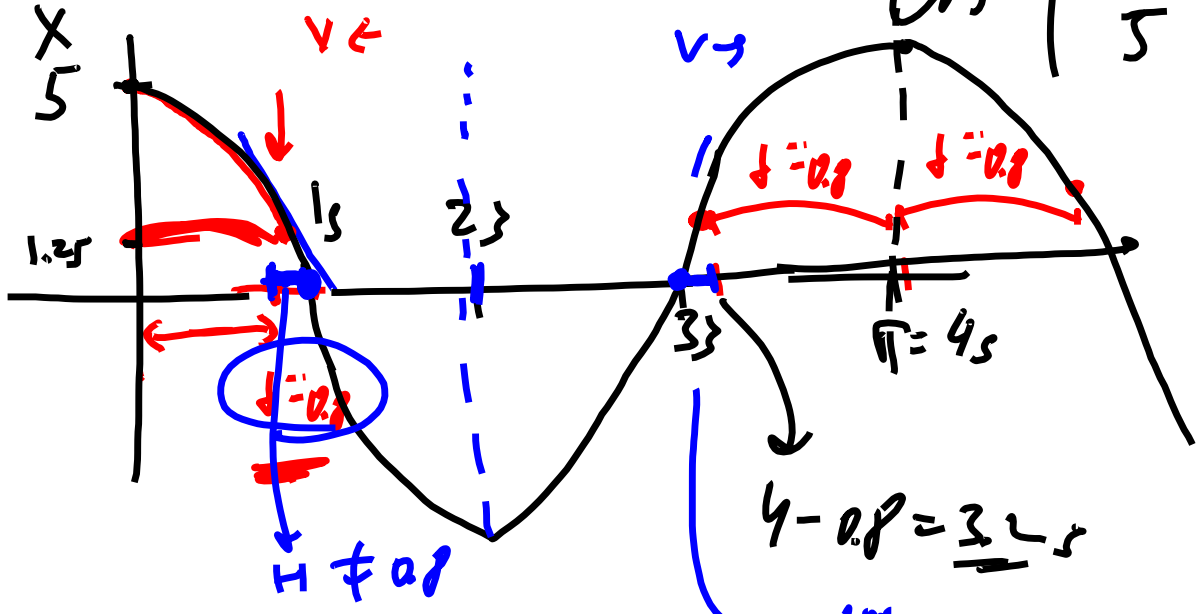
Lab 8 is in SCI 134

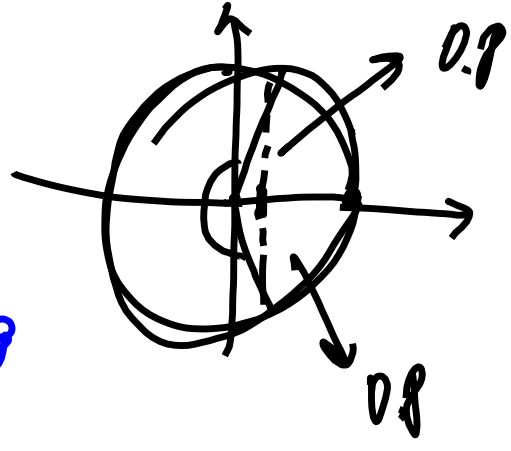
Please, login into webassing, locate LectureMCQ_L20 (PY105) and answer question 1 (but ONLY Q1!).

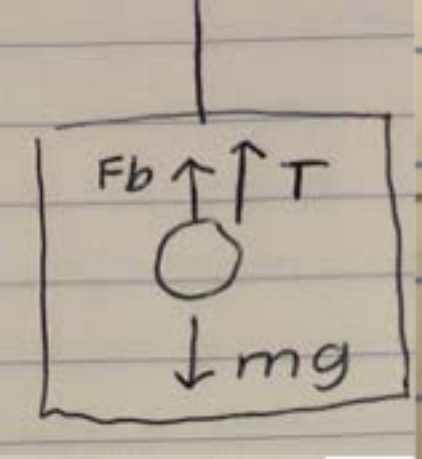
Good morning!

$X = 5 \cdot \cos\left(\frac{\pi}{2} \cdot t\right)$

$\cos^{-1}\left(\frac{1.25}{5}\right) = \frac{\pi}{2} \cdot t \pm 2\pi$



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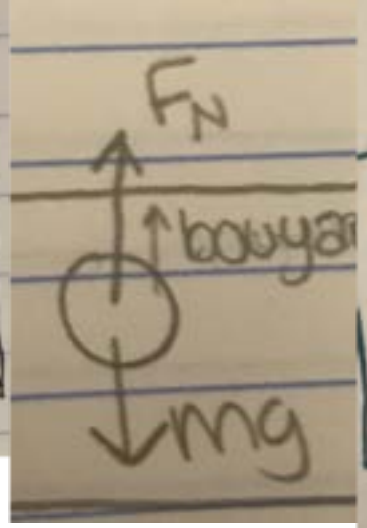
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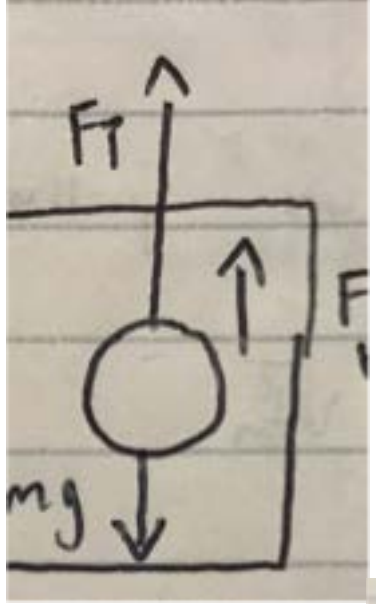
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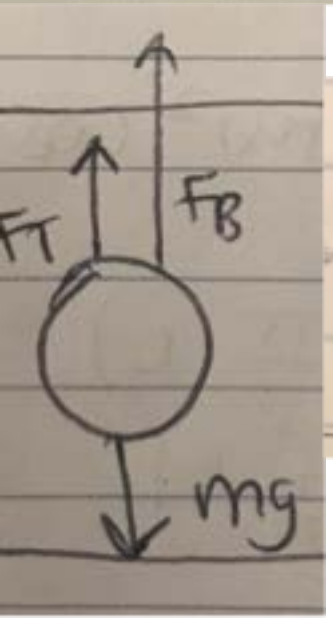
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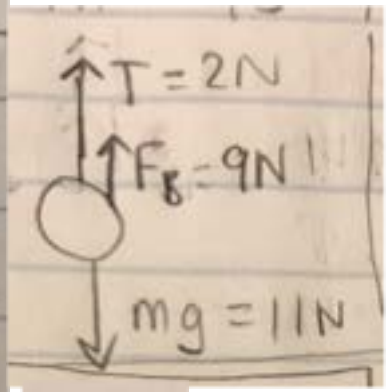
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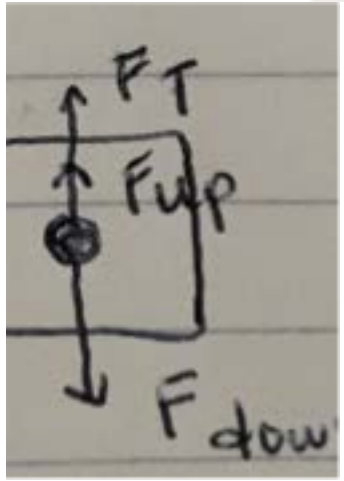
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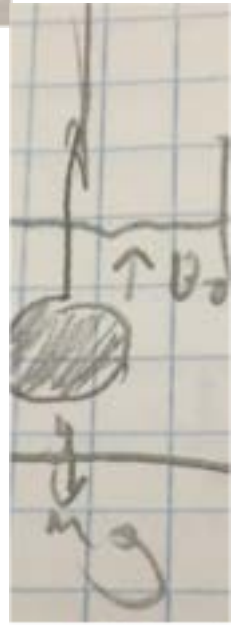
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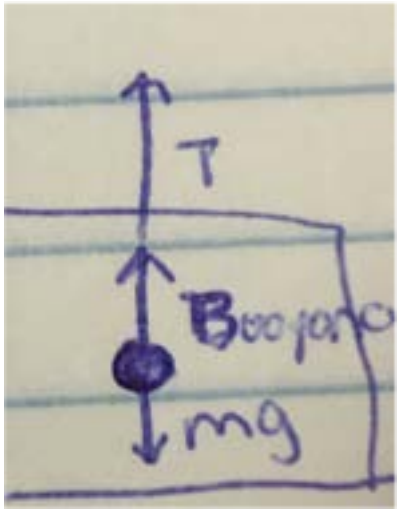
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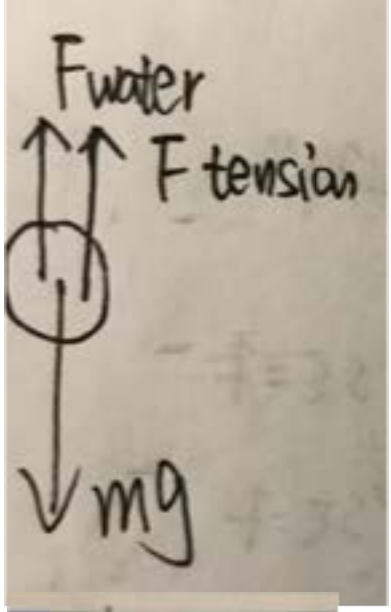
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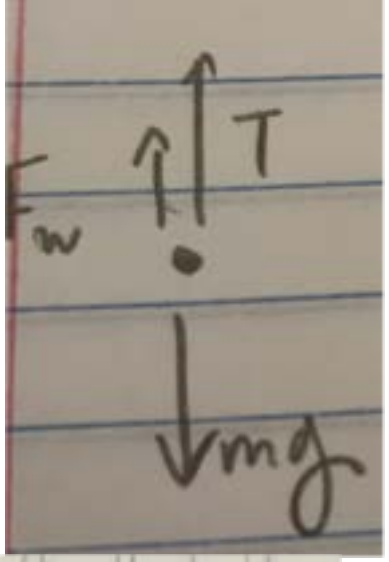
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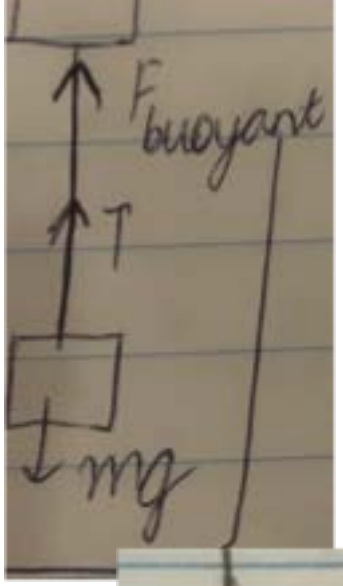
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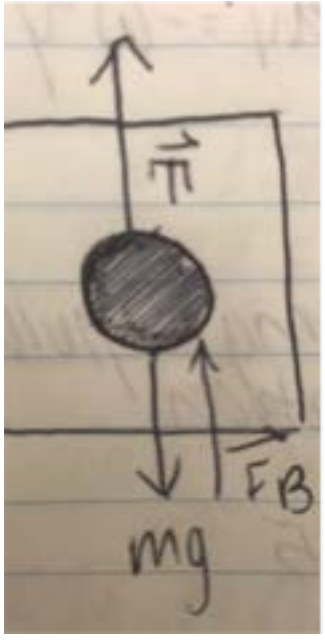
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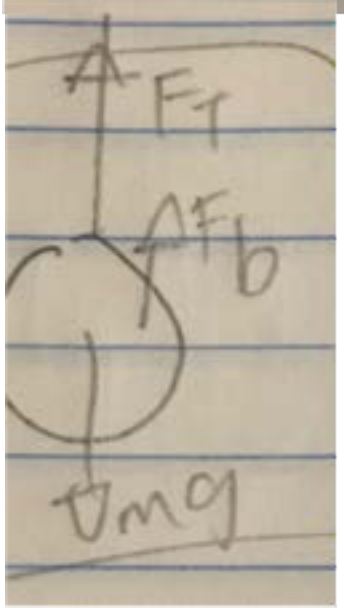
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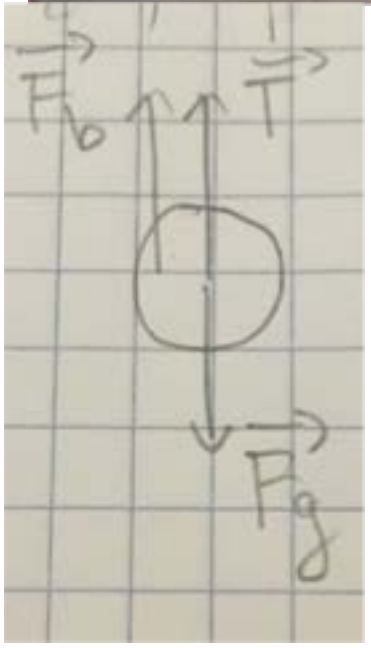
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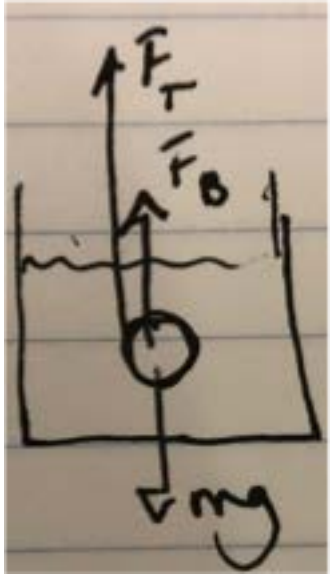
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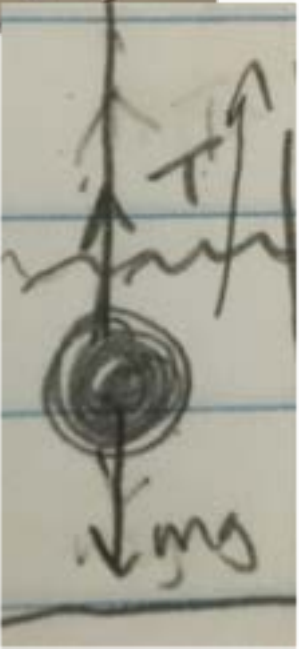
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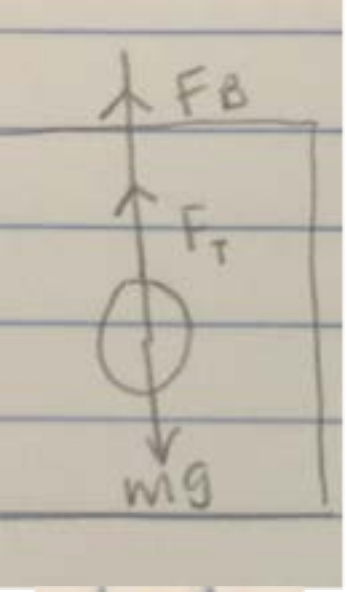
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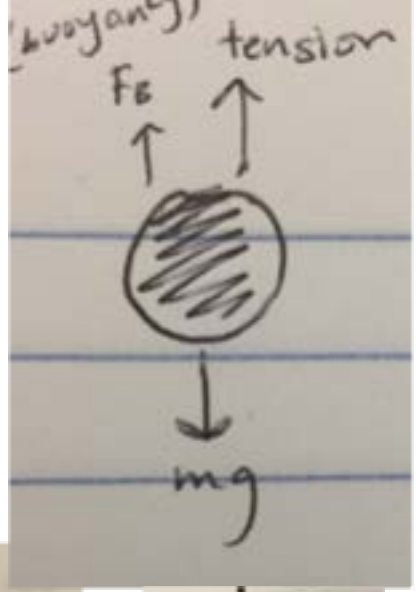
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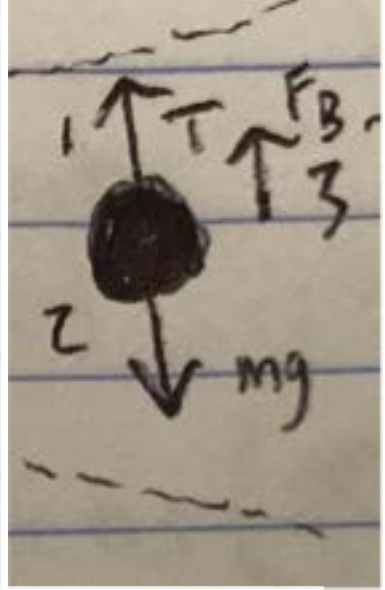
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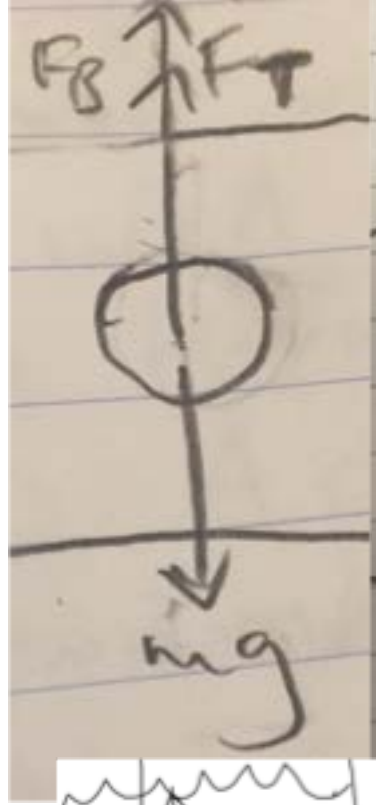
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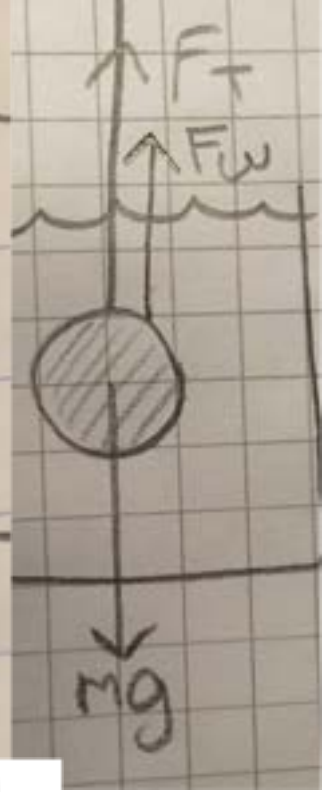
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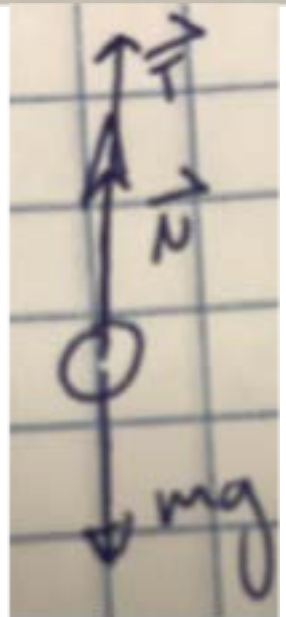
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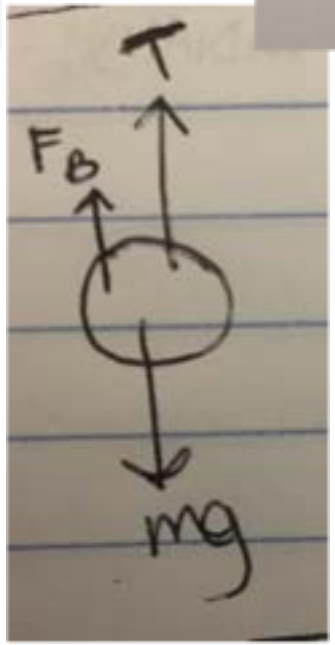
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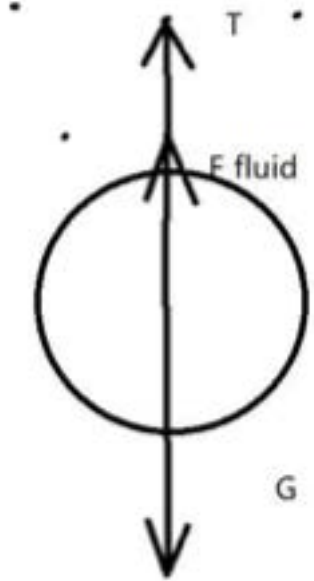
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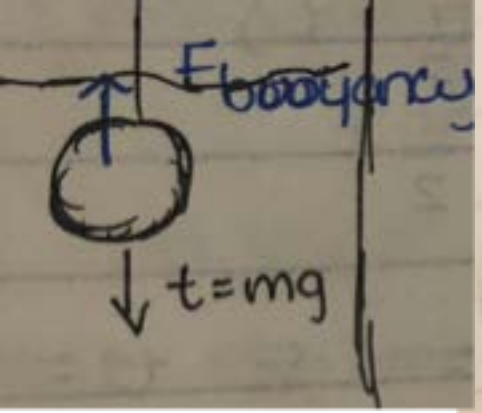
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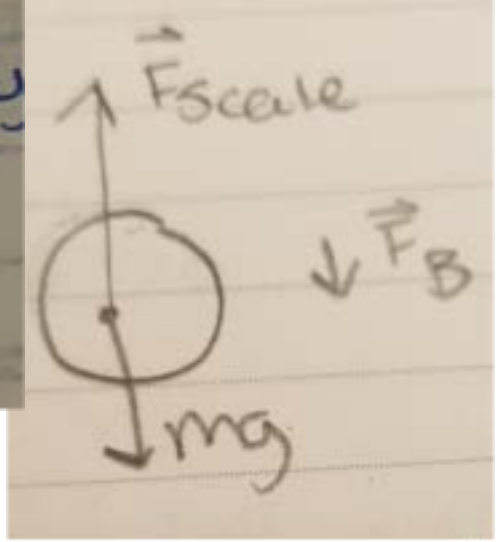
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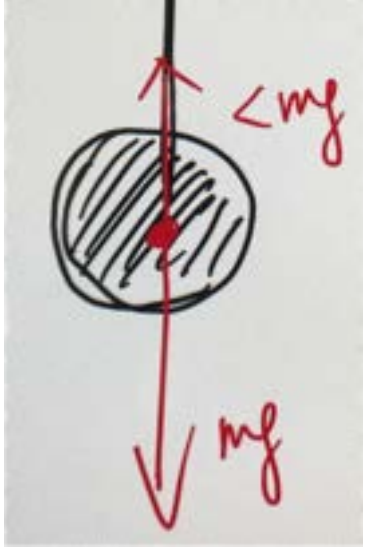
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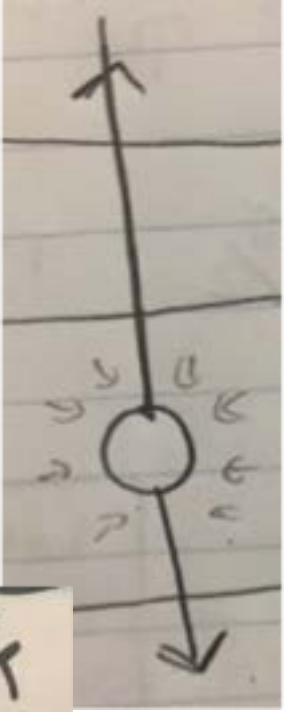

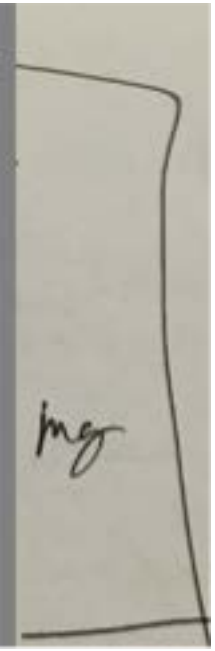
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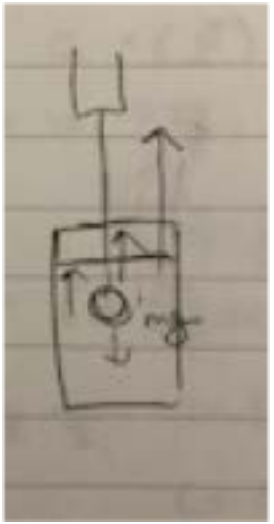

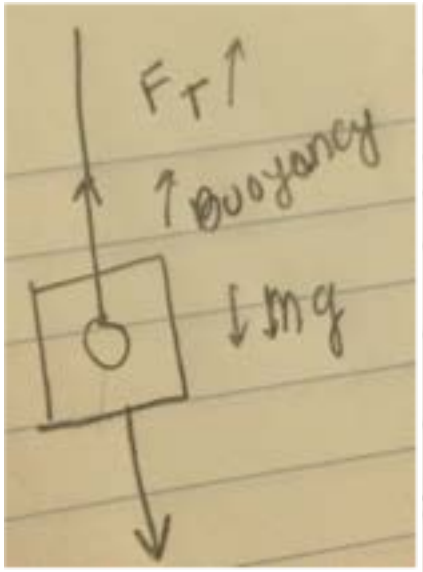
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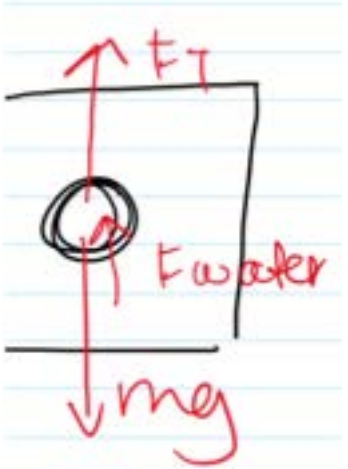
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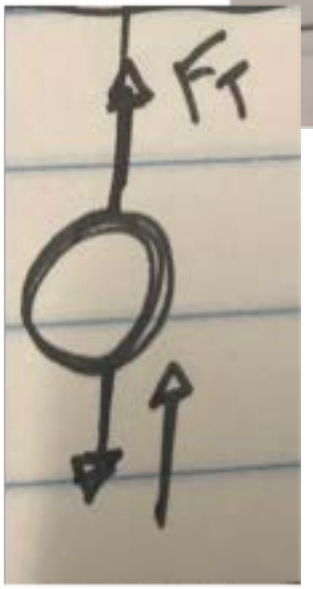
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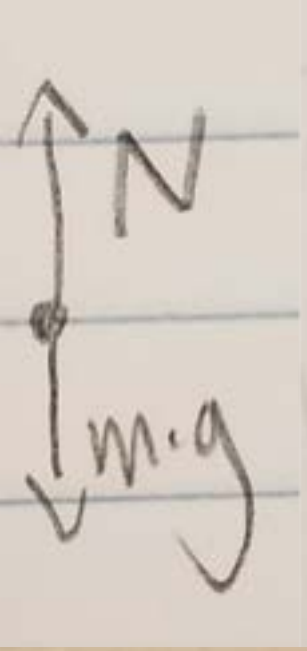
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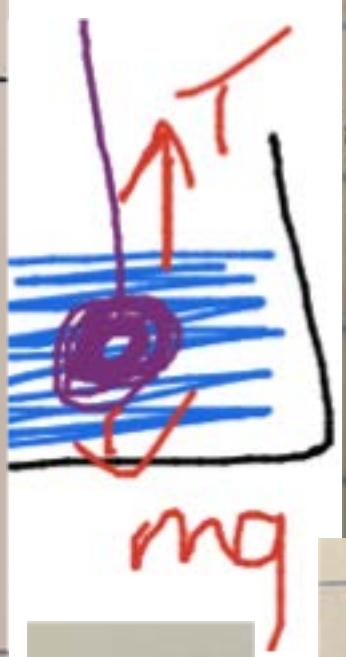
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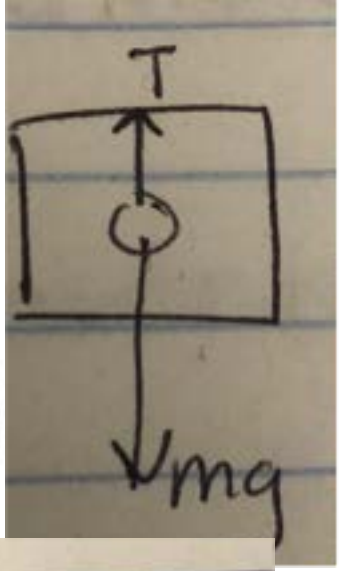
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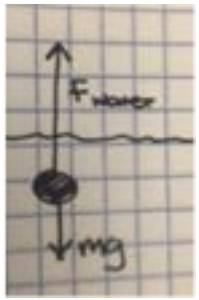
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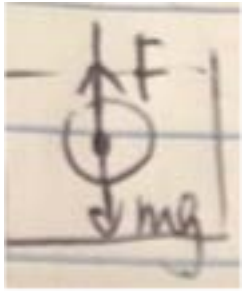
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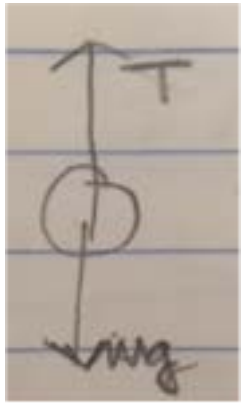
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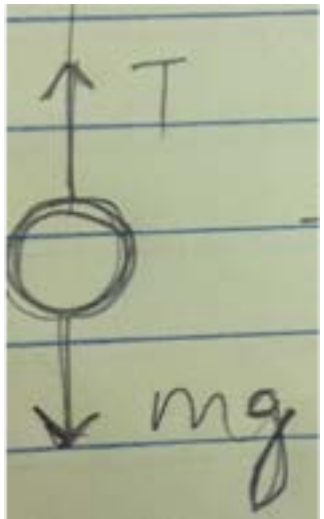
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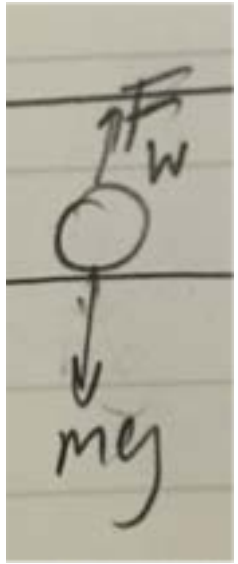
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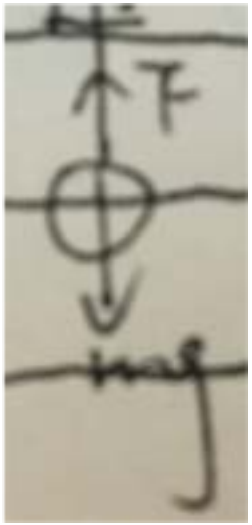
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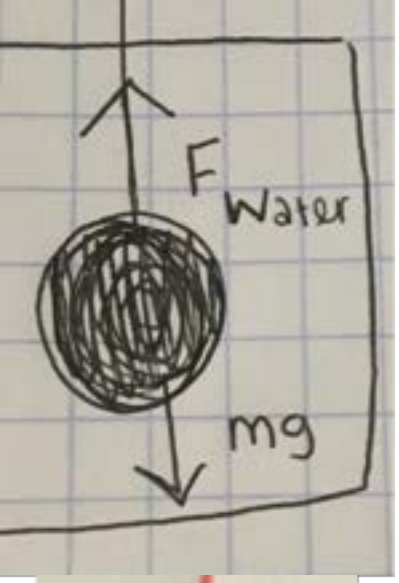
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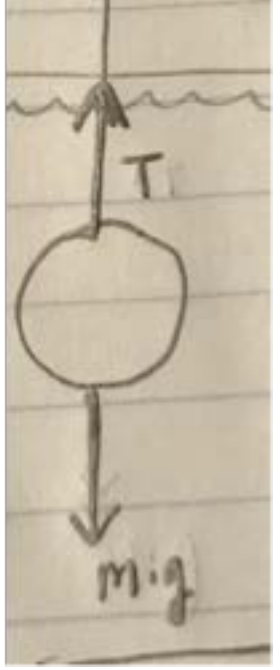
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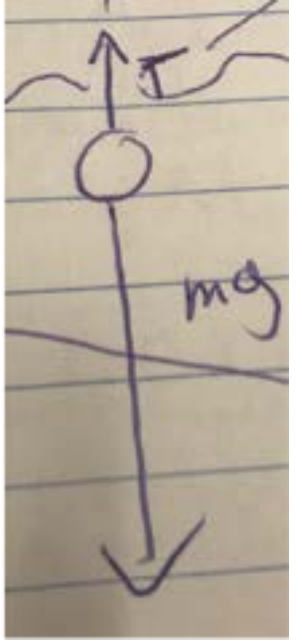
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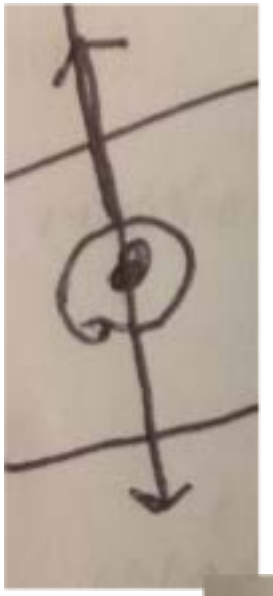

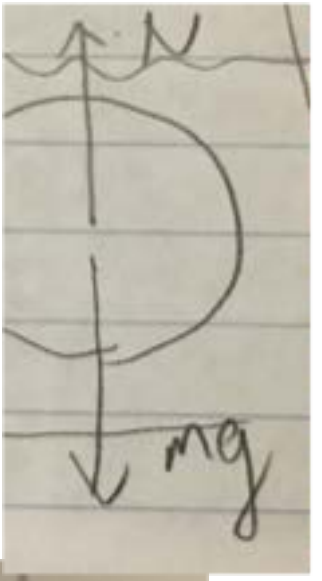
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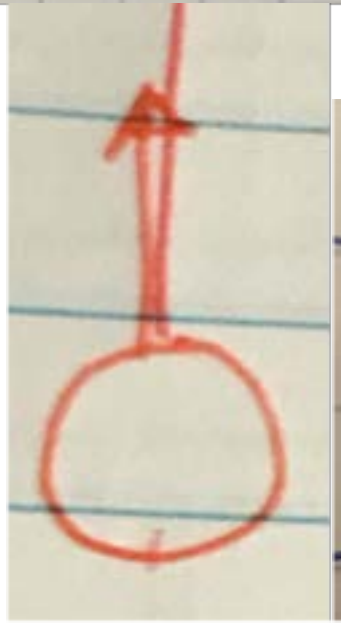

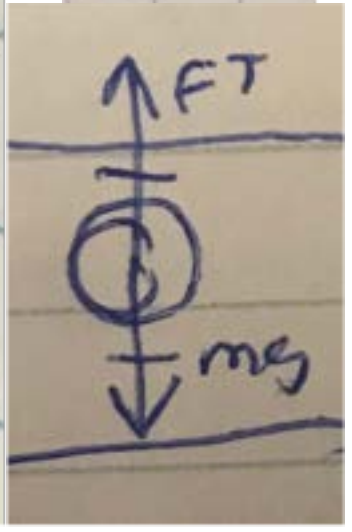
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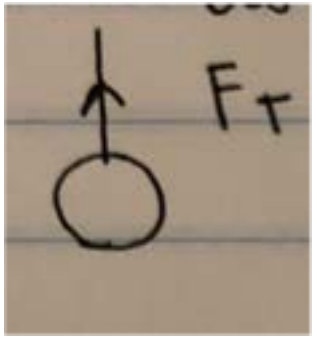
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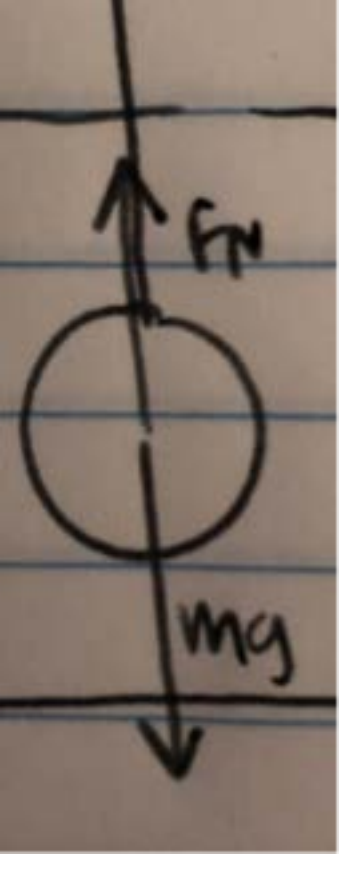
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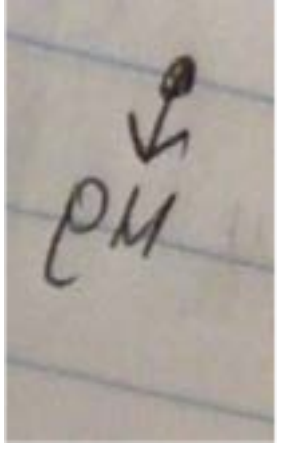
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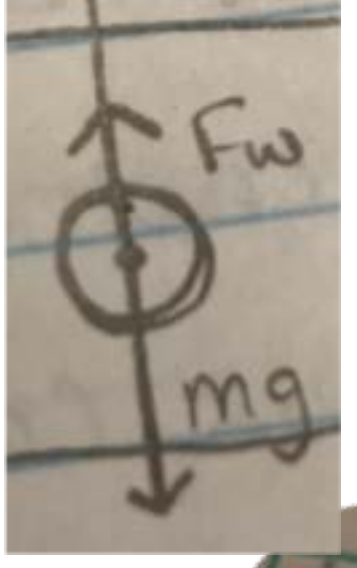
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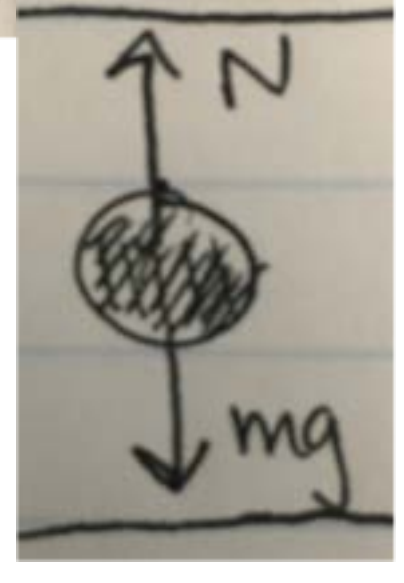
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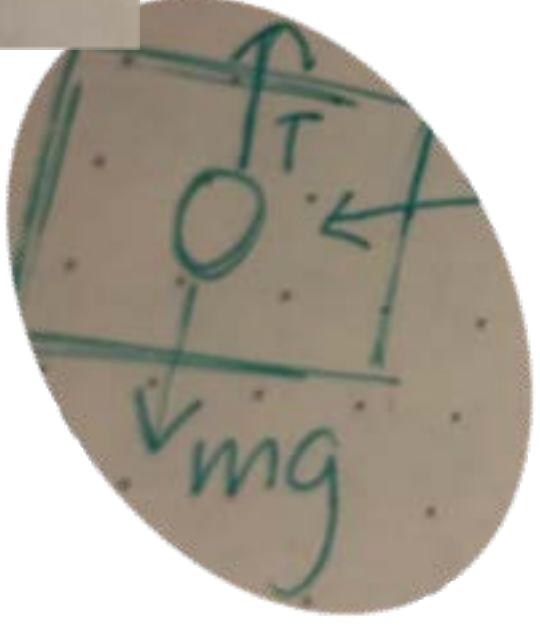
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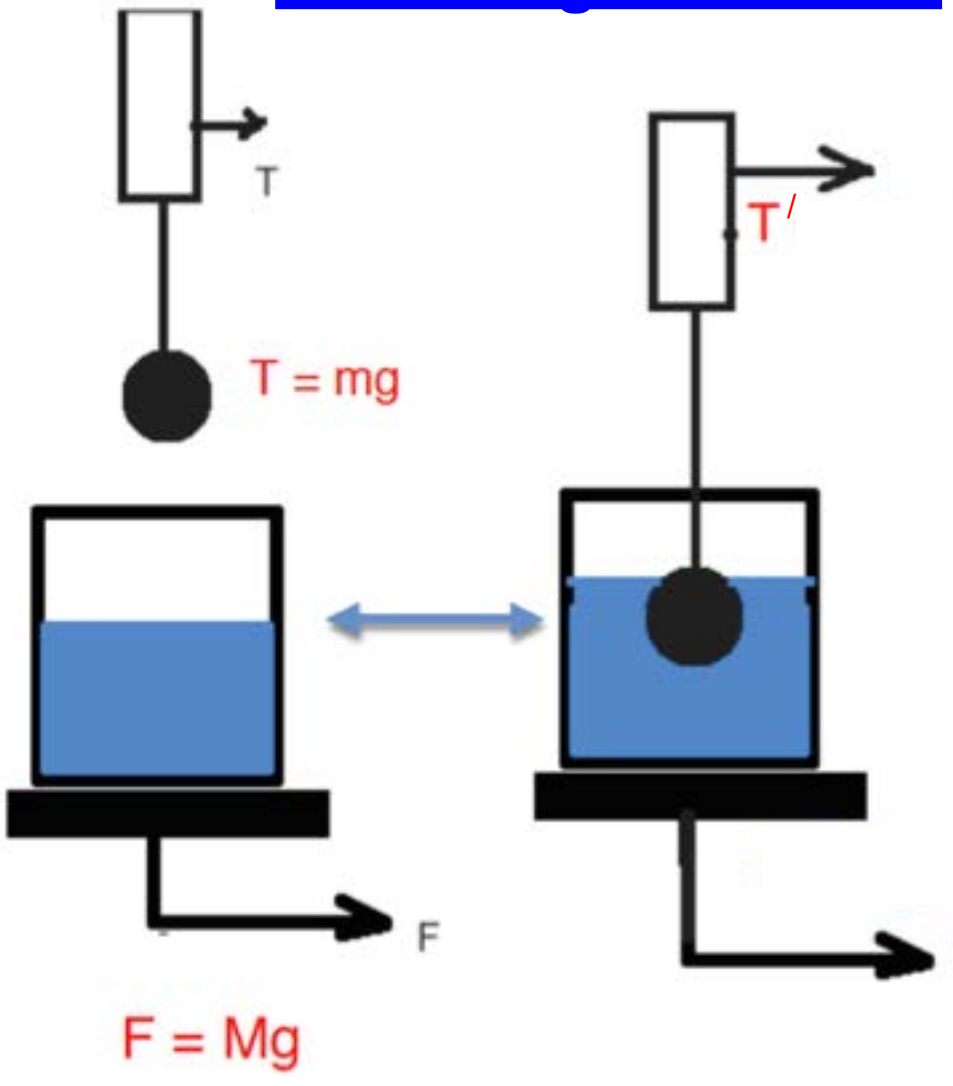
Webassign: L20 Q2



The weight of a ball in air is 10 N. The weight of a beaker with water is 40 N. The apparent weight of the ball in water is 8 N. What is the new reading of the scale?.

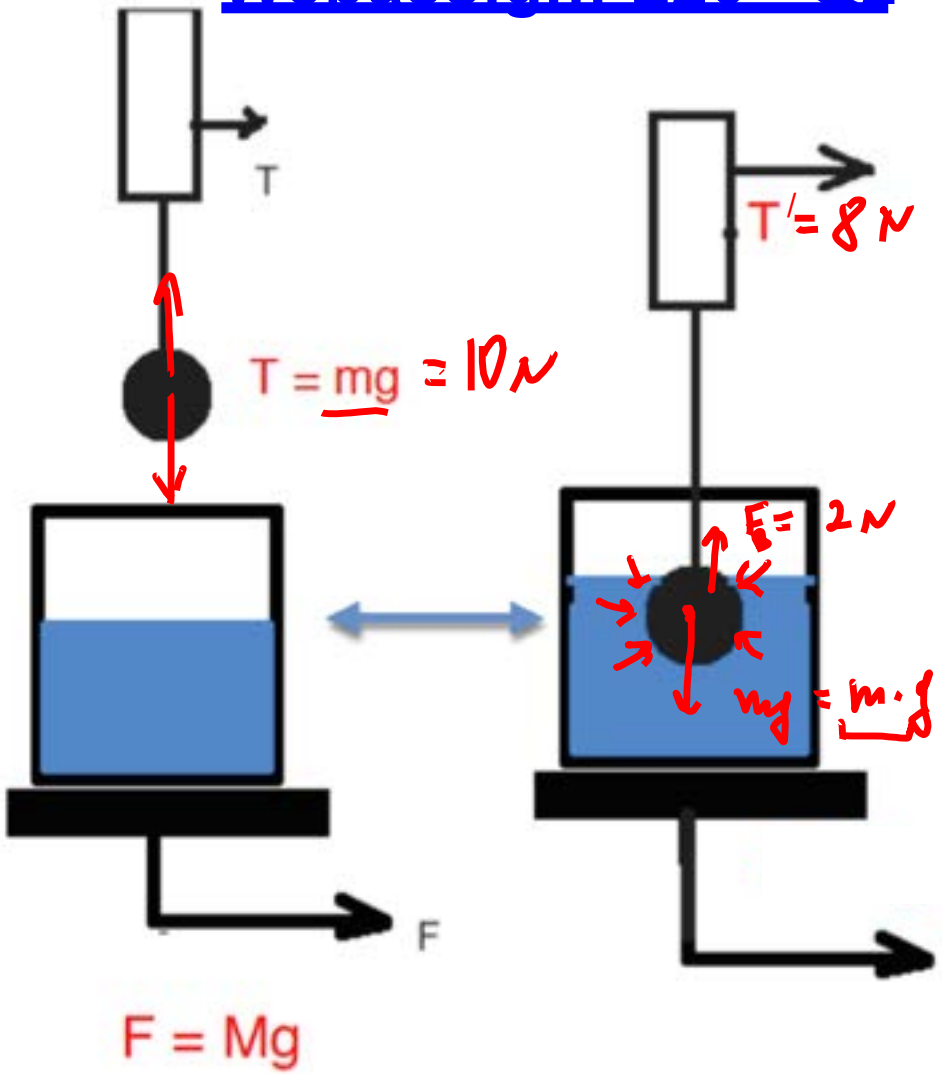
1. 40 N 2. 41 N 3. 42 N
4. 43 N 5. 44 N …

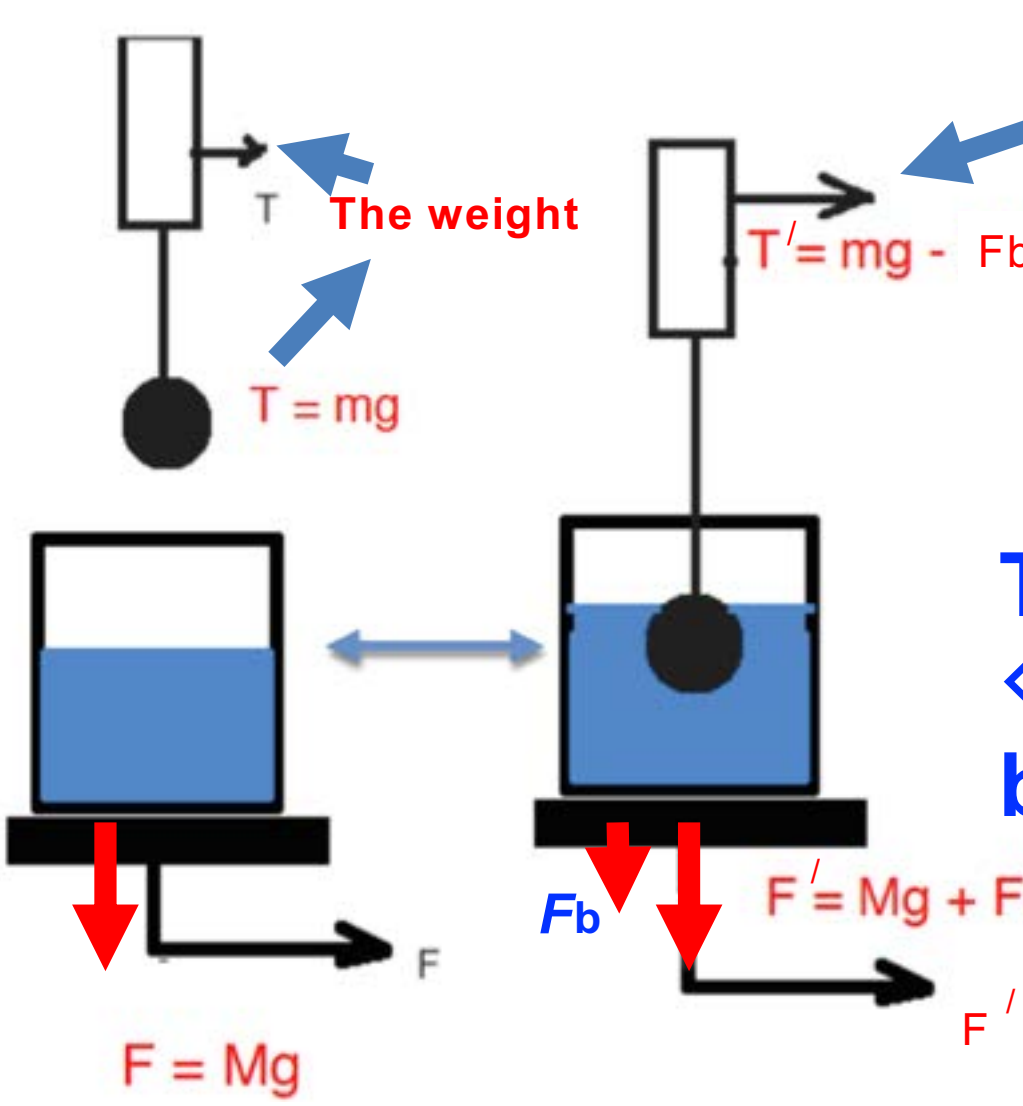
Webassign: L20 Q2

The weight of a ball in air is 10 N. The weight of a beaker with water is 40 N.

The apparent weight of the ball in water is 8 N. What is the new reading of the scale?.

1. 40 N 2. 41 N 3. 42 N
4. 43 N 5. 44 N …





$$F_b + T' = mg$$

=>

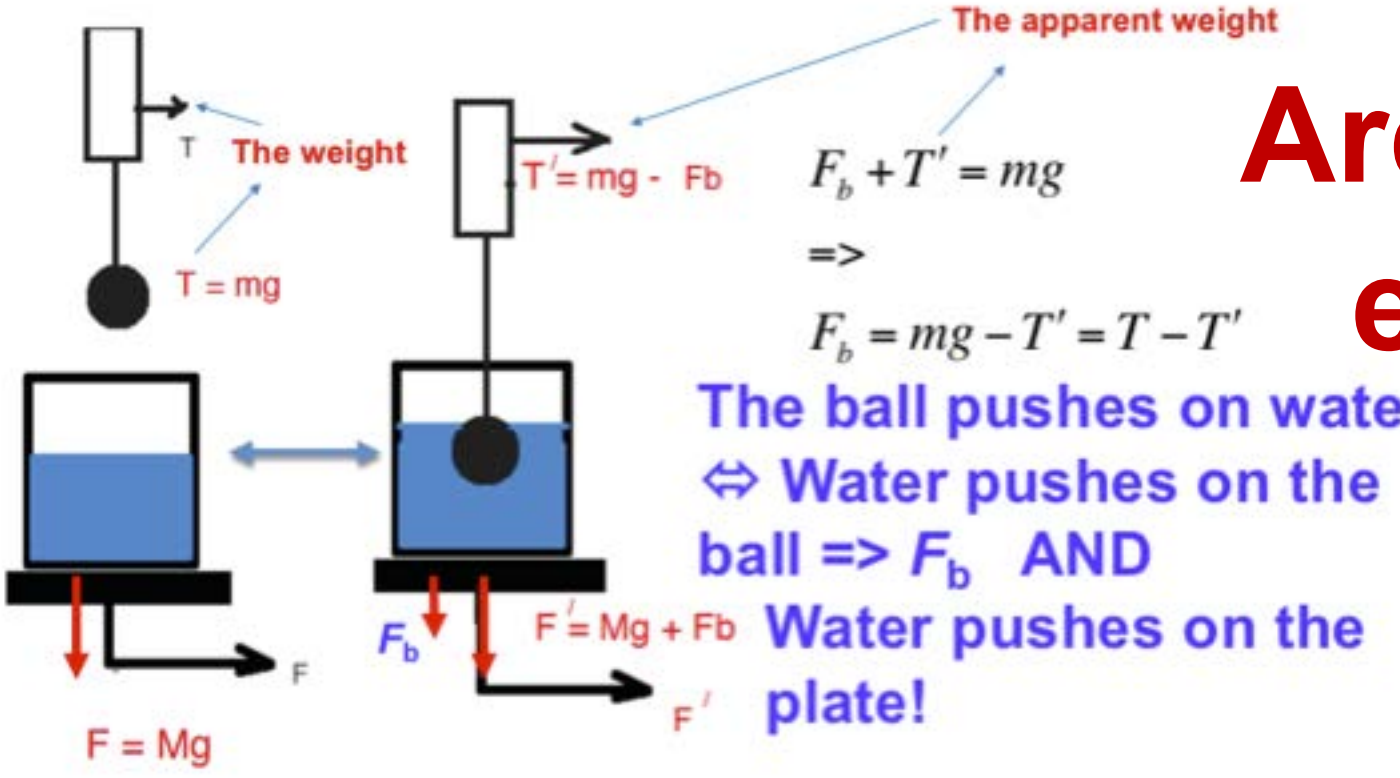
$$F_b = mg - T' = T - T'$$

The ball pushes on water!

⇔ Water pushes on the ball => F_b AND

Water pushes on the plate!

Archimedes experiment (~250 BC)



$$F_b + T' = mg$$

$$\Rightarrow$$

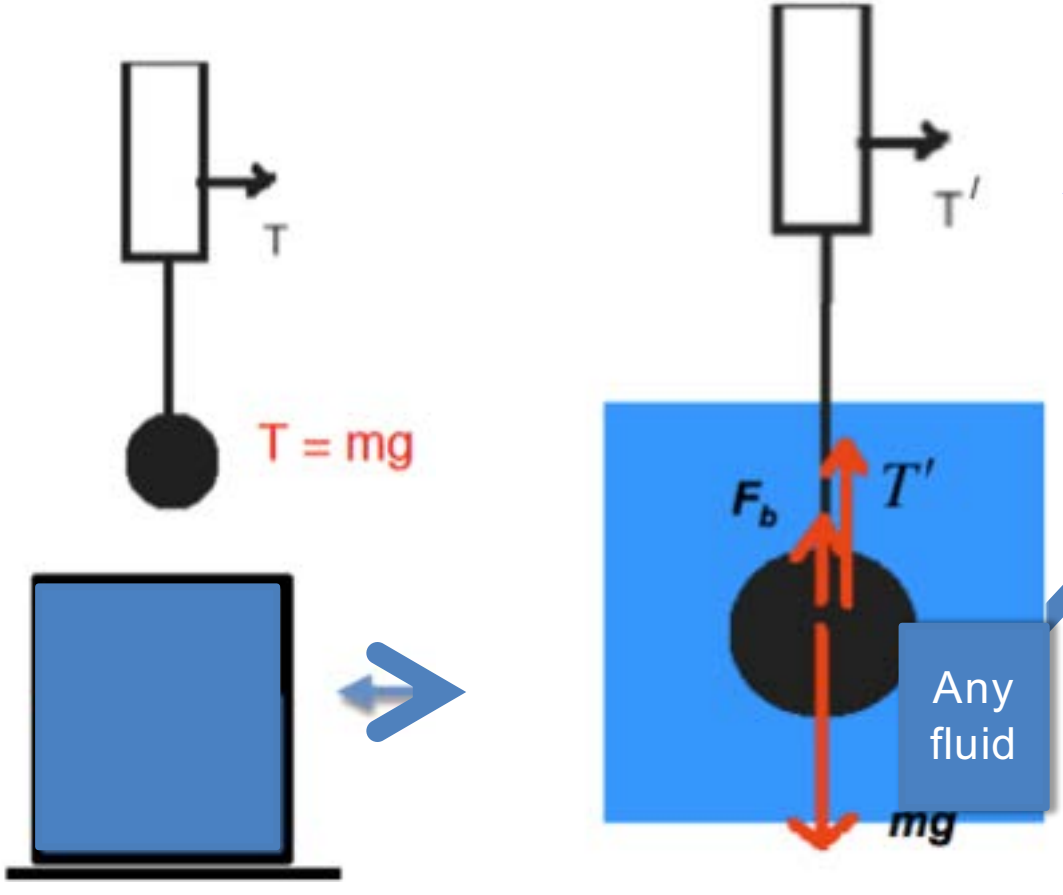
$$F_b = mg - T' = T - T'$$

The ball pushes on water!
⇔ Water pushes on the ball => F_b AND
Water pushes on the plate!

https://en.wikipedia.org/wiki/Archimedes

Buoyant force!

$F_B = T - T'$



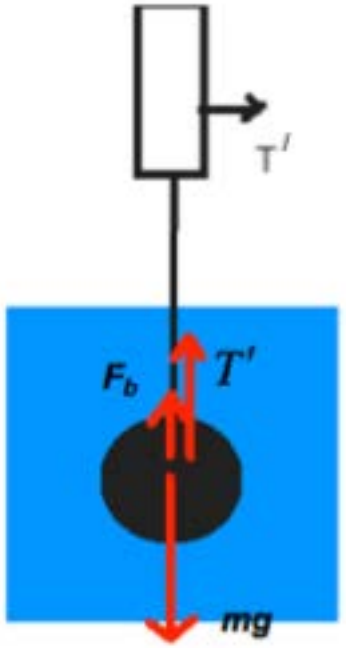
And *ALWAYS*

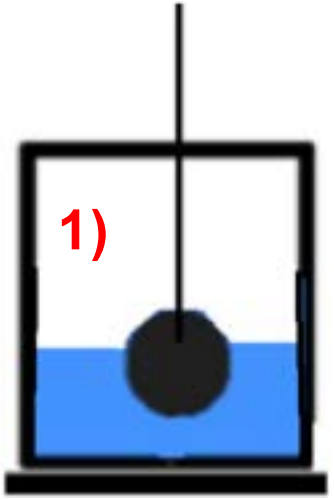
$F_B = m_{fluid\_displaced} * g$

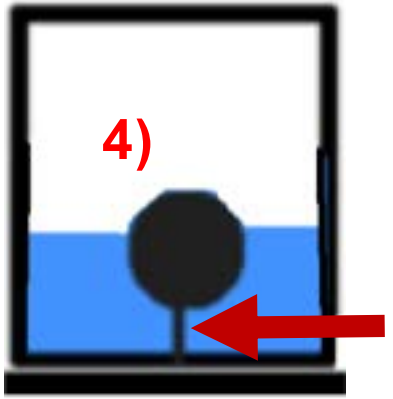
Not just water!

F_B = the ***weight*** of the fluid ***displaced*** by an object! by ***Archimedes***

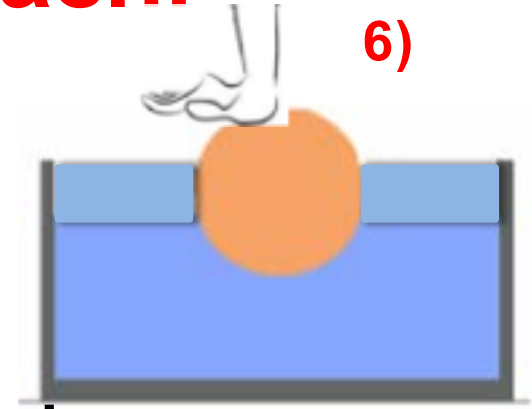
Typical situations: draw FBD for each!

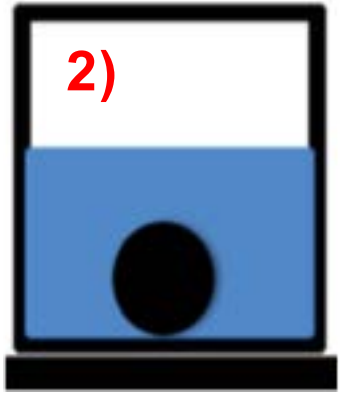


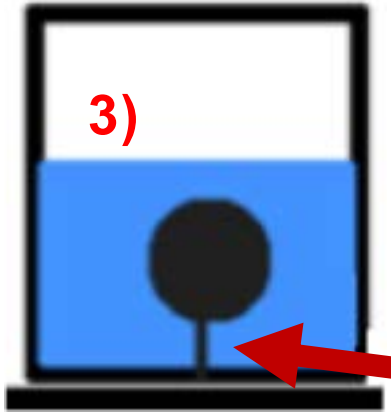




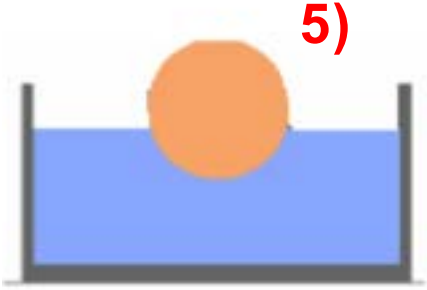
a rod

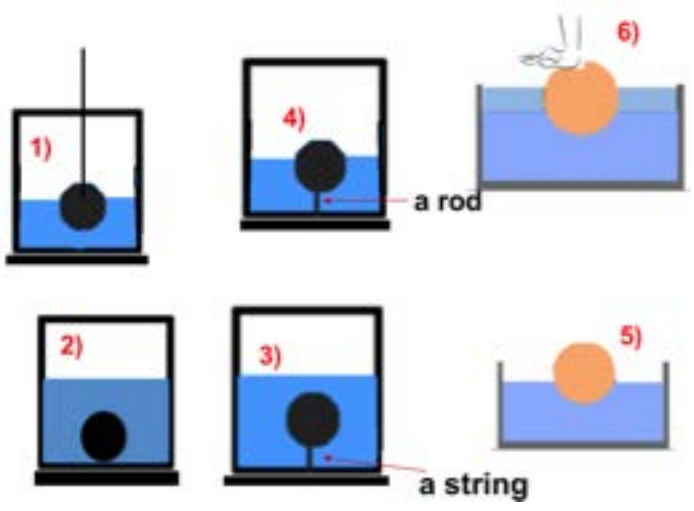


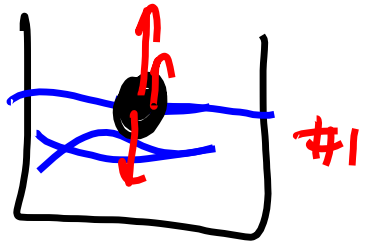


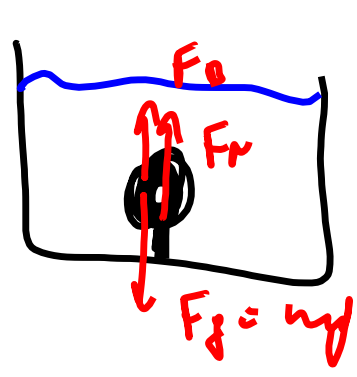


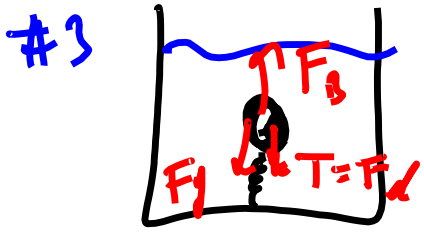
a string

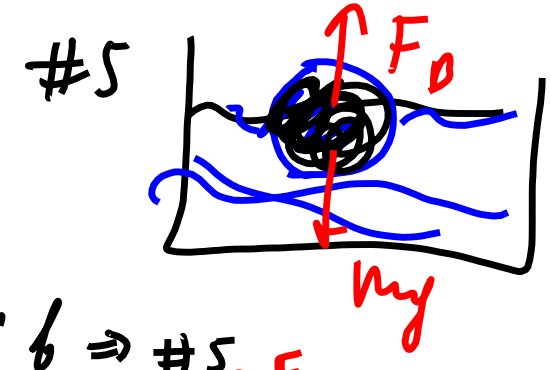


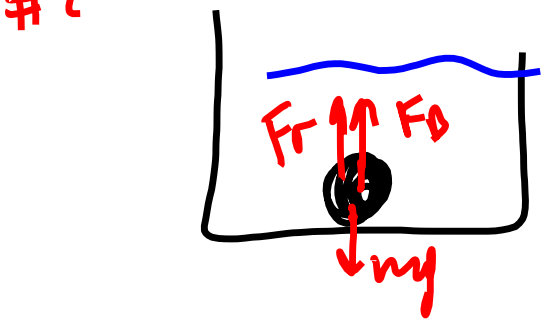

1)
2)
3)
4)
5)
6)
a rod
a string

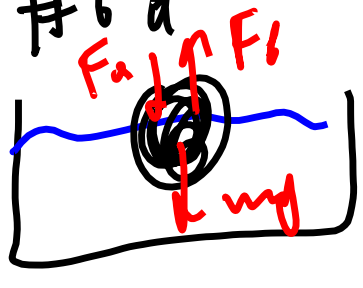

#1

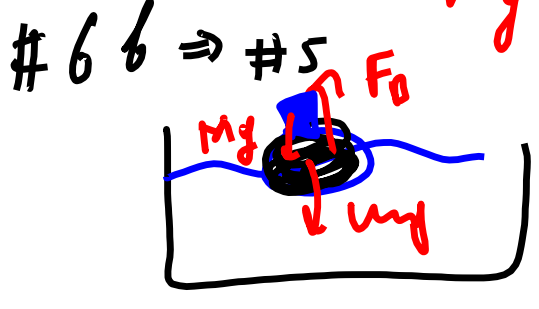

#4
F_B
F_T
$F_g = mg$


#3
F_B
F_g
$T = F_B$


#5
F_B
mg


#2
F_T
F_B
mg


#6 a
F_B
F_T
mg

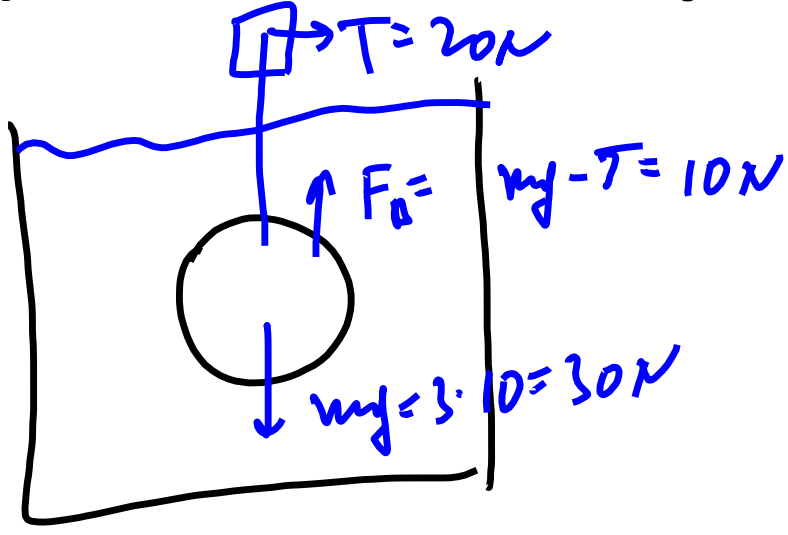

#6 b ⇒ #5
F_B
Mg
mg

A general strategy for solving problems on buoyant force.

Is essentially the same as a general strategy for solving problems on ANY force!

1. Draw a picture, convert it into FBD.
2. Set FBE (N2L for Equilibrium)
3. If necessary, add additional relationships (think what variables are connected: F_B, m, g, ρ, V, etc. – depending on forces and geometry)
4. Solve

When a 3 kg ball with diameter of 10 cm is completely immersed in some fluid its apparent weight is 20 N. Find the magnitude of the buoyant force acting on the ball. How much fluid (in kg and m^3) does the ball displace?



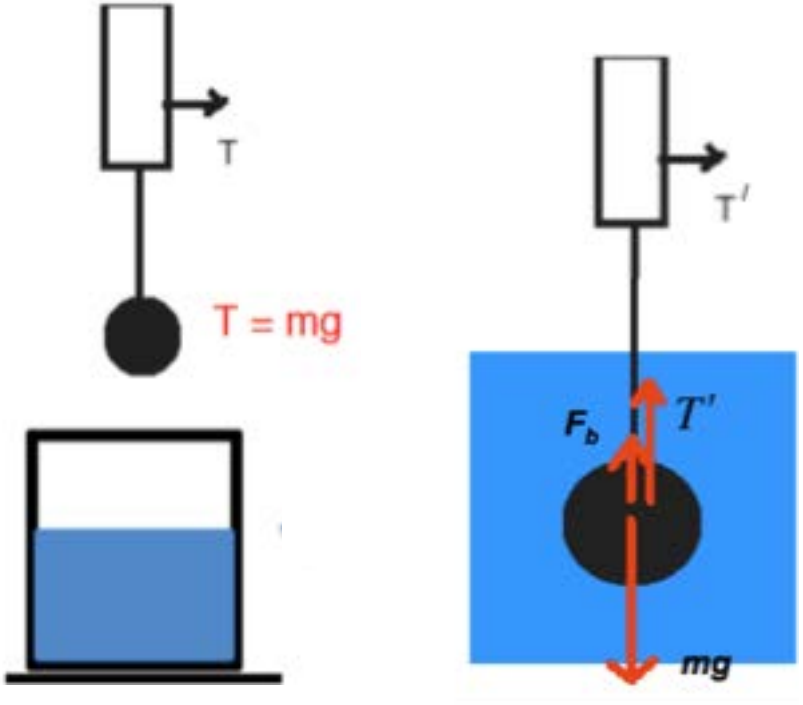
$F_B = W_{fl.d.by\ a} = m_{fl} \cdot g$

$10N = m_{fl} \cdot g \Rightarrow m_{fl} = 1kg$

$V_{fl.d.by\ a} = V_{of\ ball} = \bigcirc = \frac{4}{3}\pi r^3 =$

$= \frac{4}{3} \cdot 5 \cdot (0.05)^3$

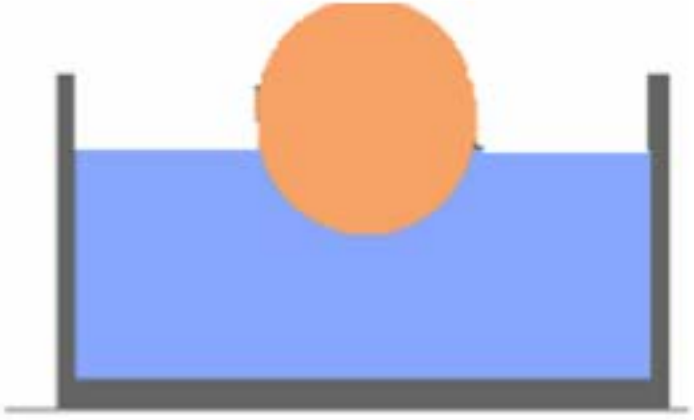
When a 3 kg ball with diameter of 10 cm is completely immersed in some fluid its apparent weight is 20 N. Find the magnitude of the buoyant force acting on the ball. How much fluid (in kg and m³) does the ball displace?



$$F_B = T - T' = 3*10 - 20$$
$$= 10 \text{ N}$$

$$m_{fluid\_displaced} = F_B/g = 1 \text{ kg}$$

$$V = \frac{4}{3}\pi\left(\frac{0.1}{2}\right)^3 = 0.0005 \text{ m}^3$$



A basketball floats in a bathtub of water.

The ball has a mass of 0.5 kg and a diameter of 22 cm (0.22 m).

Webassign: L20 Q3

What is the buoyant force?

How many forces are acting on the ball?

1 2 3 …

How much water (in kg) does the ball displace?

A basketball floats in a bathtub of water.

The ball has a mass of 0.5 kg and a diameter of 22 cm (0.22 m).

$F_B = m_{fluid\_displaced} \cdot g$

What is the buoyant force?

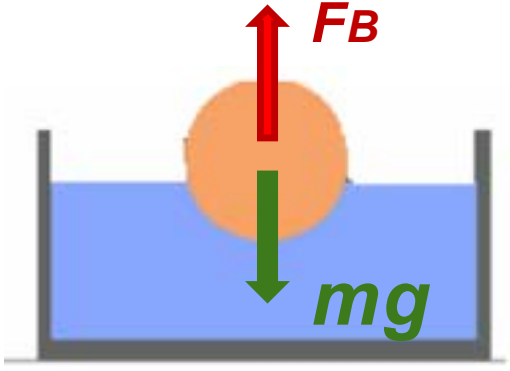
Webassign: L20 Q3

How many forces are acting on the ball?

1 2 3 ...

How much fluid (in kg) does the ball displace?

$F_g = mg = 0.5 \cdot 10 = 5N \Rightarrow 5 = m_{fl} \cdot g \Rightarrow m_{fl} = \frac{5}{10} = .5kg$



A basketball floats in a bathtub of water. The ball has a mass of 0.5 kg and a diameter of 22 cm (0.22 m).

$g = 9.8\ m/s^2$

(a) What is the buoyant force?

The ball is in equilibrium, hence

$$F_b = W = mg = 4.9\ N$$

$F_B = m_{fluid\_displaced} * g$ ⇨ $m_{fluid\_displaced} = F_B/g = 490\ g$

Buoyant force! (Again)

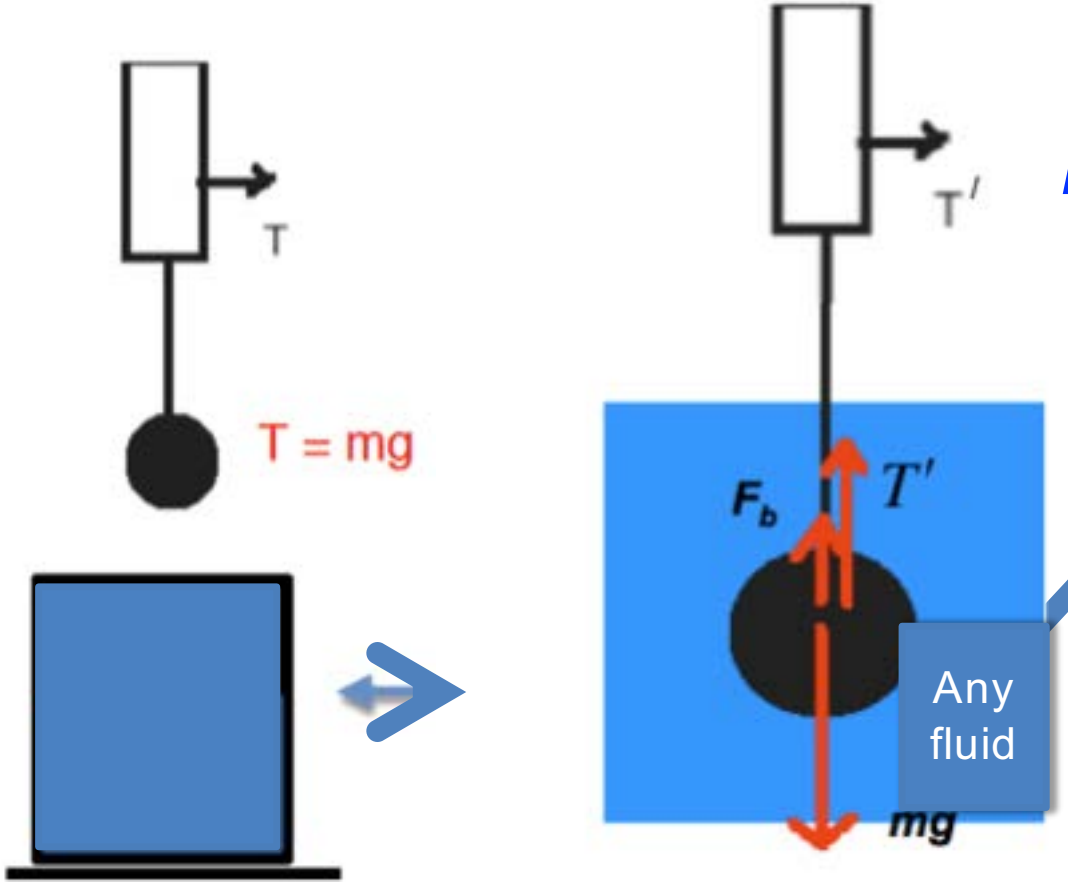
Any fluid!

$F_B = T - T'$

And ALWAYS

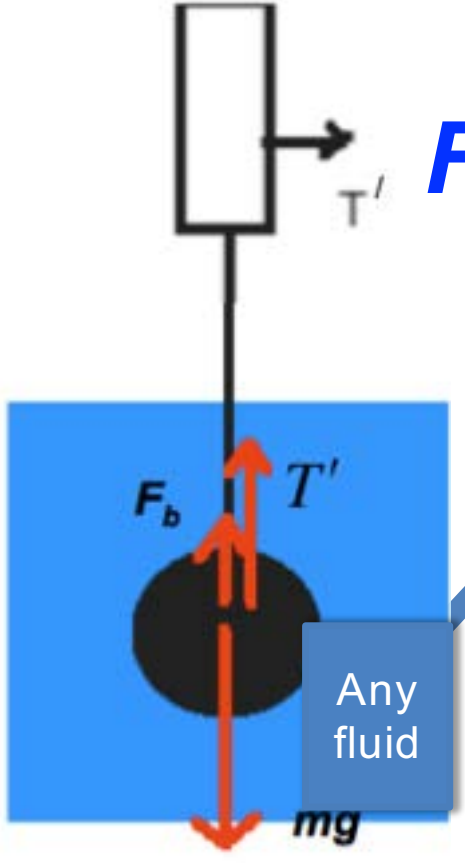
$F_B = m_{fluid\_displaced} * g$

Not just water!



F_B = the weight of the fluid displaced by an object!

Any fluid!



$F_B = m_{fluid\_displaced} * g$

Not just water!

F_B = the weight of the fluid displaced by an object!

Experiments!

The same ball; DIFFERENT fluids

DIFFERENT F_B

???

To describe how much matter (or how many elementary particles) there are on average in the medium the physical quantity *Density* is used.

Density (ro) $\rho = \frac{m}{V}$ (kg/m^3) ➡ $m = \rho V$

Some Densities

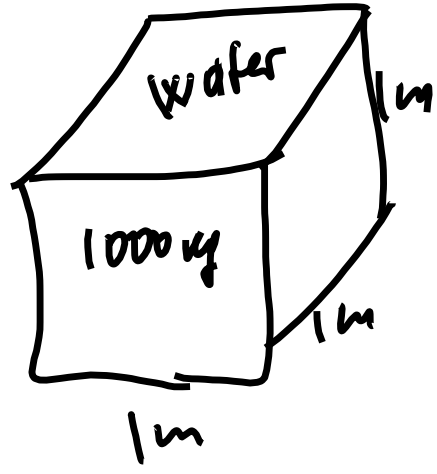
Material (or object)	Density (kg/m^3)
Air (20^0C and 1 atmosphere)	1.21
Water (4^0C and 1 atmosphere)	1000
Iron	7900
Mercury (the metal)	13600
Earth (the planet, on average)	5500

= ?? g /cm^3

Webassign: L20 Q4

Water (4^{0}C and 1 atmosphere)	1000 **kg/m^3**	**= ?? g /cm^3**

1. 1000 g/cm^3
2. 100 g/cm^3
3. 10 g/cm^3
4. 1 g/cm^3
5. 2000 g/cm^3
6. 200 g/cm^3
7. 20 g/cm^3
8. 2 g/cm^3
9. None of the above



$1000\ \frac{kg}{m^3} = 1000\ \frac{1000\ g}{100\ cm^3} =$

$1\ m = 100\ cm$

$= \frac{1000}{10000}\ \frac{g}{cm^3} = \frac{1}{10}\ \frac{g}{cm^3}$

To describe how much matter (or how many elementary particles) there are on average in the medium the physical quantity *Density* is used.

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= 1 g /cm^3

What is the mass of a 2 L bottle of soda (assume $\rho_{soda} = \rho_{water}$)?

$1\,l = 1000\ cm^3$

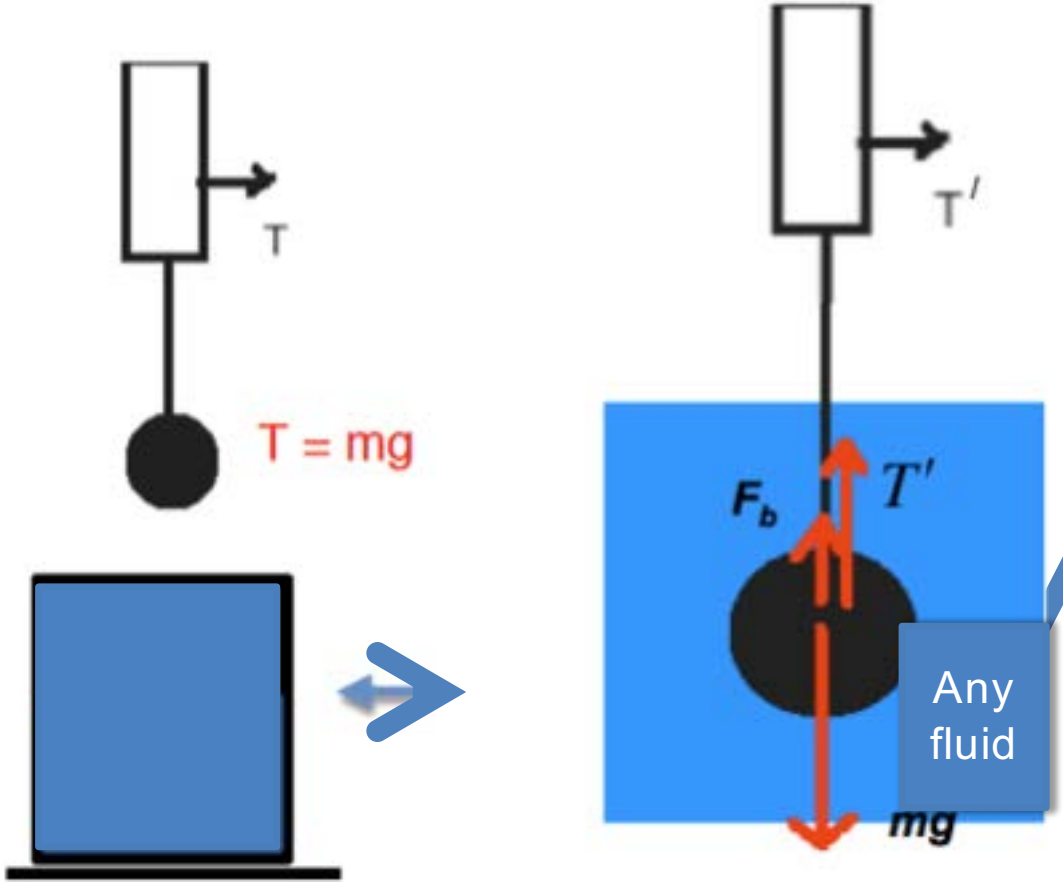
$2\,l = 2000\ cm^3 \rightarrow m_{2l} = 2000\ cm^3 \cdot 1\ \frac{g}{cm^3} = 2000\,g = 2\,kg$

Buoyant force!

$$m = \rho V$$

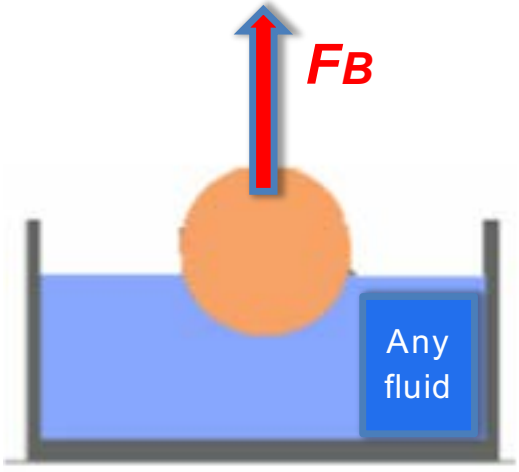
$$F_b = m_{fliud\ displaced} * g =$$

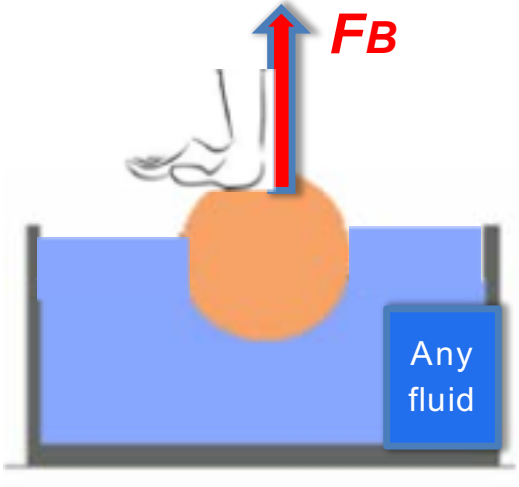
$$= \rho_{fliud} V_{displaced} * g$$



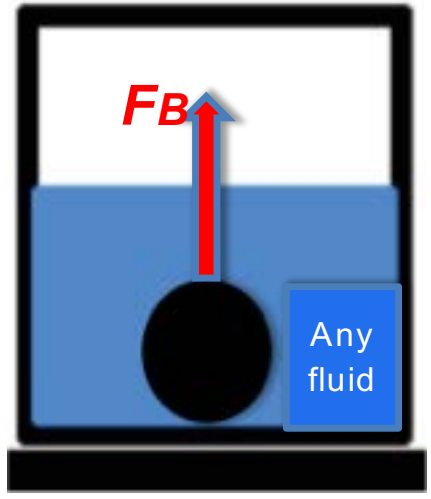
Not just water!

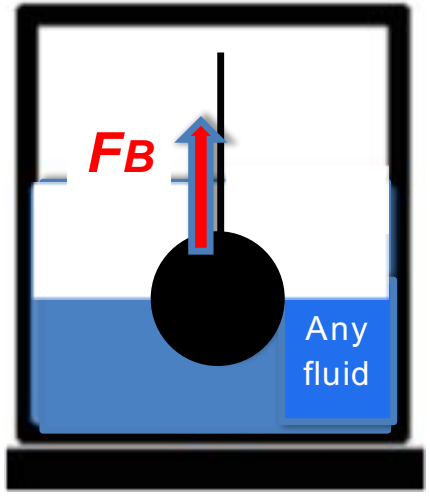
Buoyant force is *one of many acting*!





Other Forces Are Not Shown (your job!)

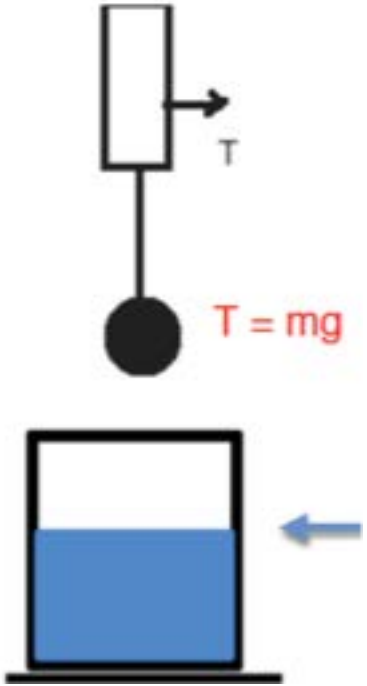




$$F_b = \rho_{fliud} V_{displaced} * g =$$

$$= \rho_{fliud} V_{of\_the\_object\_in\_the\_fluid} * g$$

Webassign: L20 Q5



When a 3 kg ball is immersed in water its apparent weight W_A is 20 N. When the same 3 kg ball is immersed in mercury its apparent weight W_A is …

1. 20 N
2. > 20 N
3. < 20 N
4. no way to say

Material (or object)	Density (kg/m^3)
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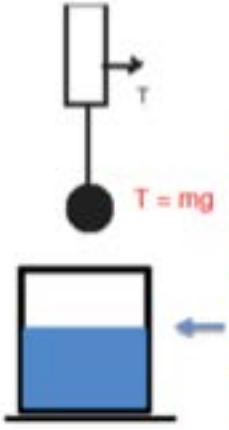

Webassign: L20 Q5

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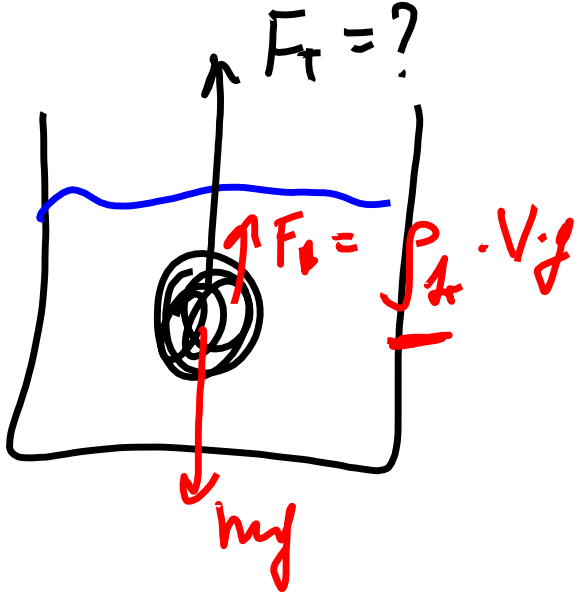
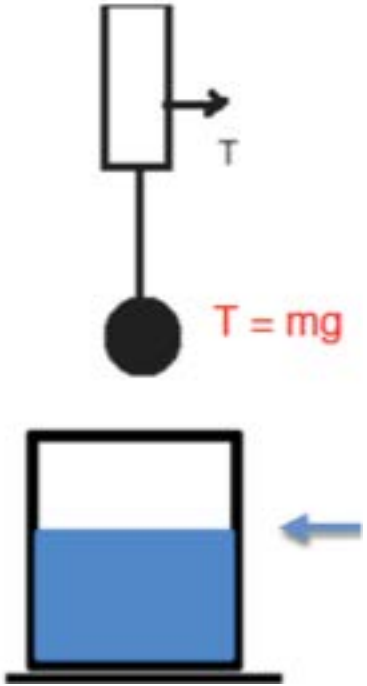


$\rho \uparrow$; $F_B \uparrow$; $F_T = mg - F_B$

Webassign: L20 Q5



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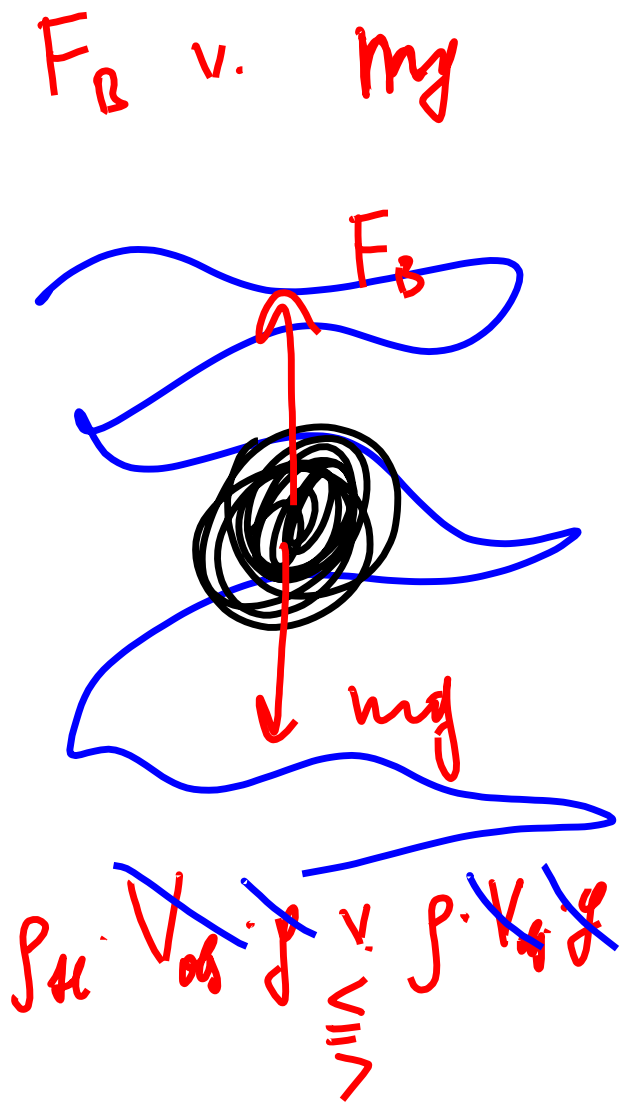
Density of the object v. **Density of the fluid**

An object is immersed in a fluid and released.

Sinking ρ_O ρ_F

Floating (in equilibrium) ρ_O ρ_F

Rising ρ_O ρ_F



Density of the object v

Density of the fluid

An object is immersed in a fluid and released.

Sinking $\rho_O > \rho_F$

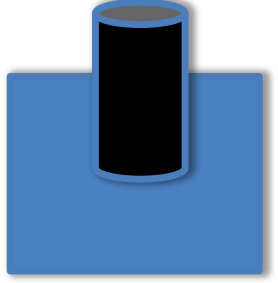
Floating (in equilibrium) $\rho_O = \rho_F$

Rising $\rho_O < \rho_F$

Correct set of symbols is ...

1. =, =, =
2. >, >, >
3. <, <, <
4. >, =, <
5. <, =, >
6. None of the above

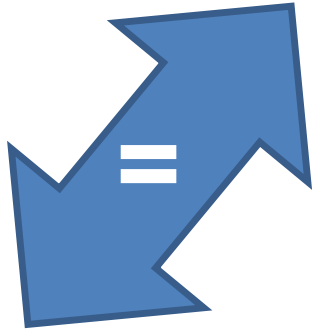
A plastic cylinder is floating in *water*.

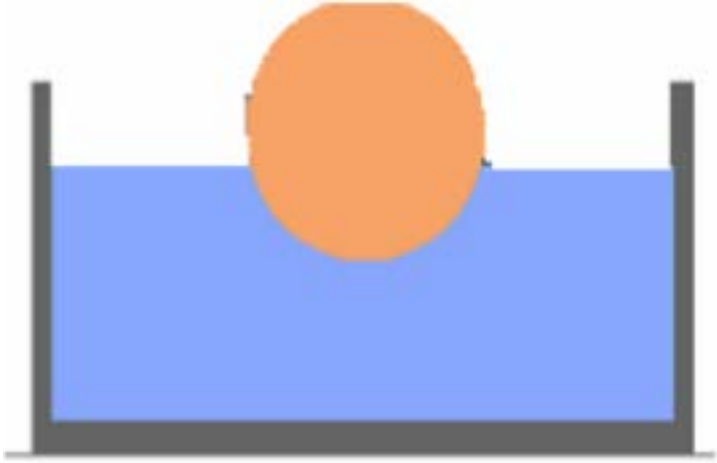


Measure the dimensions and find the mass of an object hidden in the cylinder, and also the *average* density of the cylinder.

Have we done in the past *anything* on FLOATING?

A plastic cylinder is floating in *water*. Measure the dimensions and find the mass of an object hidden in the cylinder,
and also the *average* density of the cylinder.





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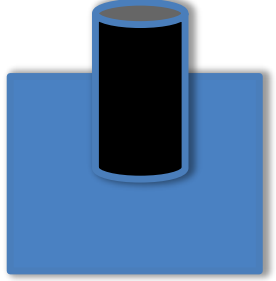
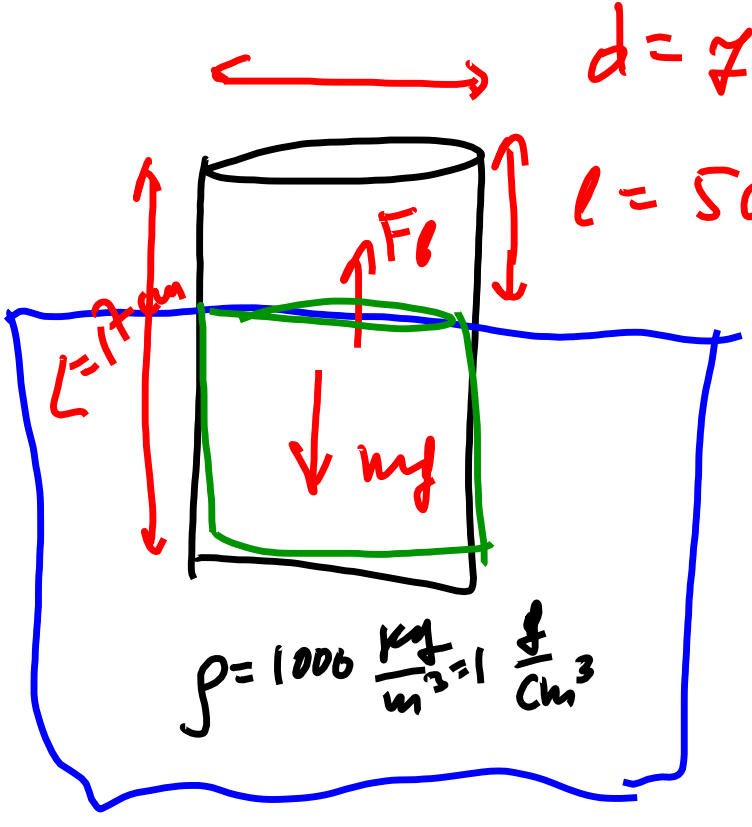
Measure the dimensions and find the mass of an object hidden in the cylinder,
and also the *average* density of the cylinder.





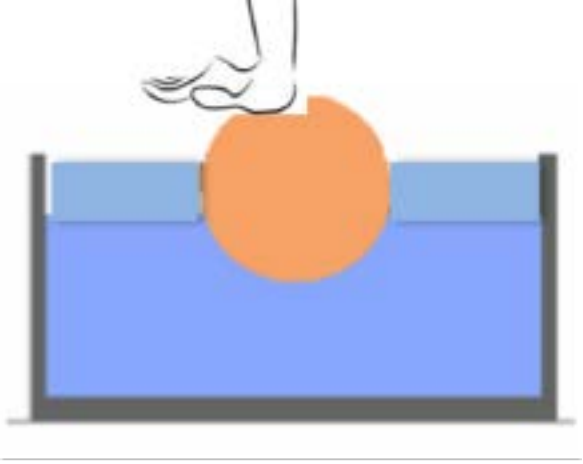
$F_B = \rho_w \cdot V_{obinw} \cdot g$

$mg = F_B = \rho_w \cdot V_{obinw} \cdot g$

$m = \rho_w \cdot V_{obinw} = 1 \cdot \frac{g}{cm^3} \cdot A \cdot H =$

$= 1 \cdot \pi \cdot r^2 \cdot (L - l) = \pi \cdot \left(\frac{7}{2}\right)^2 \cdot (17 - 5) =$

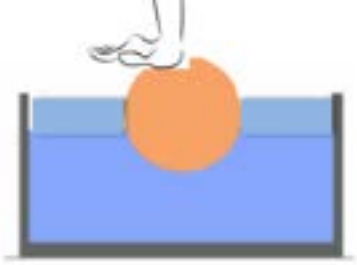
$= 461\ g = \sim 0.5\ kg$



A basketball floats in a bathtub of water.

The ball has a mass of 0.5 kg and a diameter of 22 cm (0.22 m).

What *additional* force do we need to apply to the ball to completely submerge it into water? If instead of a force we would need to add a weight, what would be the mass of that weight?



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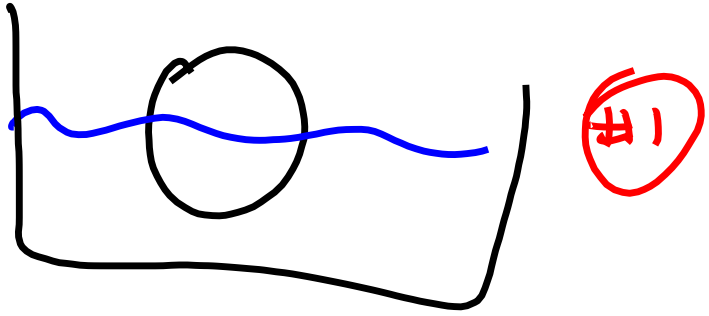

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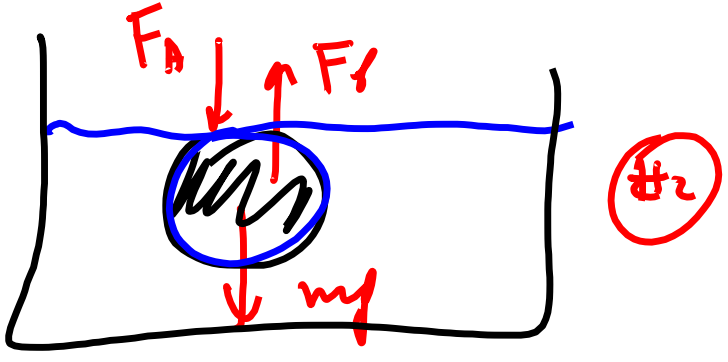


$F_A + mg = F_t$

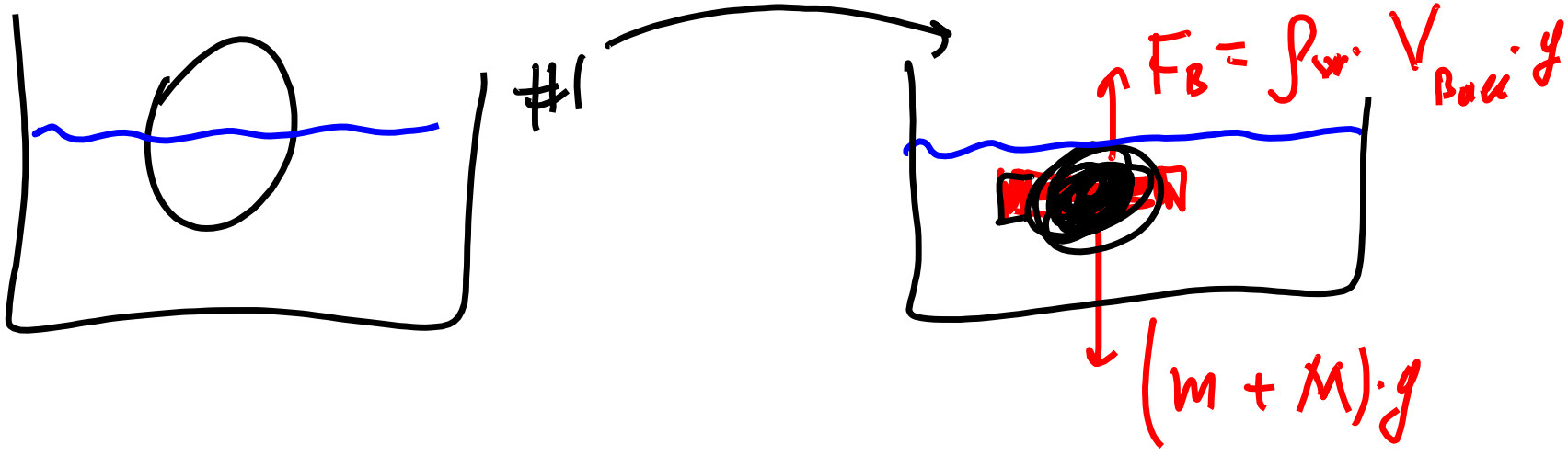
$F_A = F_A - mg = \rho_w \cdot V_{tot} \cdot g - m \cdot g =$

$= 1000 \cdot \frac{4}{3}\pi \cdot 0.11^3 \cdot 10 - 0.5 \cdot 10 =$ **50.75 N**

N ; $m_{add} \Rightarrow W = F_A$

$F_A = m_{add} \cdot g$; $m_{add} = \frac{F_A}{10}$

m = 50.75/10 = 5 kg



$$(m+M)\,g = \rho_w \cdot V_{bacc} \cdot g$$

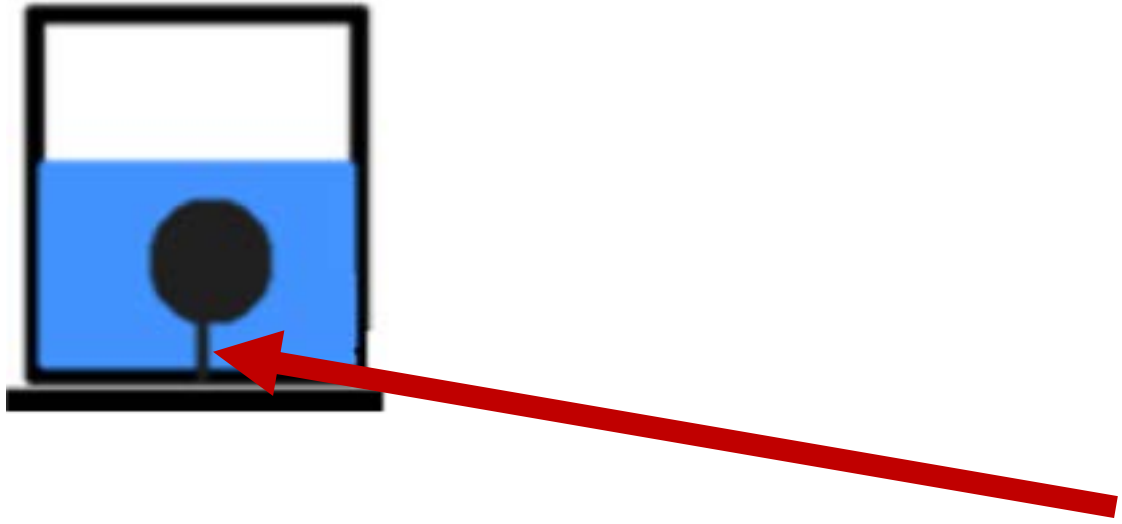
M = 1000* $\frac{4}{3}\pi \cdot 0.11^3$ **– 0.5 = 5 kg**

A boat floats in a lake. When the anchor is taken from the boat and placed on the floor of the lake the level of the water in the lake …

1. does not change

2. Rises

3. Lowers

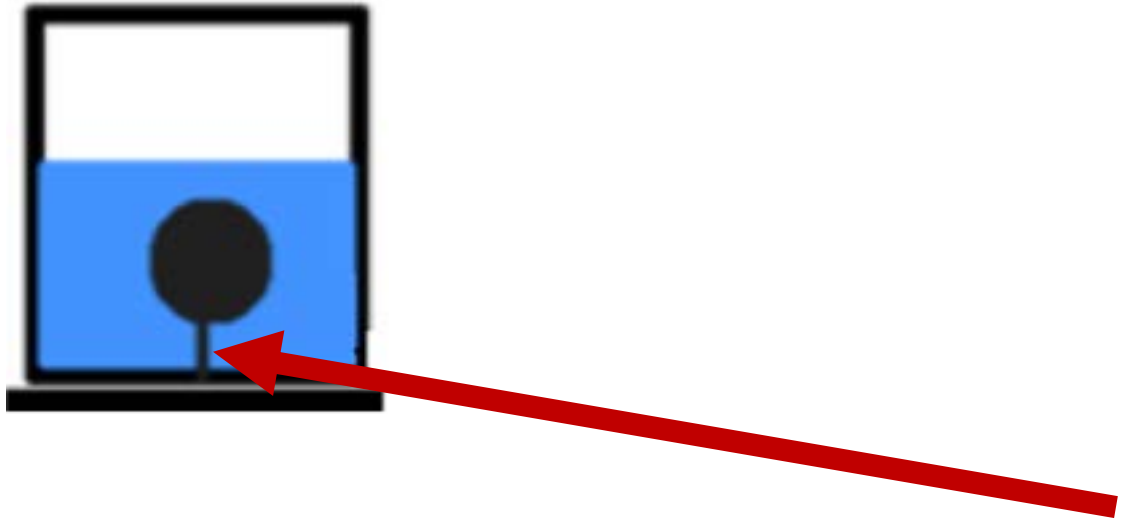


What will happen if *this* element will be removed?

1. It sinks
2. It floats

(in equilibrium)

3. It rises to the surface
4. We don't know



What will happen if *this* element will be removed?

1. It sinks
2. It floats

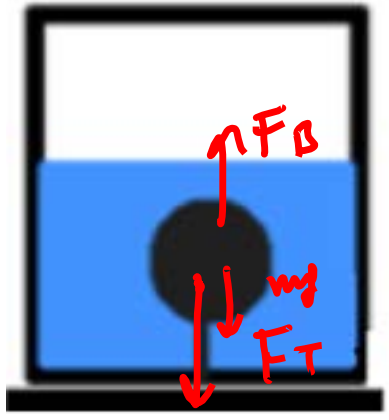
(in equilibrium)

3. It rises to the surface
4. We don't know (may be a rod, may be a string)

For the ball: d = 10 cm $\rho_{ball} = 0.8 \frac{g}{cm^3}$

Find the apparent weight of the ball in water.

If the ball was held by a spring with k = 10 N/m, What would be the elongation (the stretch) of the string?



d = 10 cm $\rho_{ball} = 0.8 \frac{g}{cm^3}$; $1 \frac{g}{cm^3} = 1000 \frac{kg}{m^3}$

Find the apparent weight of the ball in water.

$\rho_B = 0.8 \frac{g}{cm^3} = 0.8 \cdot 1000 \frac{kg}{m^3} = 800 \frac{kg}{m^3}$

If the ball was held by a spring with k = 10 N/m, What would be the elongation (the stretch) of the string?

$mg + F_T = F_B$

$F_T = F_B - mg = \rho_w \cdot V \cdot g - \rho_B \cdot V \cdot g = (\rho_w - \rho_B) \cdot V \cdot g =$

$= (1 - .8) \cdot \frac{4}{3}\pi \cdot \left(\frac{10}{2}\right)^3 \cdot 10 \; \frac{g \cdot m}{s^2}$

$F_T = |F_a| = K \cdot |\Delta x|$; $F_T = K \cdot \Delta x$; $\Delta x = \frac{|F_T|}{K} = \dots$

$mg + F_T = F_B$

$F_T = F_B - mg = \rho_w \cdot V \cdot g - \rho_B \cdot V g = (\rho_w - \rho_B) \cdot V \cdot g =$

$= (1 - .8) \cdot \frac{4}{3}\pi \cdot \left(\frac{10}{2}\right)^3 \cdot 10$ $\frac{g \cdot m}{s^2}$

$F_T = |F_a| = K \cdot |\Delta X|;$ $F_T = K \cdot \Delta X;$ $\Delta X = \frac{|F_T|}{K} = \ldots$

$F_T = (1 - .8)*(4/3)*Pi*(5)^3*10 = 1047\ g*m/s^2 = 1.05\ N$

Or, using SI system

$F_T = (1000 - 800)*(4/3)*Pi*(0.05)^3*10 = 1.05\ N$

A general strategy for solving problems on buoyant force.

Is essentially the same as a general strategy for solving problems on ANY force!

1. Draw a picture, convert it into FBD.
2. Set FBE (N2L for Equilibrium)
3. If necessary, add additional relationships (think what variables are connected: F_B, m, g, ρ, V, etc. – depending on forces and geometry)
4. Solve

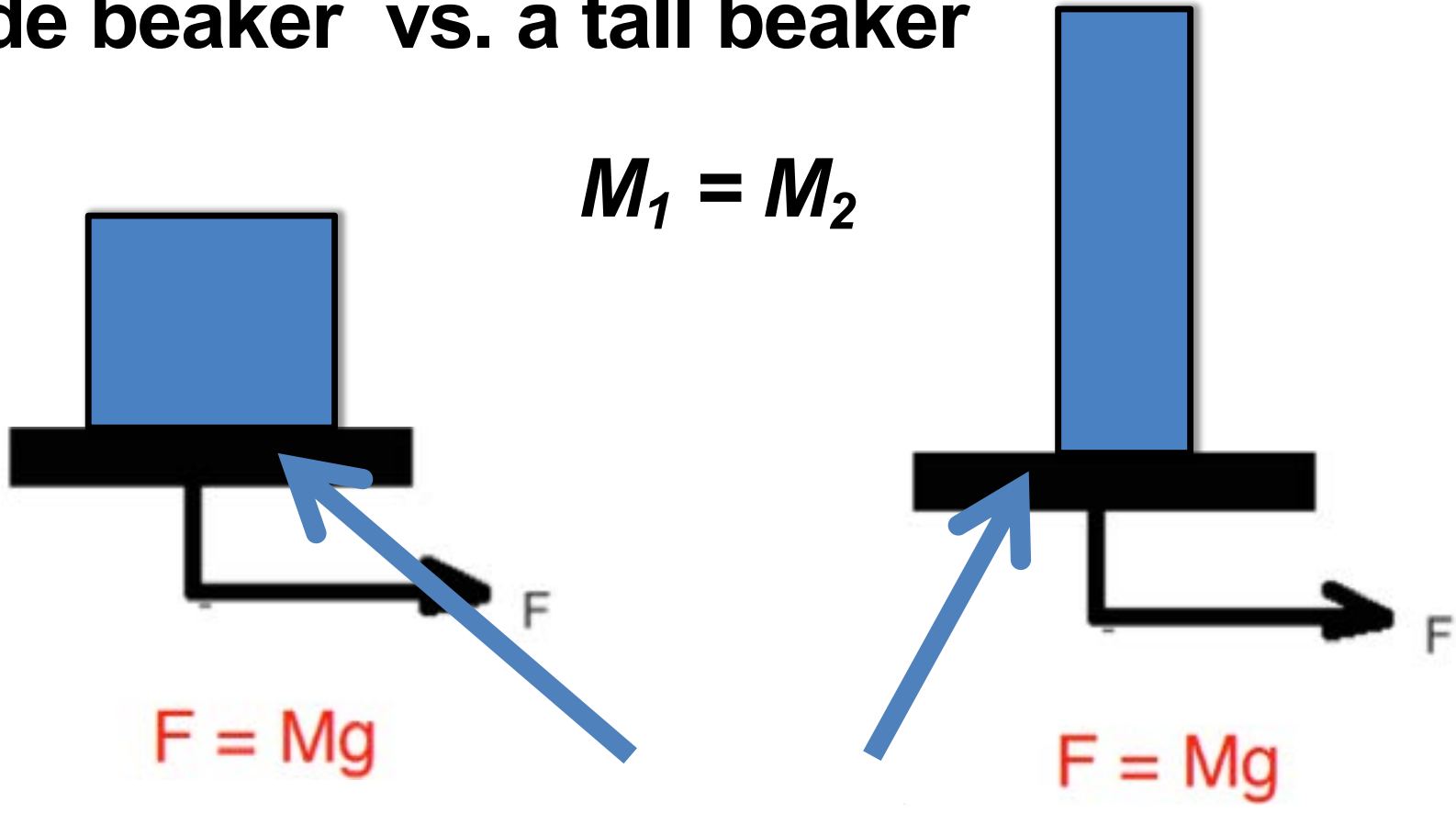
Done with buoyant force!

A general strategy for solving problems on buoyant force.

1. Draw a picture, convert it into FBD.
2. Set FBE (N2L for Equilibrium)
3. If necessary, add additional relationships (think what variables are connected: F_B, m, g, ρ, V, etc. – depending on forces and geometry)
4. Solve

A wide beaker vs. a tall beaker

$M_1 = M_2$



"Force distribution"

Dose it matter?

“force distribution” = Pressure

Snowshoes make difference!

Pressure

$$P = \frac{F}{A} = \frac{F_{1m^2}}{1m^2}$$

The SI unit is Pa

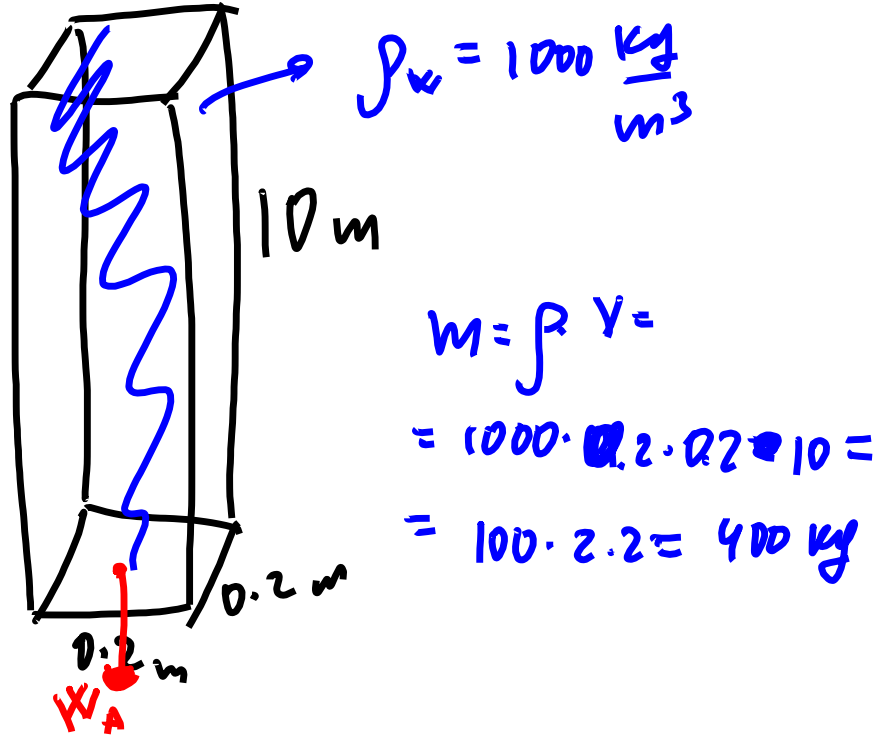
= “FROCE DISTRIOBUTION OVER AREA”

The SI unit Pa = N/m^2

A 10 m tall rectangular plastic column with the base of 20 cm by 20 cm is filled with water. Calculate the weight of the water in the column.

Weight of water W = …

1. 1000 N
2. 2000 N
3. 3000 N etc.



A 10 m tall rectangular column with the base of 20 cm by 20 cm is filled with water. How much pressure does the water exerts on the bottom of the column?

W = 400*10 =

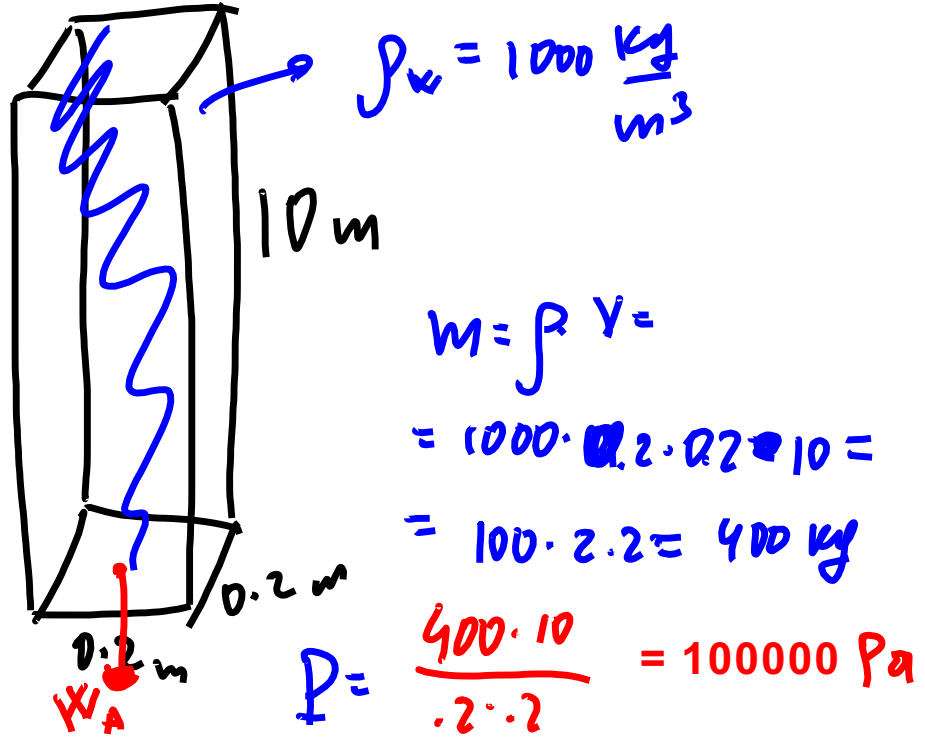
1. 1000 N
2. 2000 N
3. 3000 N
4. 4000 N

A 10 m tall rectangular plastic column with the base of 20 cm by 20 cm is filled with water. Calculate the weight of the water in the column.

How much pressure does the water exerts on the bottom of the column?

A 10 m tall rectangular plastic column with the base of 20 cm by 20 cm is filled with water. Calculate the weight of the water in the column.

$$P = \frac{400 \cdot 10}{.2 \cdot .2} = 100000 \text{ Pa}$$

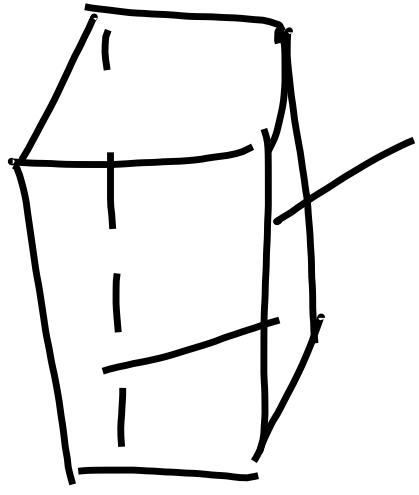


$m = \rho V =$

$= 1000 \cdot 0.2 \cdot 0.2 \cdot 10 =$

$= 100 \cdot 2.2 = 400$ kg

$$P = \frac{400 \cdot 10}{.2 \cdot .2} = 100000 \text{ Pa}$$



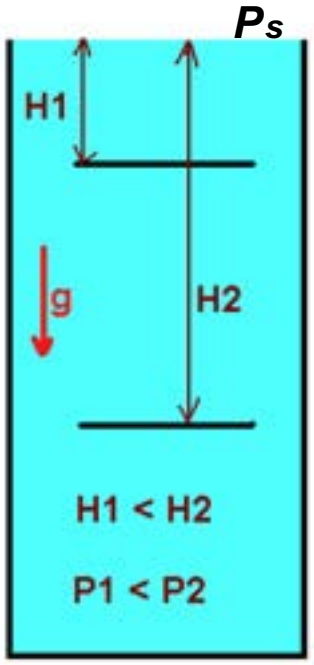
$$V = A \cdot H$$

$$m = \rho V = \rho A \cdot H$$

$$W = m \cdot g = \rho A \cdot H g$$

$$p = \frac{W}{A} = \frac{\rho A \cdot H \cdot g}{A} = \rho \cdot H \cdot g$$

Pressure in a medium



The lower the level is (deeper in fluid), the more is the pressure provided by the fluid.

***Static* fluid!**

"The pressure at the bottom…"

The reason is the force of gravity acting on the liquid.

The top plate has less fluid above it then the bottom plate!

Which one?

or

$m = \rho V$

$V = Ah$

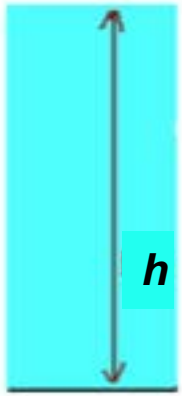
The amount of the fluid acting on the bottom plate.

The amount of the fluid acting on the top plate.

$$P = \frac{F_{mg}}{A}$$

$$P = \frac{mg}{A} = \frac{\rho V g}{A}$$

$$P = \frac{\rho A h g}{A} = \rho g h$$



$P_{total} = P_{surface} + P_{gauge}$

Gauge pressure