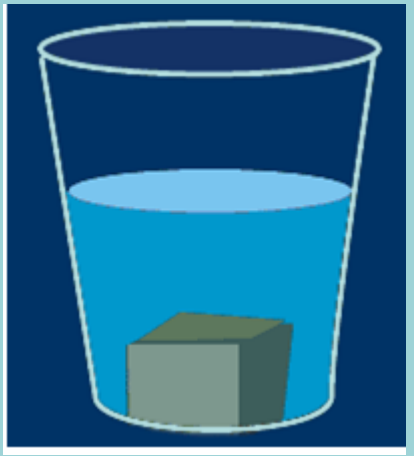
BUOYANT FORCES

PhySci 4.13



Attendance link: http://goo.gl/forms/e73P8Ozu2X

Expectations

- Required Class Connects
  - Tuesday, Wednesday, & Thursday
  - 10:30-11:30 am

- Be active and participate in class.
- Be respectful to your classmates

- Be positive in the chat box and use it correctly.
- Have a working microphone!
  - You will need it during the lessons and break out rooms.

- If you have a question, please place it in the chat box and repost it if I don’t see it.

Objectives

- Explain that the buoyant force on an object is equal to the weight of the fluid that the object displaces.
- Explain that an object floats when its density is less than the density of the fluid surrounding it.
- Apply the principle of buoyant force to predict whether objects will float or sink in a fluid.

Will it float or sink?

- The largest ship in the world is the *Jahre Viking*, an oil-carrying tanker.
- This super-sized ship is 1,504 feet long and 264 feet wide, longer than 5 football fields laid end-to-end.
- If the Empire State building was laid on its side, the *Jahre Viking* would be longer by 253 feet!
- Crew members use bicycles to get from place to place on the ship.
- The *Jahre Viking* is largely constructed of steel, so how can a big, heavy ship like this actually float?

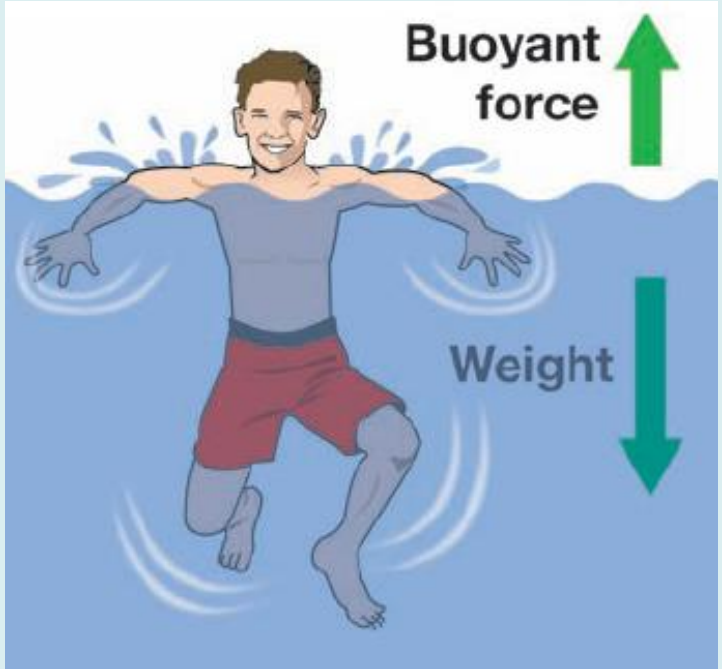
BUOYANCY

- <u>BUOYANCY</u> = the ability to float in a fluid.
  - Examples of fluids = water, air, other liquids and gases
- <u>BUOYANT FORCE</u> = the upward force that acts on a submerged object.
  - It acts opposite of gravity

Buoyancy is a force

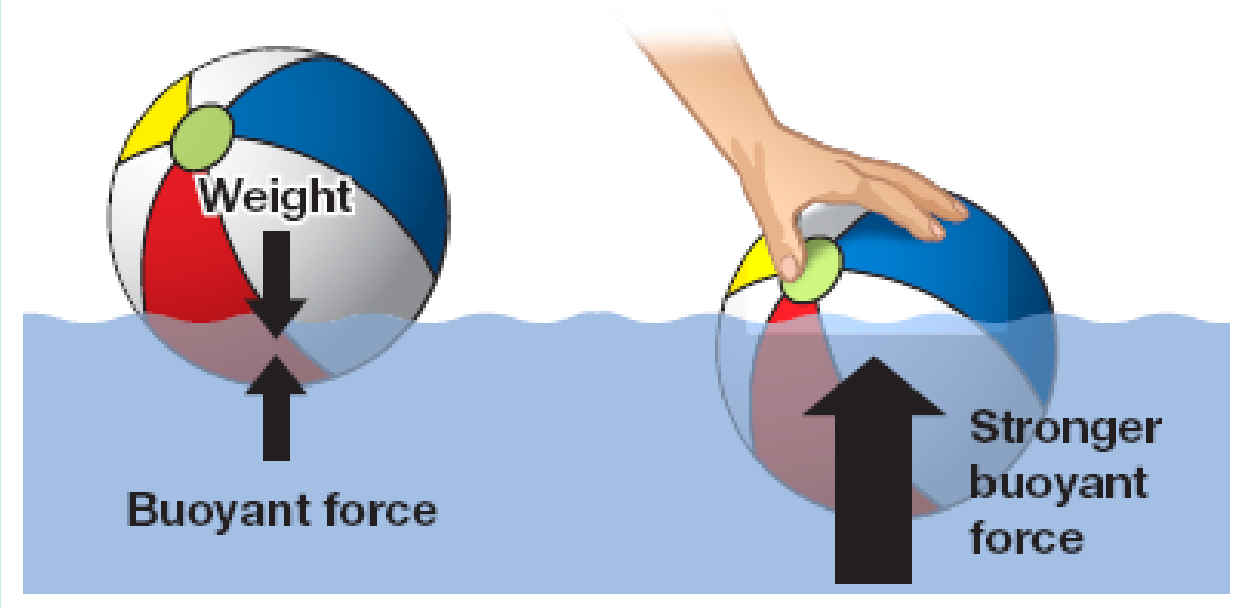
- *Buoyancy* is a measure of the upward force a fluid exerts on an object that is submerged.

The water in the pool exerts an <u>upward force</u> that acts in a direction opposite to the boy's weight.

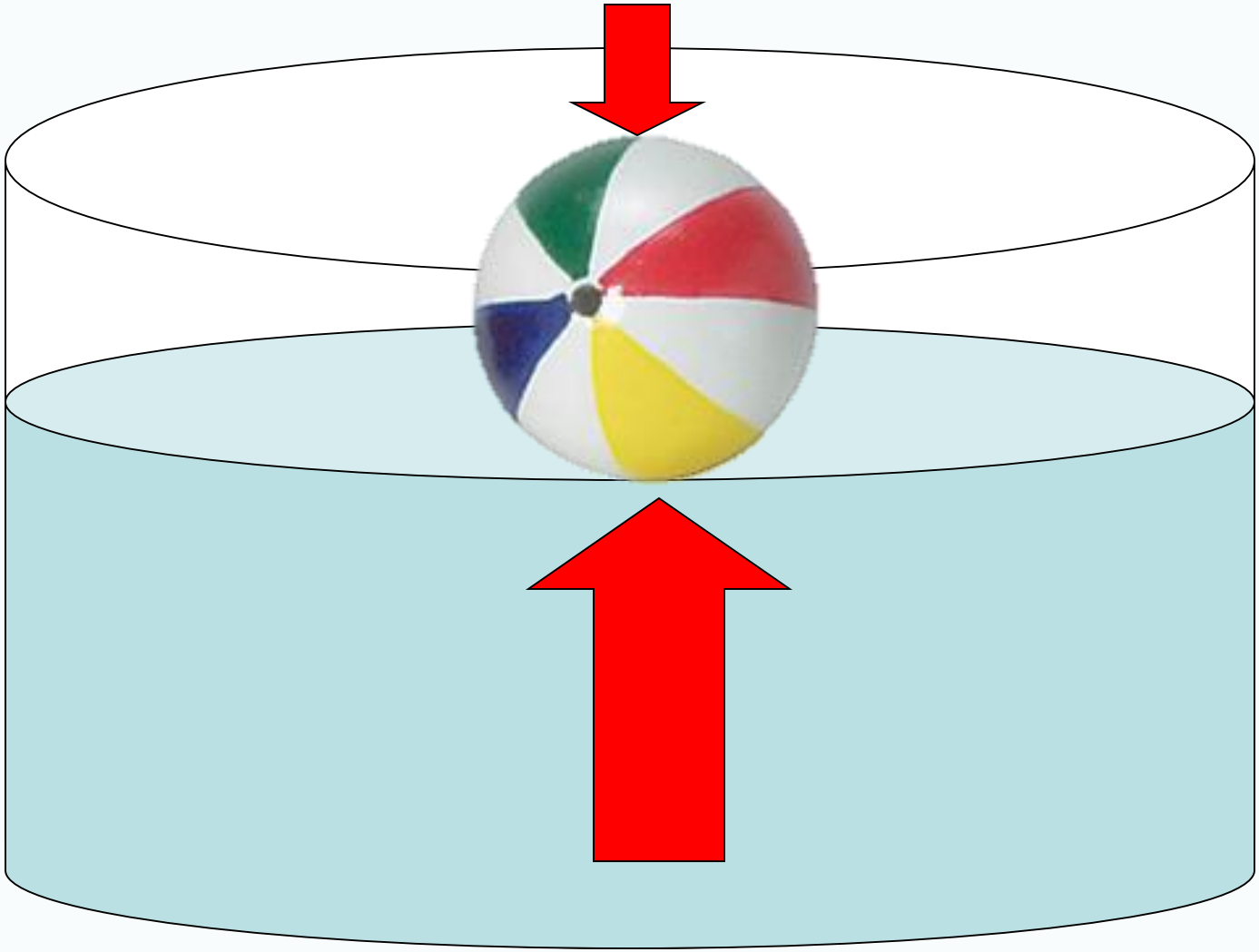


Volume and buoyancy

- The strength of the buoyant force on an object in water depends on the <u>volume</u> of the object that is underwater.



As you keep pushing downward on the ball, the buoyant force gets stronger and stronger. Which ball has more volume underwater?

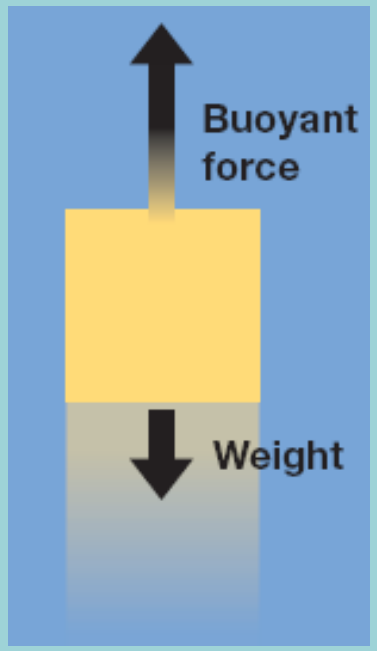


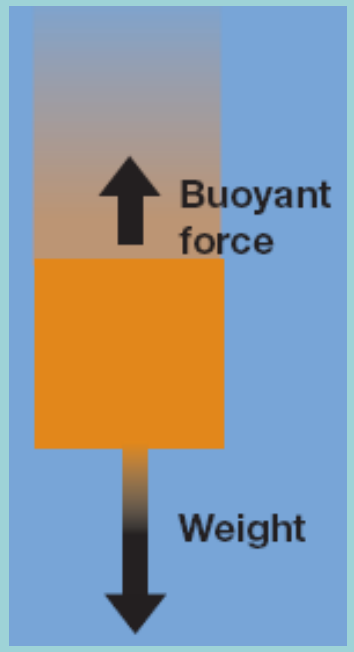
The Buoyant Force is greater than the weight of the ball so it floats.

Sinking and floating

- Buoyancy explains why some objects sink and others float.

§ **Whether an object sinks or floats depends on how the buoyant force compares with the weight.**

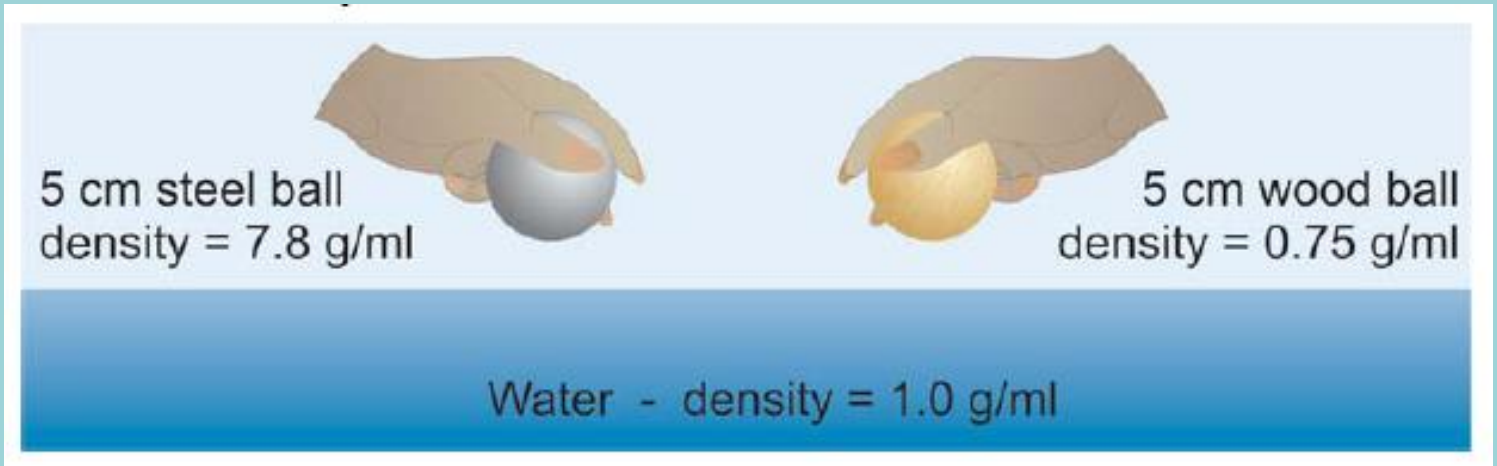




Density and buoyancy

If you know an object's density you can quickly predict whether it will sink or float.

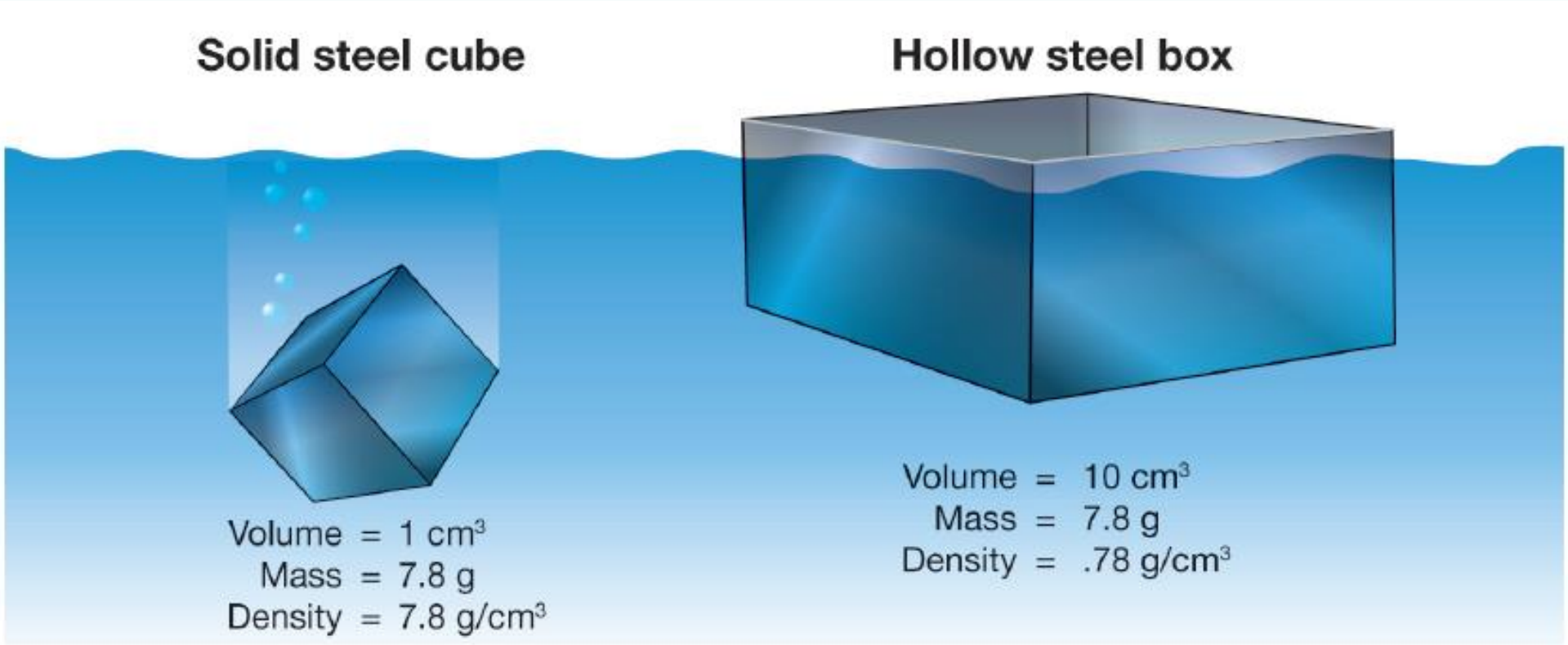
A B



Which ball will sink in water?
Which ball will float in water?

Boats and apparent density

- *Apparent density* determines whether an object sinks or floats.



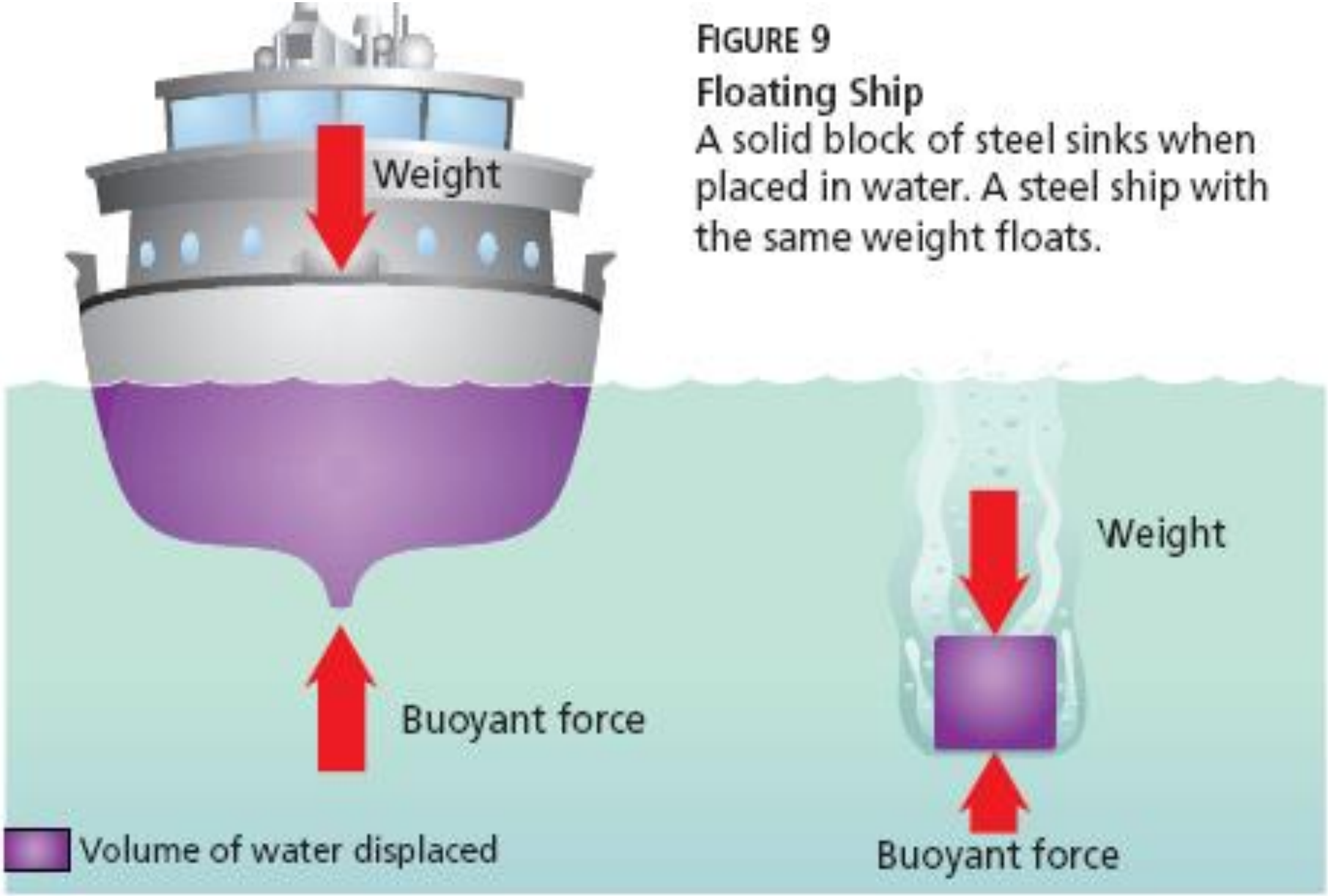
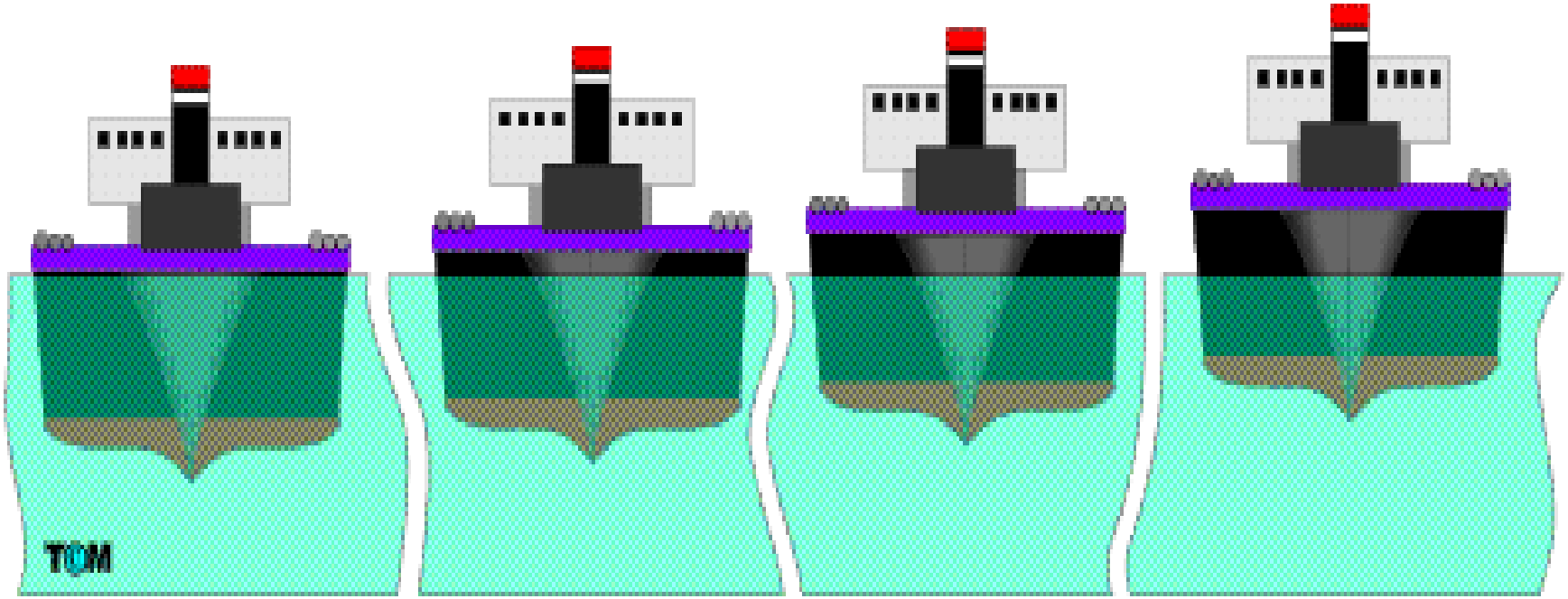


FIGURE 9

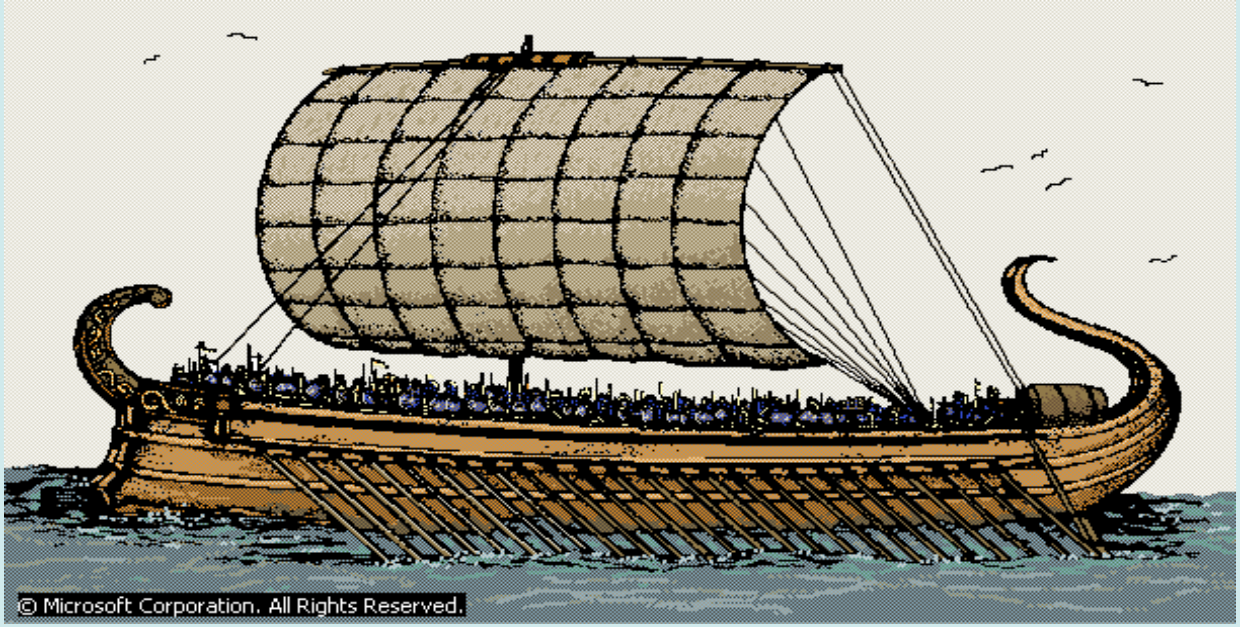
Floating Ship

A solid block of steel sinks when placed in water. A steel ship with the same weight floats.

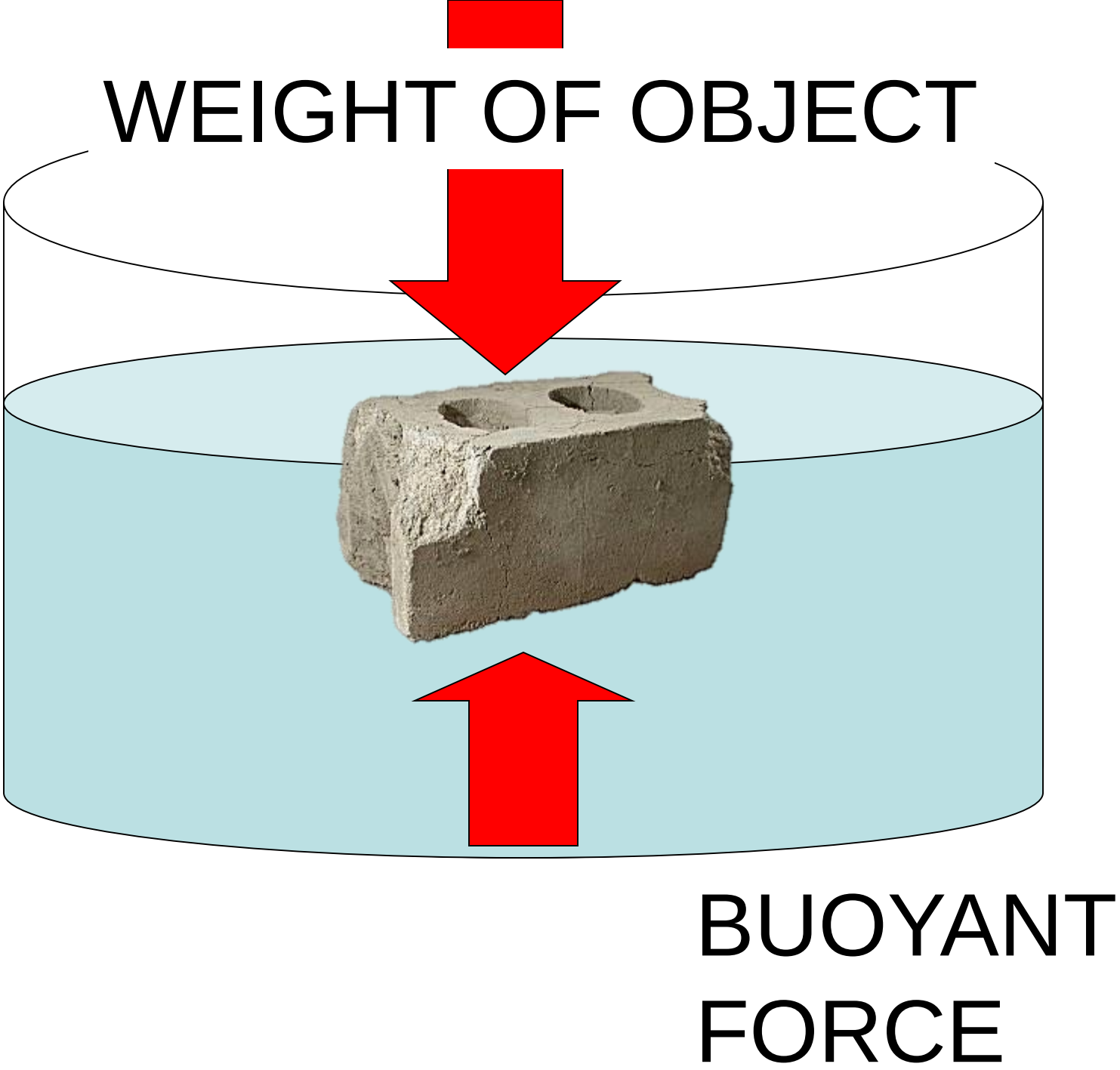


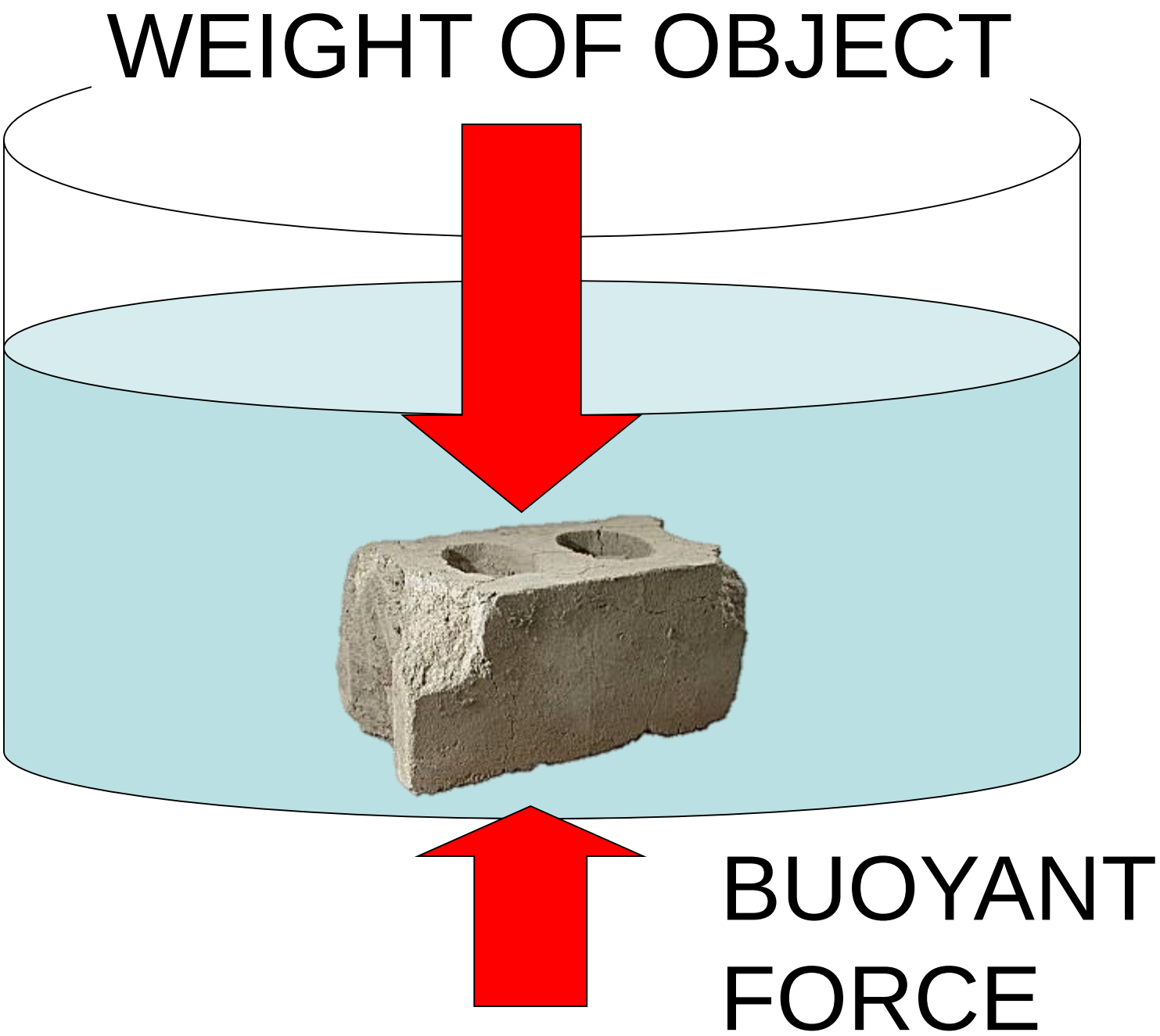
warm fresh water | cold fresh water | warm sea water | cold sea water

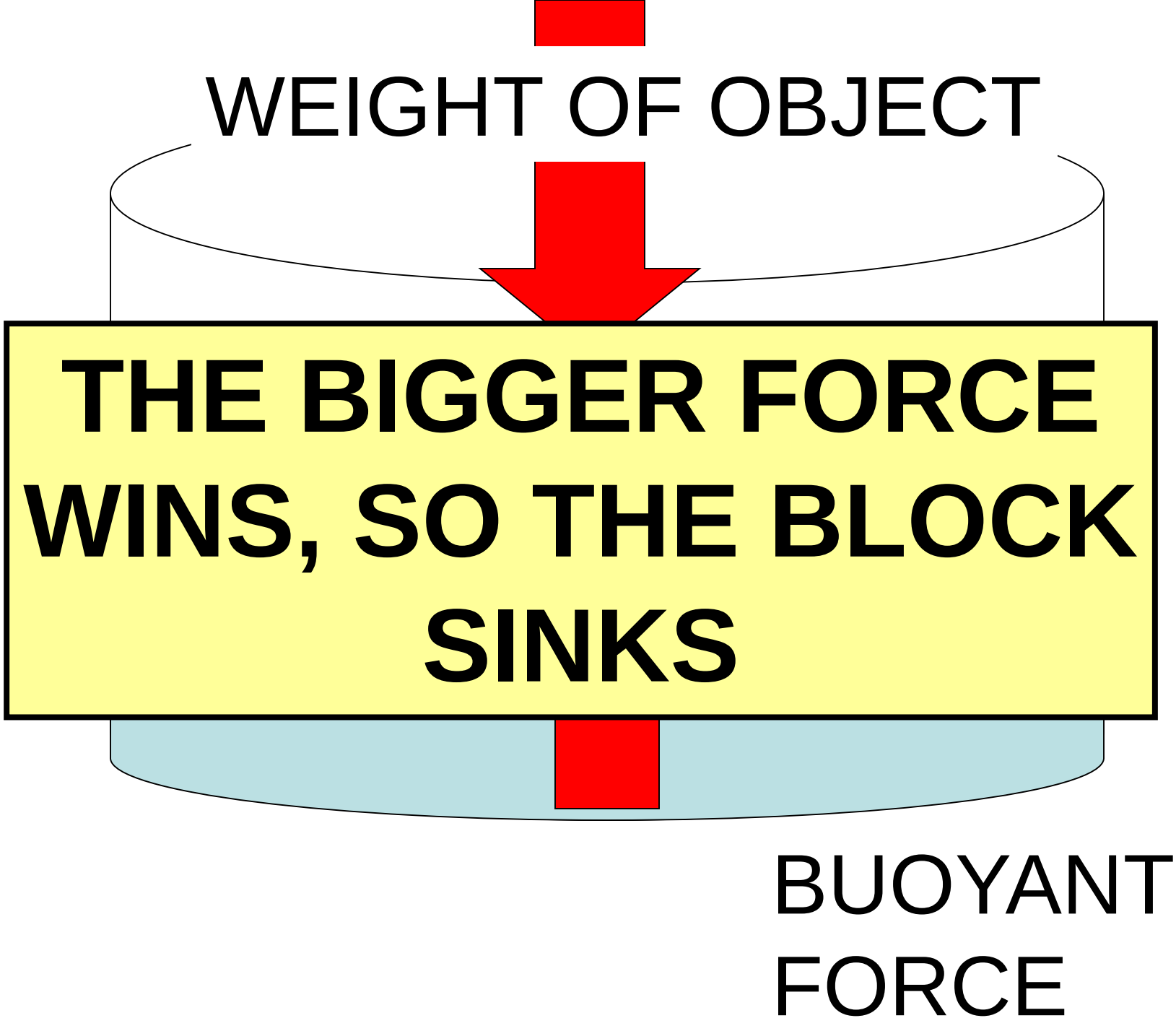
Why is the depth of ship immersed in the water different?



Fresh water less dense than sea water and warm water less dense than coldwater so warm fresh water need to be displaced more to keep the uptrust force equal with weight of the boat so it still can float.


WEIGHT OF OBJECT
BUOYANT
FORCE


WEIGHT OF OBJECT
BUOYANT
FORCE


WEIGHT OF OBJECT
THE BIGGER FORCE WINS, SO THE BLOCK SINKS
BUOYANT FORCE

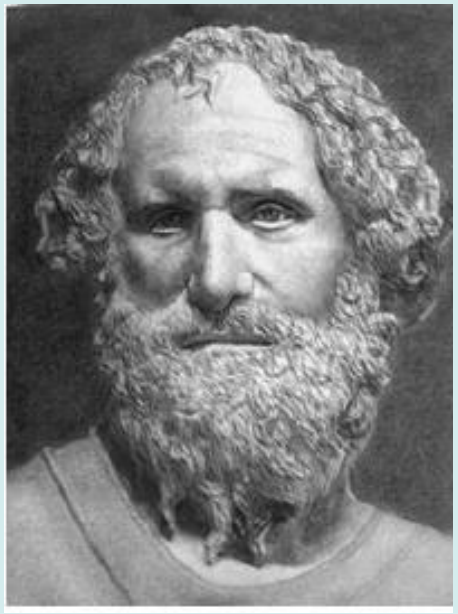
It’s Mythbuster’s time!

- Mythbuster's: Let's Talk Buoyancy

- http://science.howstuffworks.com/6540-mythbusters-lets-talk-buoyancy-video.htm

Archimedes' Principal

- In the third century BC, a Greek mathematician named Archimedes realized that buoyant force is <u>equal</u> to the weight of fluid displaced by an object.
- A simple experiment can be done to measure the buoyant force on a rock with a spring scale when it is immersed in water.



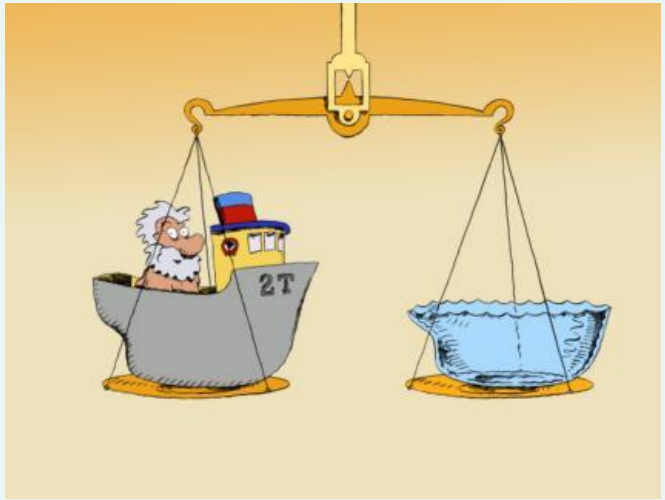
The law

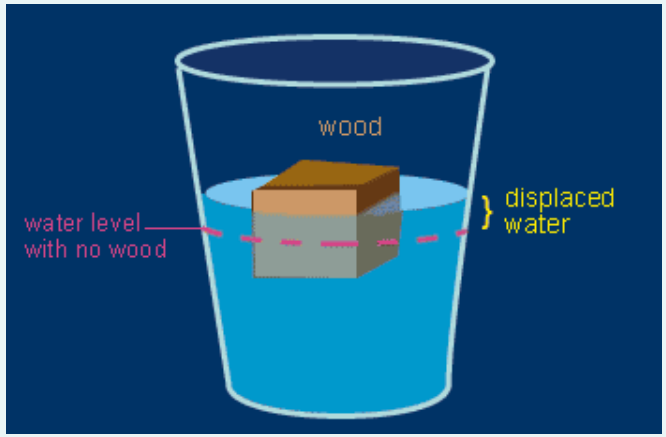
- **Archimedes' Principle**, law of physics that states that when an object is totally or partially immersed in a fluid, it experiences an upthrust equal to the weight of the fluid displaced.

The principle is most frequently applied to the behavior of objects in water, and helps to explain floating and sinking, and why objects seem lighter in water. It also applies to balloons in the air.

Archimedes' Principle

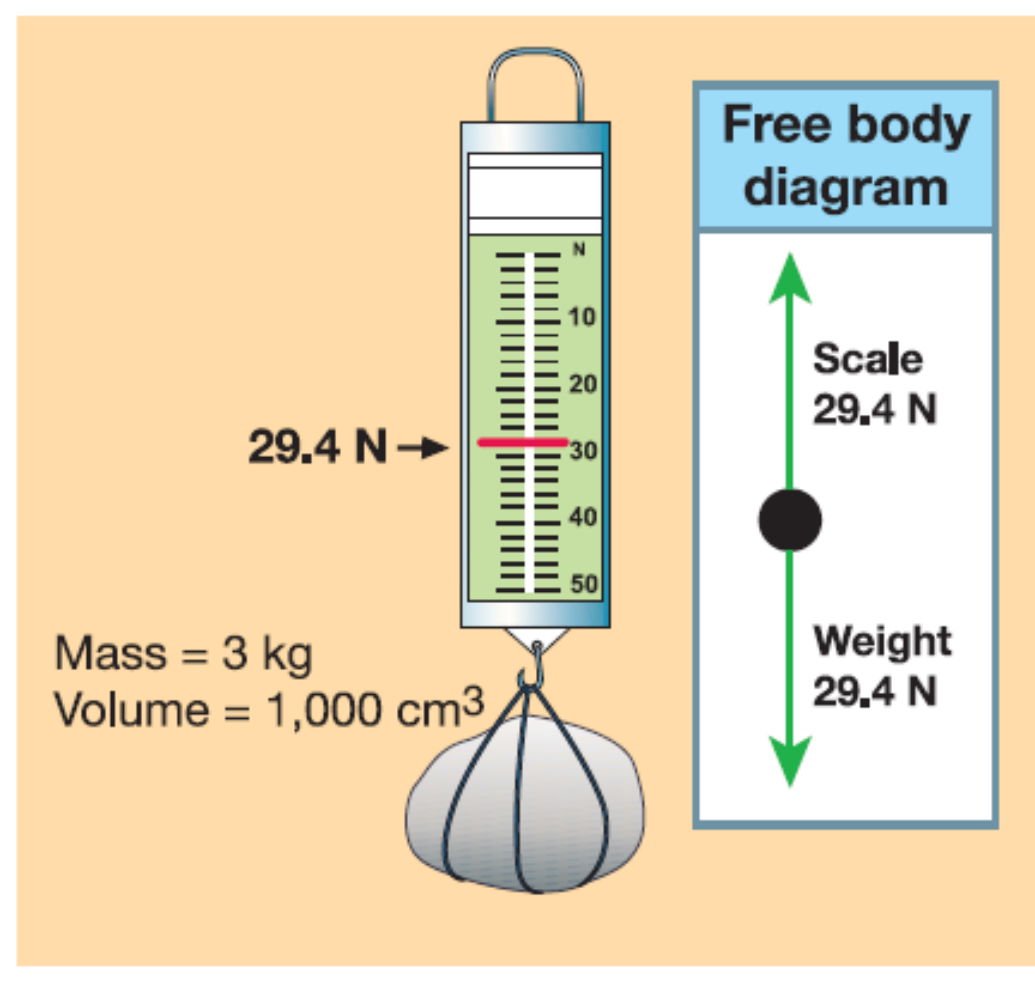
- The Archimedes' Principle states that the buoyant force on an object in a fluid is **<u>equal</u>** to the **<u>weight</u>** of the displaced fluid
  - *Example*: Suppose a block displaces 250 mL of water.
  - 250 mL of water weighs about 2.5 N.
  - According to the principle, the buoyant force (pushing upwards) on the block is 2.5 N.





Weight and buoyancy

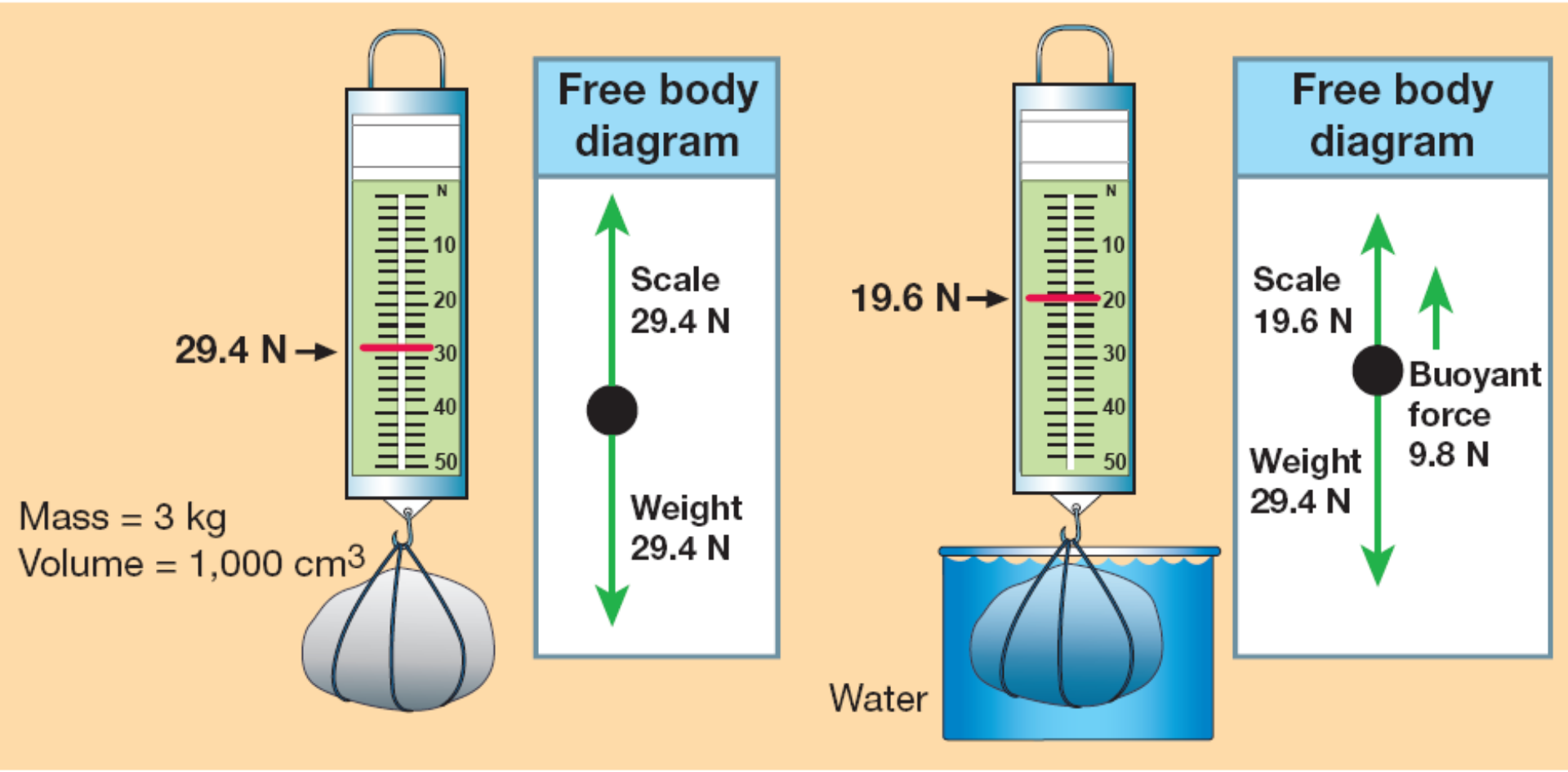
- *Weight* is a force, like any other pushing or pulling force, and is caused by Earth's gravity.
- It is easy to confuse mass and weight, but they are not the same.
- Weight is the downward force of gravity acting on mass.



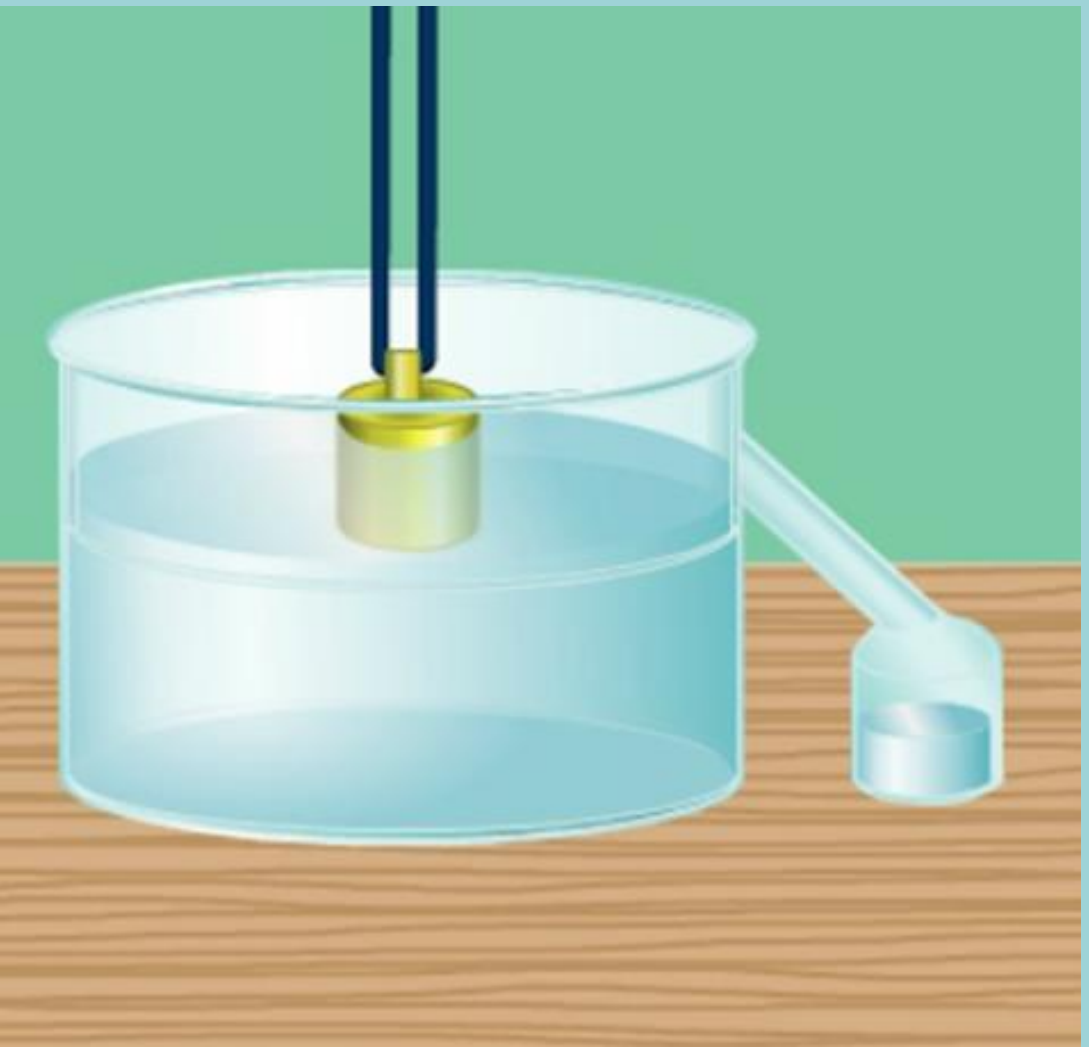
What is the rock's weight?

What is the rock's mass?

Archimedes' Principle



Review



The relationship between the weight of the water in the catch bucket and the object in the beaker shows that **the weight of the volume of the water is equal to the buoyant force of the object.**

DENSITY

$$d = m / v$$

DENSITY OF WATER = 1 g/cm^3

- If the object has a <u>higher density, it sinks</u>.
- If the object has a <u>lower density, it floats</u>.
- if the object has the <u>same density, it flinks (floats in the middle of the water)</u>.

CHANGING DENSITY

You can change an object’s density by:

1. Increasing/decreasing its mass
2. Increasing/decreasing its volume

$$d = \frac{m}{v}$$

Floating or Sinking

A matter of density

- Density = mass ÷ volume

	mass (kg)	Volume(l)	density
Rock	8	5	1.6
Water	5	5	1

- Rock is more dense than water so it sinks.

Question

Which object will float? Why?

Object	Buoyant force on object (N)	Weight of object (N)
A	39	45
B	40	55
C	83	100
D	66	60

AN OBJECT FLOATS

CAUSES:

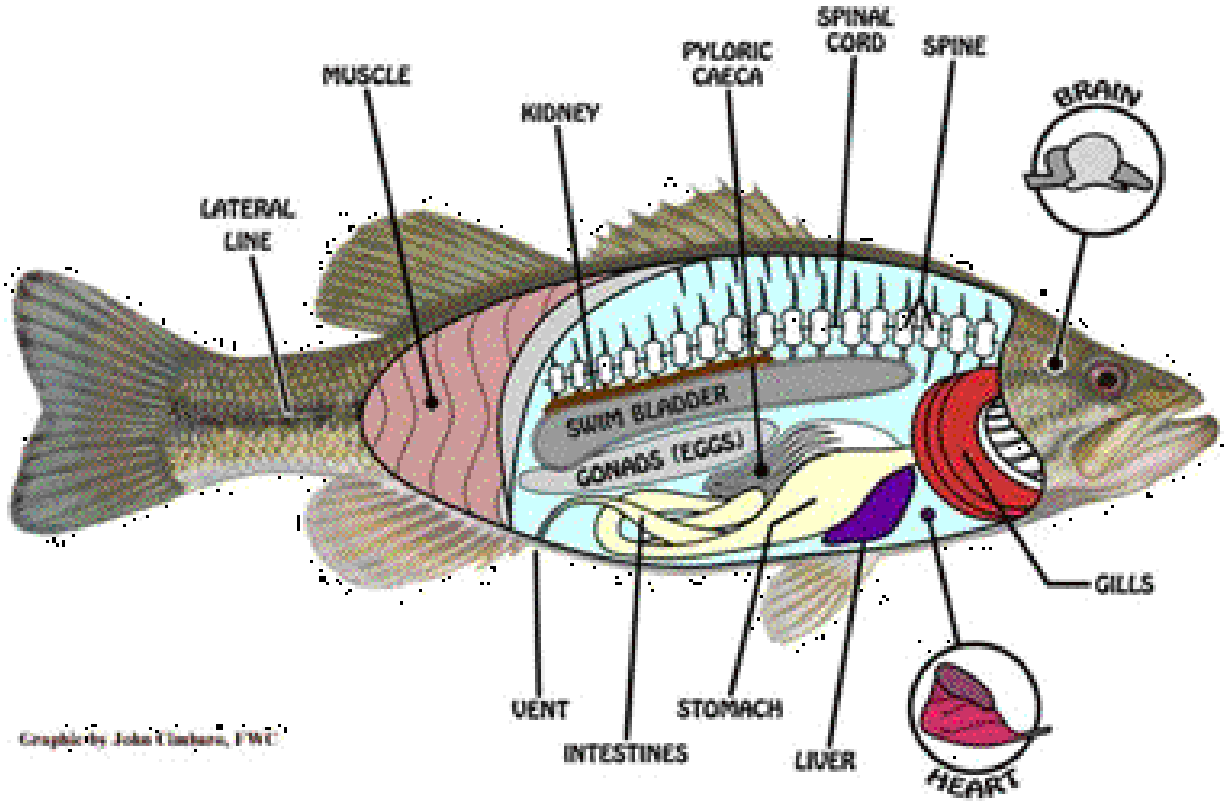
- Weight is less than the buoyant force.
- Object is less dense than the fluid
- Object decreases its mass and becomes less dense than the fluid.
- Object increases its volume and becomes denser than the fluid.

AN OBJECT SINKS

CAUSES:

1. Weight is greater than the buoyant force.
2. Object is denser than the fluid
3. Object increases its mass and becomes denser than the fluid.
4. Object decreases its volume and becomes denser than the fluid.

How does a fish change depth?



The gas bladder fills with air making the fish less dense and the fish floats up. With less air in the gas bladder the fish becomes more dense and sinks.

APPLICATIONS

Hot air balloon

1. rises upwards

(Upthrust > Weight of hot air (helium gas) + weight of airship fabric + weight of gondola + weight of passengers.)(balloon expand)

2..descends

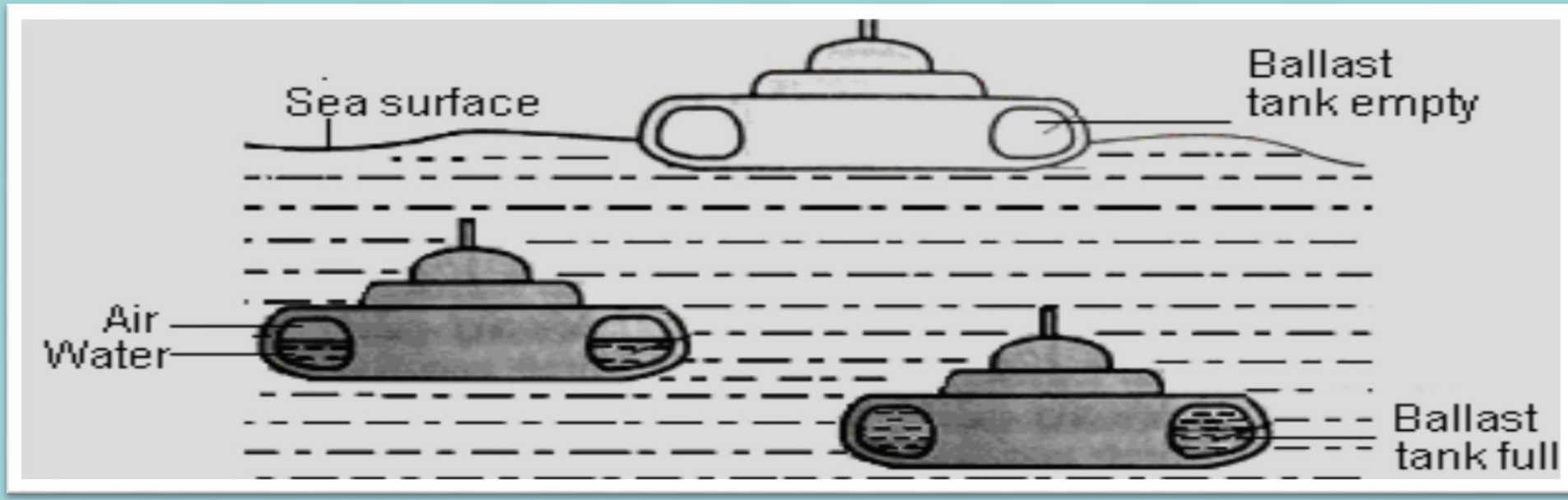
(Upthrust < Weight of hot air (helium gas) + weight of airship fabric + weight of gondola + weight of passengers.)(balloon shrinks)

3. stationary

(*Upthrust* = Weight of hot air (helium gas) + weight of airship fabric + weight of gondola + weight of passengers.)(balloon size uncanged)

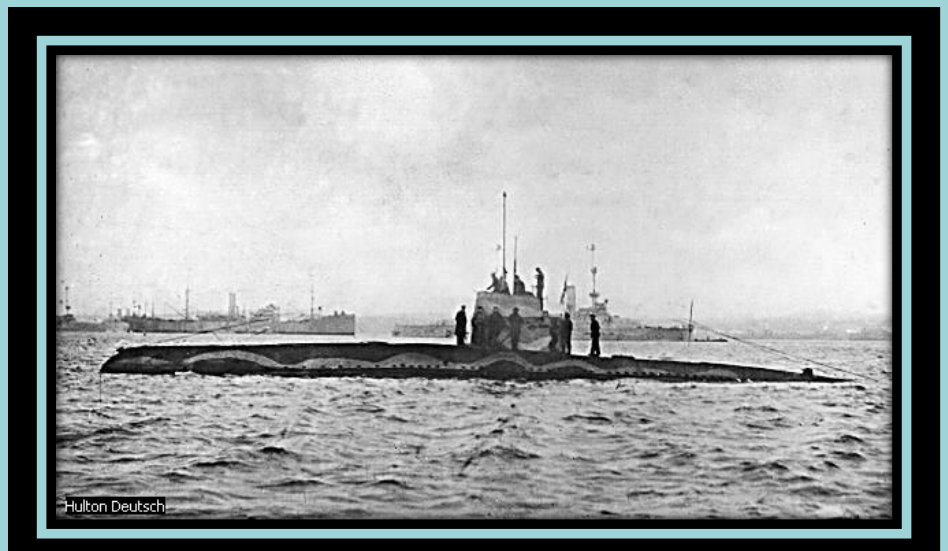
PLIMSOLL LINE OF THE SHIP

The density of sea water varies with location and season. To ensure that a ship is loaded within safe limits , the Plimsoll line marked on the body of the ship acts as a guide.



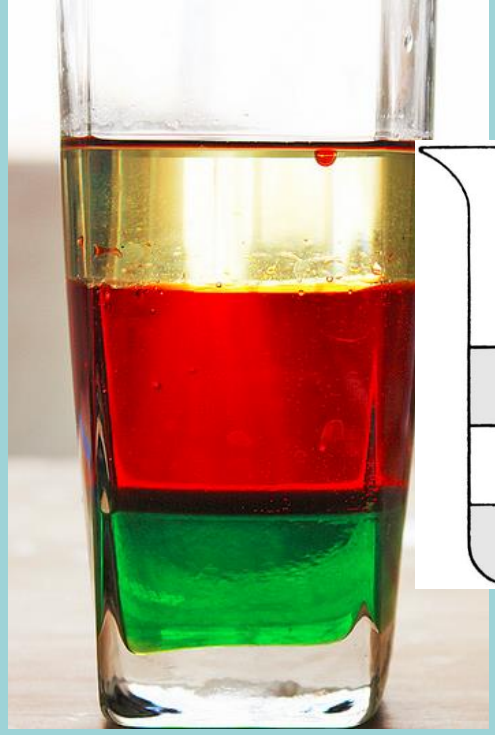
If ballast tanks empty ⇒Upthrust > weight ⇒ submarine rises to surface
If ballast tanks full ⇒ Upthrust < weight ⇒ submarine sinks to bottom

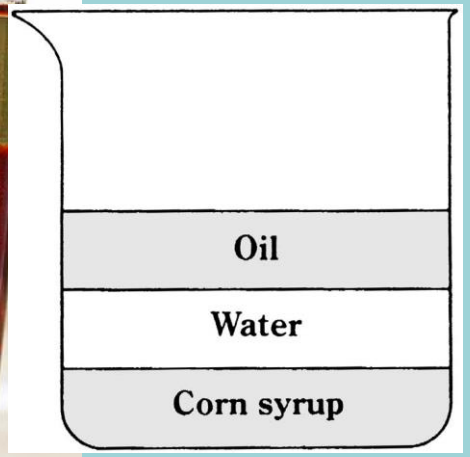
SUBMARINE



Density and Ocean Currents

- Did you know that there are underwater waterfalls in the ocean?
- While it may seem strange for water to fall through water, it really happens due to density differences in ocean water coming from different sources.




Oil
Water
Corn syrup


Oil
Water
Syrup

Assignment

- OLS
  - Online 5 questions

- There are a few extra practice problems on the next few slides.

Will it float or sink?

- Let’s look at something we’re more familiar with….Soda!
- Write down 2 ***similarities*** between these two cans.
- Write down 2 ***differences***.
- Predict what happens when a can of regular coke and a can of diet coke is placed into regular tap water.

Will it float or sink?

- What did you see?
  - The diet coke floats & the regular sinks.
- Why does the diet float??
  - Regular soda contains 39 grams of sugar.
  - Diet coke contains 100 mg of Nutra-sweet.
  - More "stuff" (matter) is crammed into the same amount of space, or VOLUME, and that increases the MASS.
  - The relationship of Mass to Volume is Density.

Some Problems to do:

- 1. Find the density of a substance with a mass of 5kg and a volume of 43 m^3
- 2. Suppose you have a lead ball with a mass of 454g. What is its volume? (density of lead is: 11.35 g/cm^3)
- 3. What is the mass of a 15mL sample of mercury? (density of mercury is: 13.55 g/cm^3)
- 4. A block of pine wood has a mass of 120g and a volume of 300 cm^3. What is the density of wood?

Answers

- 1. D= M/V
  D = 5 kg / 43 m^3 Which equals: 0.12 kg/ m^3

- 2. Volume: V = M/D
  = 454 g / 11.35 g/cm^3 = 40 cm^3

- 3. Mass: M = D x V
  M =13.55 g/mL x 15 mL = 203 g

- 4. D= M/V
  = 120g / 300 cm^3 = 0.4 g/cm^3