

Density and Buoyancy

Take a guess at what these terms mean.

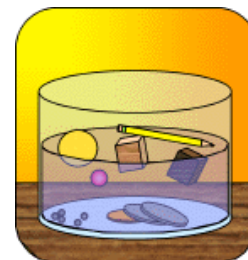
You may have heard them before.



Here are a couple of hints:

Density helps explain why a piece of steel sinks in water and a beach ball floats.

Buoyancy explains why a huge piece of steel in the shape of a ship floats!



Density

- can be described as the crowdedness of the particles in a substance



- Scientifically, it is the amount of substance that occupies a particular space.

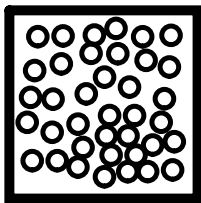
- Can be measured (Discussed later)

- A “heavy” substance has a high density
- A “light” substance has a low density



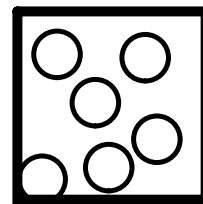


-According to the particle theory, different substances have different sized particles. The size of the particles determines the number of particles that can fit into a given space. Each substance has its own unique density, based on its particle size.



Liquid A

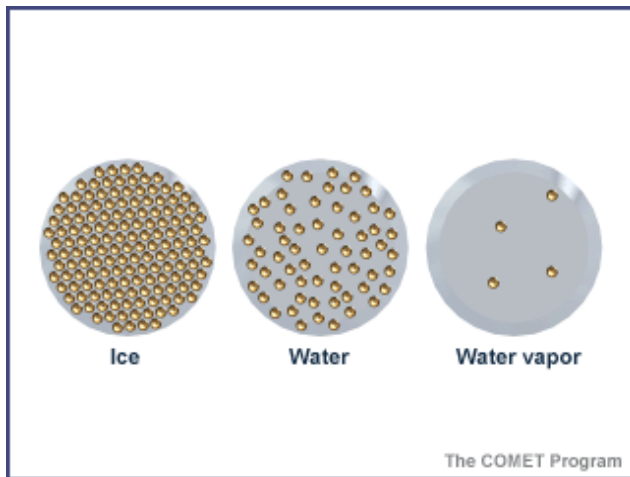
- small particles
so many can fill
the area



Liquid B

- Large particles
so few fill the
area

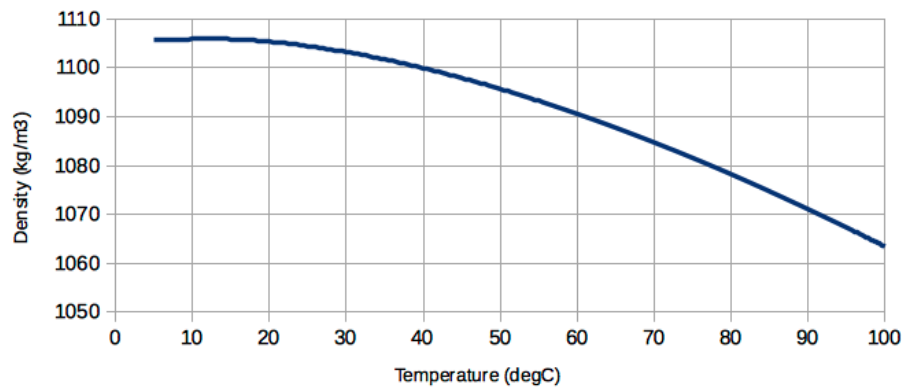
-Each substance has its own density



You can see with ice there is more particles bunched together in the area. Water the particles are spread out some BUT with water vapor the particles are really spread out.

Heavy Water - Temperature and Density

www.engineeringtoolbox.com



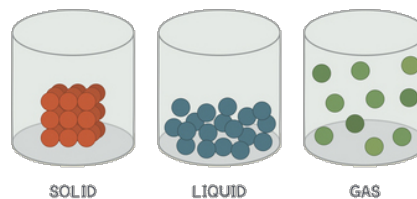
As temperature increases the density of water decreases



Density of Solids, Liquids, and Gas

The only way the density of a substance will change is if it changed states.

Ex) Liquid water is a different density than solid water and water vapor



Water

Both liquid water and water vapor have the same type of particles and the particles are all the same size.

Why is water vapor less dense than liquid water?

According to the particle theory of gas, gas particles have more space between them than liquid particles. Therefore, water vapor would have fewer particles than liquid water.

The density of the water vapor is less than the density of the liquid water.

Dolphin can leap through the air and dive back into water smoothly and effortlessly.



Solid objects can move easily through liquids and gases. The particle theory states that fluid properties of water and air allow water particles and air particles to move out of the way solids.



You cannot push through a solid substance, like ice, since the particles are held strongly together and will not push aside.



How are Mass and Volume Related?

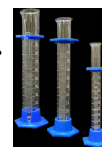
-To determine a substance density, you first must find out how much of the substance occupies a space.

Mass – The amount of matter in a substance
- Measured in kilograms (Kg) or grams (g)



Volume – The amount of space occupied by a substance

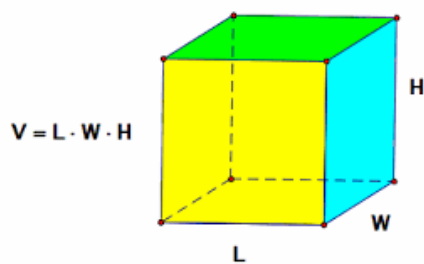
- Volume of liquids can be measured using measuring cups, graduated cylinders.



- Volume of gases can be determined by measuring volume of the containers that hold them

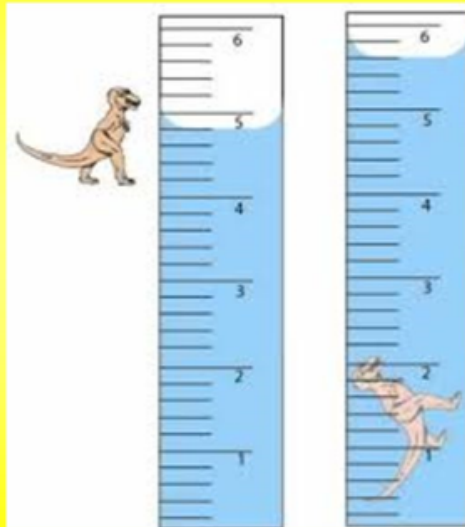
Capacity – The greatest amount of fluid that a container can hold. (Measured in Liters or millimeters)

Don't copy



[Archemedes inventions : Golden crown in water bath - YouTube](#)

Measuring VOLUME by displacement



- Used to measure *irregular* or non-box shapes.
- When you can't measure length x height x width
- $5.6 - 4.8 = 0.8$ ml

We sometimes confuse weight with mass. When you step on a scale at home you are getting your mass.

Force - is a push or pull.

Gravity - is a natural force that causes an object to move toward the center of the earth.

Weight - is the force of gravity exerted on an object.

 - Measured in Newtons (N)

The pull of gravity everywhere on an earth' surface is the same. It is a downward force of 9.8 N for every kilogram of its mass. (9.8N/kg)

Ex) A bag of sugar has a mass of 2kg

2 kg x 9.8 N = 19.6 N BUT weighs 19.6 N

1kg

You Try

Assume you have a mass of 50 kg. What would be your weight on earth?

Supplies soon needed for activity

Density Formula

Density of a substance can be determined by calculating its mass-to-volume ratio.

	Shorthand	Rearranged
Density = $\frac{\text{mass}}{\text{volume}}$	$D = \frac{m}{V}$	$V = \frac{m}{D}$ $m = V \times D$

-For liquids density is measured in g/mL or g/L

-For solids density is measured in g/cm³

Density of water is 1.00 g/mL

A substance that had a density of 2.85 g/mL would _____ in water. It is _____ dense than water.

A substance that had a density of 0.82 g/mL would _____ in water. It is _____ dense than water.

Fifth Grade Lesson 2.5 The Density of Liquids

5th Grade Lesson 2.5 Density of Liquids

ACS
Chemistry for Life®


Copy link

Phenomena students observe:

- Corn syrup sinking in water, and vegetable oil floating on water

Question to investigate:

- Is vegetable oil more or less dense than water?



More videos

Science concepts covered:

- Each liquid has its own characteristic density.

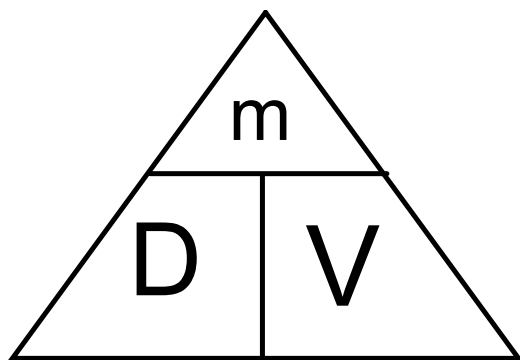
0:00 / 5:03 • Intr...

Which substance would float or sink in water?

Substance	Density of substance	Sink or Float
A	0.35 g/mL	
B	1.02 g/mL	
C	0.99 g/mL	

Table 5.1 on page 141 shows the approximate densities of common substances

Helps with rearranging



$$D = \frac{m}{V} \quad m = D \times V \quad V = \frac{m}{D}$$

Ex1) Find the density of an object with a mass of 10 g and a volume of 2 cm³.

(Answer:)

$$D = \frac{m}{V} \quad m = D \times V \quad V = \frac{m}{D}$$

Ex2) Find the volume of an object with a density of 18.7g/cm^3 and a mass of 6g .

Ex3) Find the mass of an object with a Volume of 10 L and density of 14 g/L

Name: _____

Density worksheet

$$D = \frac{m}{V}$$

$$m = D \times V$$

$$V = \frac{m}{D}$$

SHOW WORK

a) 4cm^3 of a mystery substance has a mass of 3.2 g. What is the density of the mystery substance?

$$V = 4\text{cm}^3$$

$$m = 3.2\text{g}$$

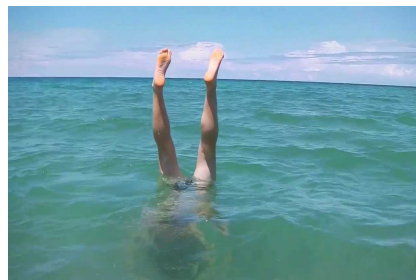
$$D = ?$$

b) A diamond with a volume of 2cm^3 has a mass of 7 g, what is its density?

c) The density of a cork is 0.2g/cm^3 . If I have a cork with a mass of 0.4 g, what would its volume be?

d) The density of steel is 7.8g/cm^3 . If you have a steel cube that has a volume of 10cm^3 , what would its mass be?

Which is easier to do?



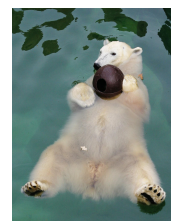
Water exerts an upward force that helps support you when you do a handstand.

Buoyancy - is the ability of a fluid to support an object floating in or on the fluid.

The particles of a fluid apply a force in a upward force which is opposite to the force of gravity.



- Buoyancy is measured in Newtons (N)



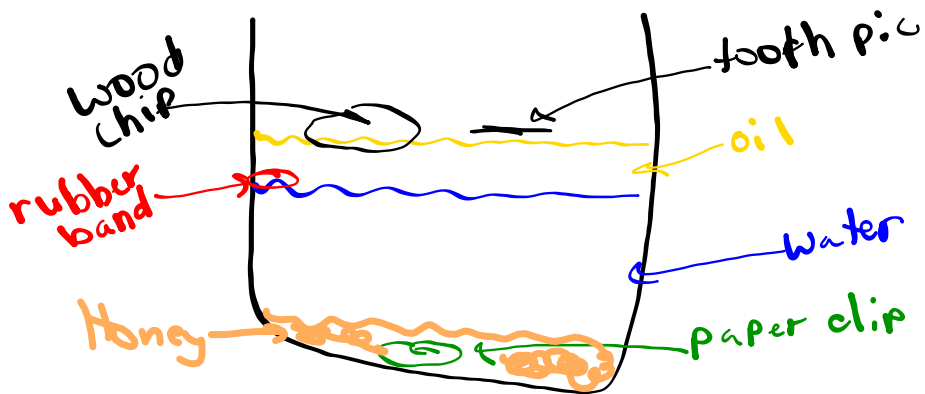
Recall Gravity - is a natural force that causes an object to move toward the center of the earth.

Floating occurs when an object does not fall in air or sink in water, but remains suspended in fluid.

Displace - To move something out of the way. Example) A solid object can displace water out of a container.

Density Tower Page 145

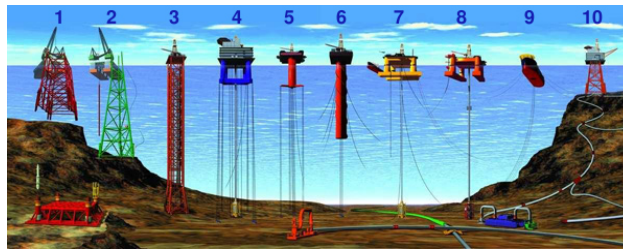
Need Oil, water see through jar, wood chip, toothpick, paperclip



Oil is on top of water (So oil is less dense than water)



[How Offshore Oil Rigs Work - YouTube](#)



How can people or oil rigs float in water if their density is greater than water?

Water can support objects that have densities greater than water, as long as the weight of the object is spread over a large enough area.

[Deepwater Horizon In Their Own Words \(Full Episode\) | In Their Own Words - YouTube](#)

[10 years later: Scientists learn long-term impact of Deepwater Horizon spill - YouTube](#)

Watch Deep Water Horizon
PRIME

Average Density - total mass divided by total volume

ex) Ships can be built of steel (density of steel is 9.0 g/cm^3) as long as they have large, hallow hulls. A large hallow hull ensures the density of the ship is less than the water.

[Why do big ships float? \[Buoyancy and flotation explained\] - YouTube](#)



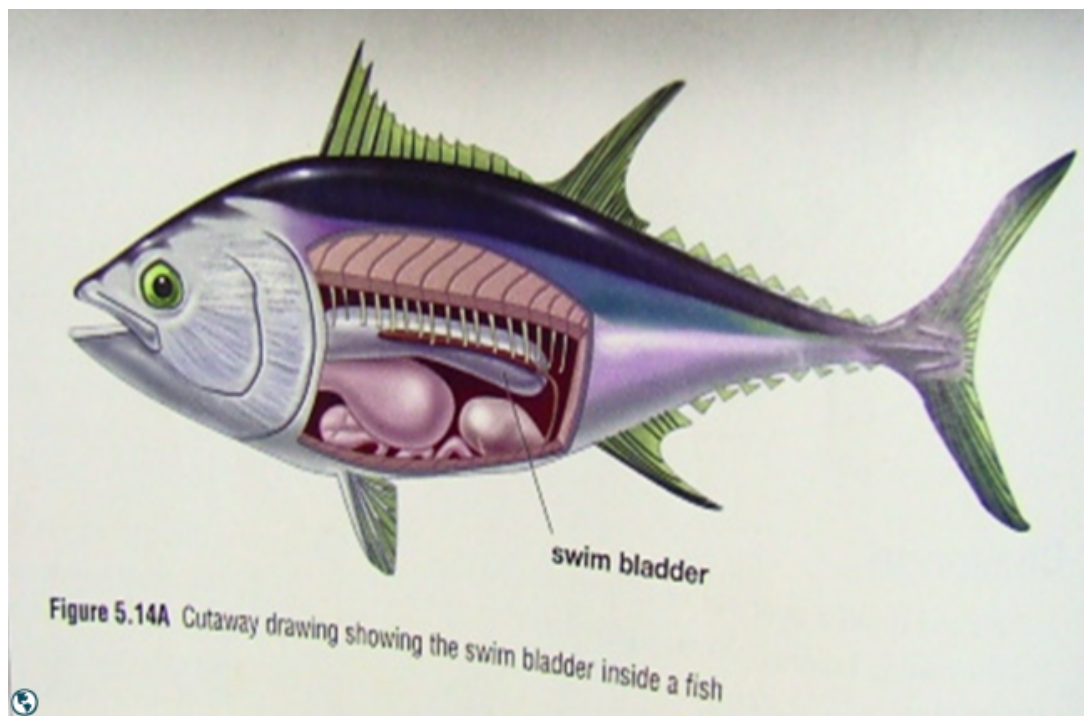
[Displacement vs Planing Hulls - YouTube](#)



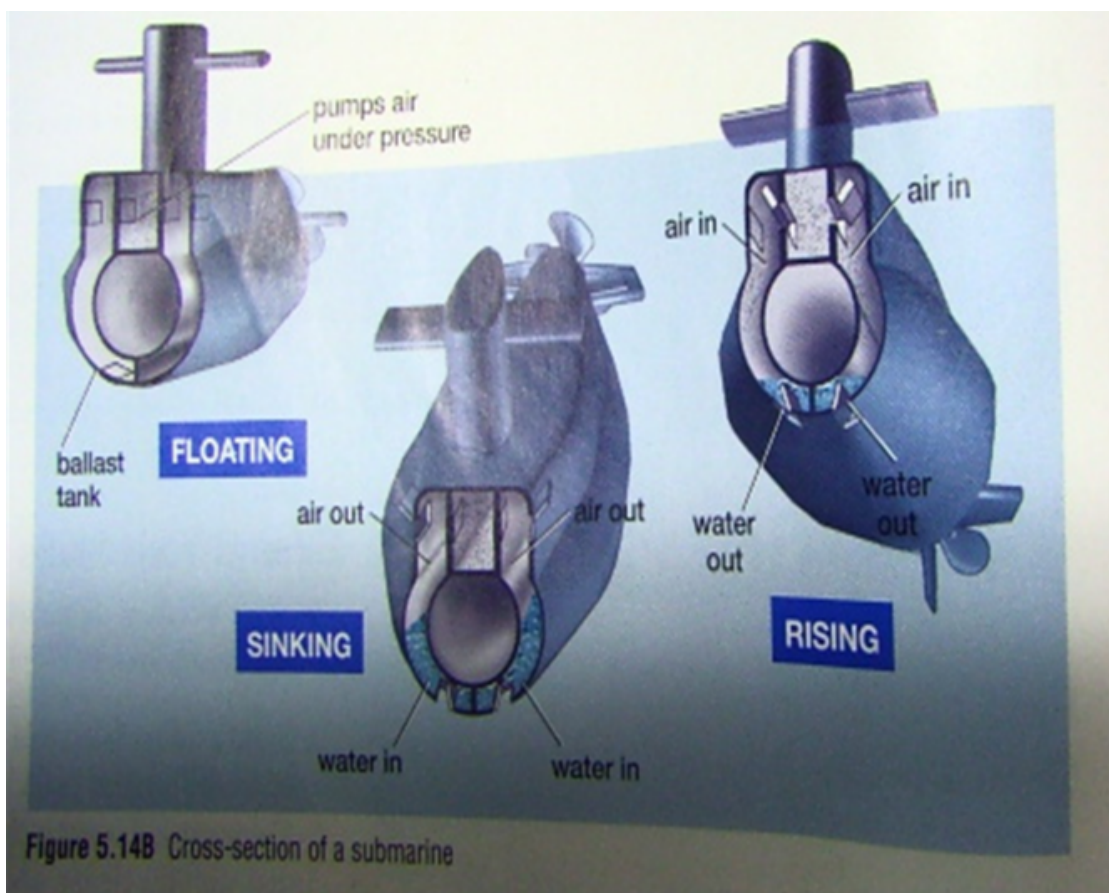
↓ reason why ships float

ex) Fish have a air bladder - a sack full of air.

The fish's depth depends on how much air is in his sack. As the amount of air decreases, the fish sinks. As the amount of air increases, the fish rises closer to the surface. This depth control structure has been adapted in the submarine.




[BEST Bony Fish Anatomy and Fish Dissection Rainbow Trout Biology, Trout Dissection - YouTube](#)



Бил нүе - Буоуансу



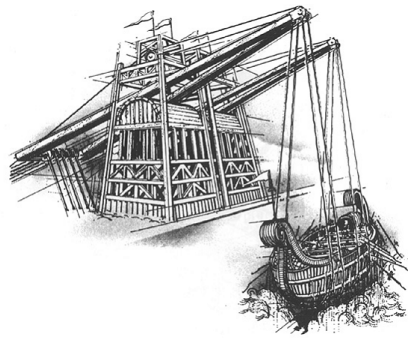
22 min

 Buoyancy, Density, Water Displacement

Archimedes

Archimedes Story

Archimedes was born in Syracuse, Greece in 287 BC and died in 212 BC. Archimedes loved geometry. He explored all kinds of shapes, trying to measure their areas and volumes.



Archimedes tried to work with very large numbers. The Greeks did not have digit symbols like we do and they had no zero. Numbers were represented with letters. It was difficult to do the math that you do easily. Archimedes invented many items useful to his time. He invented several war machines, and then oversaw and helped with their construction. One of these can be seen to the right. It was known as Archimedes claw. The long ropes would have a claw like attachment on their ends. The operators (it took nearly the entire population of Syracuse to operate the claw) would hook onto an incoming ship and then tip it over, wrecking the ship. When the ships were far from shore, Archimedes would use one of his many types of catapults, to hurl rocks, wood, or other objects at ships. He also invented a machine, sometimes known as 'the death ray' which harnessed solar power, and could even set ships ablaze. Archimedes created many machines that were well ahead of his time. When Archimedes was only 22 years old, his cousin Hiero, came to him for help.



Hiero had been elected king of Syracuse after a great battle in which he had led the Syracusans to victory. Hiero felt he should have a golden crown made to show his gratitude to the gods for their assistance with the battle.



Hiero had weighed out a specific amount of gold and gave it to a goldsmith to make the crown. There were rumors that the goldsmith kept some of the gold. It was said the crown he had made for Hiero was actually made of both gold and silver mixed together. Hiero was very upset by the thought of being cheated.

Archimedes was unsure how to help his cousin at first. He watched the water spill over the sides of the tub when he stepped into the bath and he had an idea! Archimedes noticed that the further his body was in water, the more water poured over the sides of the tub. He knew how to solve Hiero's problem.

It is said, Archimedes was so excited by his discovery that he jumped right out of the bath, and ran home without even dressing. He shouted, "Eureka, Eureka!" which is Greek for, "I have found it! I have found it!"

He had discovered a way to measure the volume of an irregularly-shaped object. He found that an object, when submerged in water, displaced a volume of water equal to its own volume. By measuring the volume of the displaced water, the volume of the object could be determined, regardless of the its shape. We now know this discovery, relating to water displacement and buoyancy, as Archimedes principle.

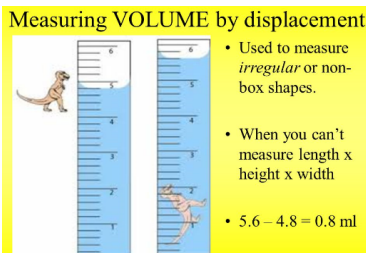
Archimedes could measure the volume of the crown by measuring the volume of the water spilled when the crown was submerged in water. He compared this to the amount spilled with the same weight of pure gold.



He proved the rumors to be correct - Hiero had been cheated by the goldsmith.

When Archimedes was 75, Syracuse was captured by the Romans. It is said Archimedes was so deep in thought when approached by a Roman soldier, he was killed by the soldier for ignoring him.

Without Archimedes our world might possibly be a very different. He was once quoted as saying "Give me a lever long enough and a fulcrum on which to place it, and I shall move the world." Archimedes has inspired many people and many technologies.



PRINT THIS OUT

Archimedes knew that the density of the crown had to match the density of the gold. ($D = \frac{\text{mass}}{\text{volume}}$)

- the mass of the crown was easily measured with a balance
- Volume was measured with displace water

[Archimedes Principle: Explained in Really Simple Words - YouTube](#)



When an object is places in a fluid, the object displaces some of the fluid because of the force of gravity pulling down on the object.

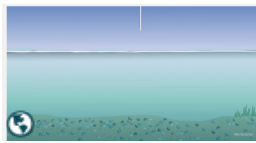
Archimede's Principle

1) The volume of the object equals the volume of fluid that it displaces.

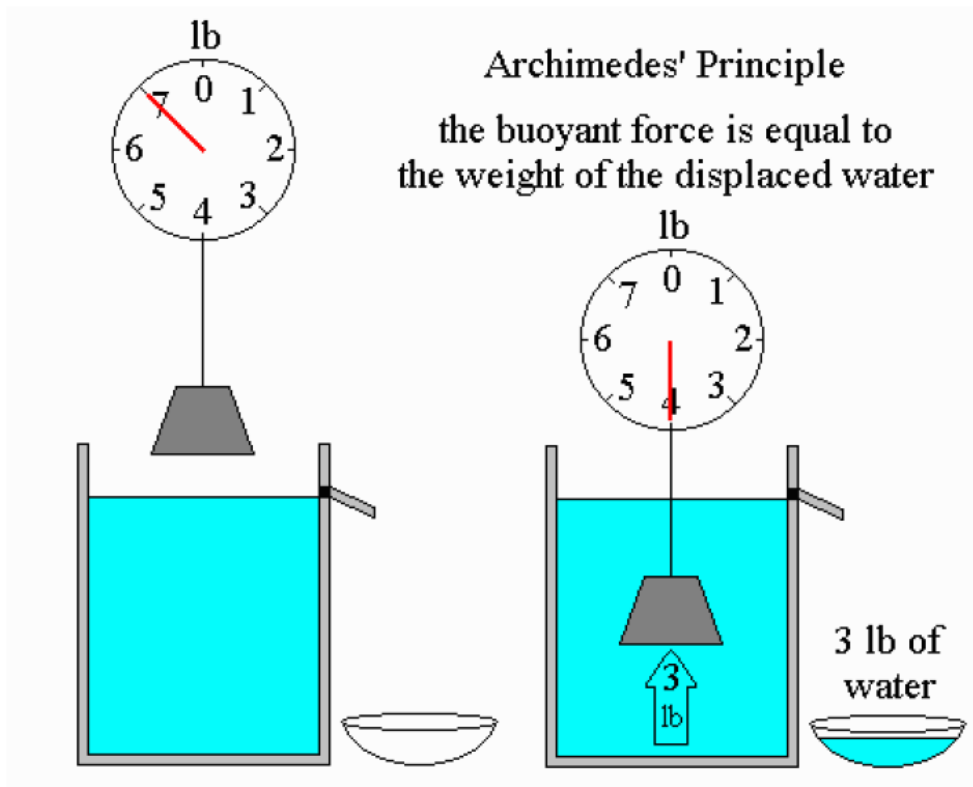
2) The buoyant forces acting on an object submerged in a fluid equals the weight of the fluid displaces by th object.

see next page

Archimedes took it further.. [Archimedes principle & buoyancy | fluids | Physics | Khan Academy - YouTube](https://www.khanacademy.com/science/fluids/a/what-is-buoyancy/a/Archimedes-principle-and-buoyancy/v/archimedes-principle-and-buoyancy)



"When an object is immersed in a liquid the apparent loss of weight of an object is equal to the upthrust and this is also equal to the weight of the liquid displaced".



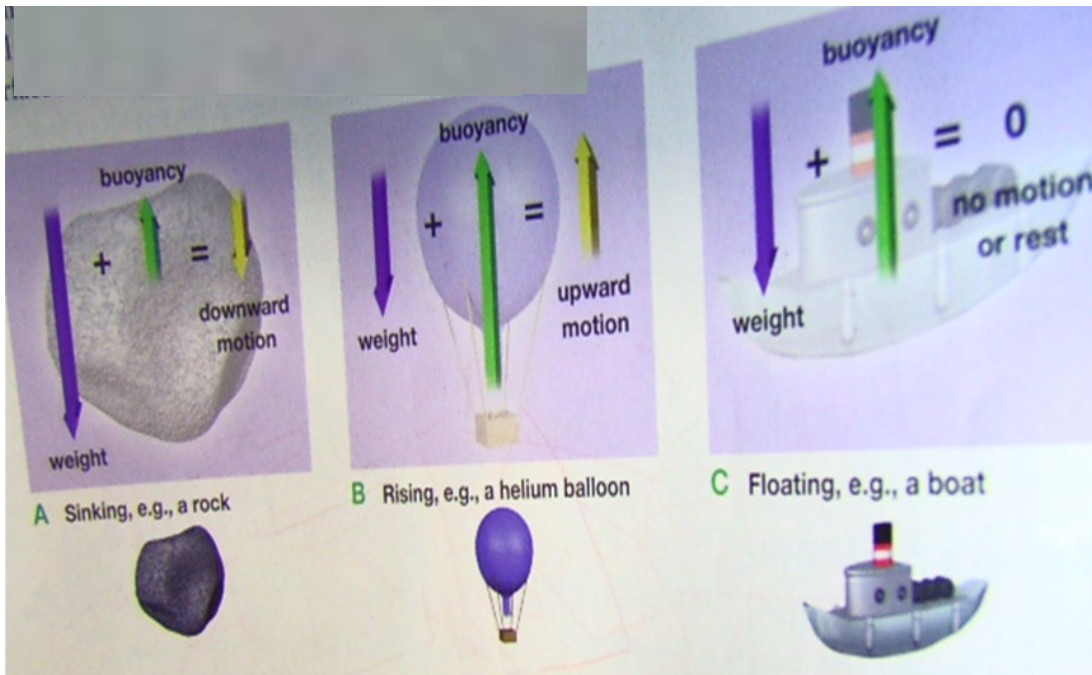
Archimedes knew that the density of the crown had to match the density of the gold. ($D = \frac{\text{mass}}{\text{volume}}$)

- the mass of the crown was easily measured with a balance
- Volume of crown was set by displaced water

Gold has density of 19.32g/cm^3 from chart

Neutral Buoyancy - is when the amount of force pulling down (gravity) equals the amount of force pushing up (buoyancy)

- you float Weight = buoyance force --> then float
 Weight less than buoyance force then float



Hydrometer - an instrument designed to measure a liquids density



Measure density of beer



Test Review

Page 160 - 162

1, 4a, 5, 7(a,b,c), #8(b), #12, #13(a,b)



attached here

1) The property of fluids that allow objects to float is density

An instrument that measures density hydrometer

pg 160

1)

The property of fluids that allow objects to float. Density

An instrument that measures the density. →hydrometer

Increase as the volume of a ship's hull increases average density

This value equals the density of substances. Mass to volume ratio

The pull of gravity on a mass weight

The space occupied by an object Volume

Opposes the force of gravity buoyant force

4a) Weight is the amount of gravity exerted on an object

Buoyant force is the upward force given by a fluid on an object.

5) An object placed in a fluid, it will displace a volume of fluid. The volume of the fluid displaced will equal the volume of the object. The weight of the objects volume is the buoyant force exerted by the fluid on an object..

7a) At a volume of 50 the substance with the largest mass is material 1 (highest on grid)

b) The substance that takes up the most space at 100 g is material 3 since it takes up about 35 cm^3 while material 2 has 12.5 cm^3 and material 1 has about 10 cm^3 .

c) Material 1

$$\frac{560\text{g}}{50\text{cm}^3}$$

$$= 11.2 \text{ g/cm}^3$$

Material 2

$$\frac{395\text{g}}{50\text{cm}^3}$$

$$= 7.9 \text{ g/cm}^3$$

Material 3

$$\frac{140\text{g}}{50\text{cm}^3}$$

$$= 2.8 \text{ g/cm}^3$$

12) Model boat mass 320g and displaces 260 g of water. It will sink since the weight of the boat is greater than the weight of the water it displaces.

13a) To make a substance that is less dense than water sink in water you squish it in a ball (must displace a volume of water less weight than volume of substance)

13a) To make a substance that is denser than water float in water you spread out the area and decrease average density

Reviewing Key Terms

1. • the property of fluids that allows objects to float: *density* (5.1)
 - an instrument that measures density: *hydrometer* (5.3)
 - increases as the volume of the ship's hull increases: *average density* (5.3)
 - this value equals the density of a substance: *mass-to-volume ratio* (5.2)
 - the pull of gravity on a mass: *weight* (5.2)
 - the space taken up by an object: *volume* (5.2)
 - opposes the force of gravity: *buoyant force* (5.3)

Note: BLM 5-20, Fill in the Blanks/Vocabulary Check, and BLM 5-21, Word Search/Vocabulary Check, can be provided to students who require or want extra review.

Understanding Key Ideas

2. (a) Mass is the amount of matter in a substance. It is a constant. Weight is the pull of gravity on a given mass and will vary depending on how strong the pull of gravity is on the object.
(b) Mass is the amount of matter in a substance. Density is the amount of matter in a specific volume. For a specific substance the density is constant.

2. (b) Density is a constant. Weight is a force that varies depending on how strong the pull of gravity is on the object.

(b) Mass is the amount of matter in a substance. Density is the amount of matter in a specific volume. For a specific substance the density is constant.

(c) Weight is the downward pull of gravity on a mass. Buoyancy is the force that acts on an object immersed in a fluid, pushing up away from Earth.

(d) The density of a substance is a specific number. It is an intrinsic property of the substance. This means it does not change. Average density is found by adding all the masses of all of the substances in a system, and then dividing by the total volume of the system.

3. (a) A chocolate bar has a mass of 56 g and a weight on Earth of $0.56 \text{ kg} \times 9.8 \text{ N/kg} = 5.4 \text{ N}$.

(b) A 100 mL sample of water has a mass of 100 g.
The density of water is $\frac{100 \text{ g}}{100 \text{ mL}} = 1.00 \text{ g/mL}$.

(c) A $6 \text{ cm} \times 4 \text{ cm} \times 3 \text{ cm}$ block has a mass of 100 g. The force of gravity acting on the block is about 1 N. The buoyant force, however, depends on the volume of the block, which is $6 \text{ cm} \times 4 \text{ cm} \times 3 \text{ cm} = 72 \text{ cm}^3$. This means the block should displace about 72 g of water. So the buoyant force acting on the block is equal to about 72 N.

(b) How could a knowledge of buoyancy make the work easier when you are clearing rocks from a swimming area? (5.3)

5. Restate Archimedes' principle in your own words. (5.3)

7. The graph on the next page shows the densities of three different substances. (5.2)

(a) Which substance has the largest mass if the volume is 500 cm^3 ?

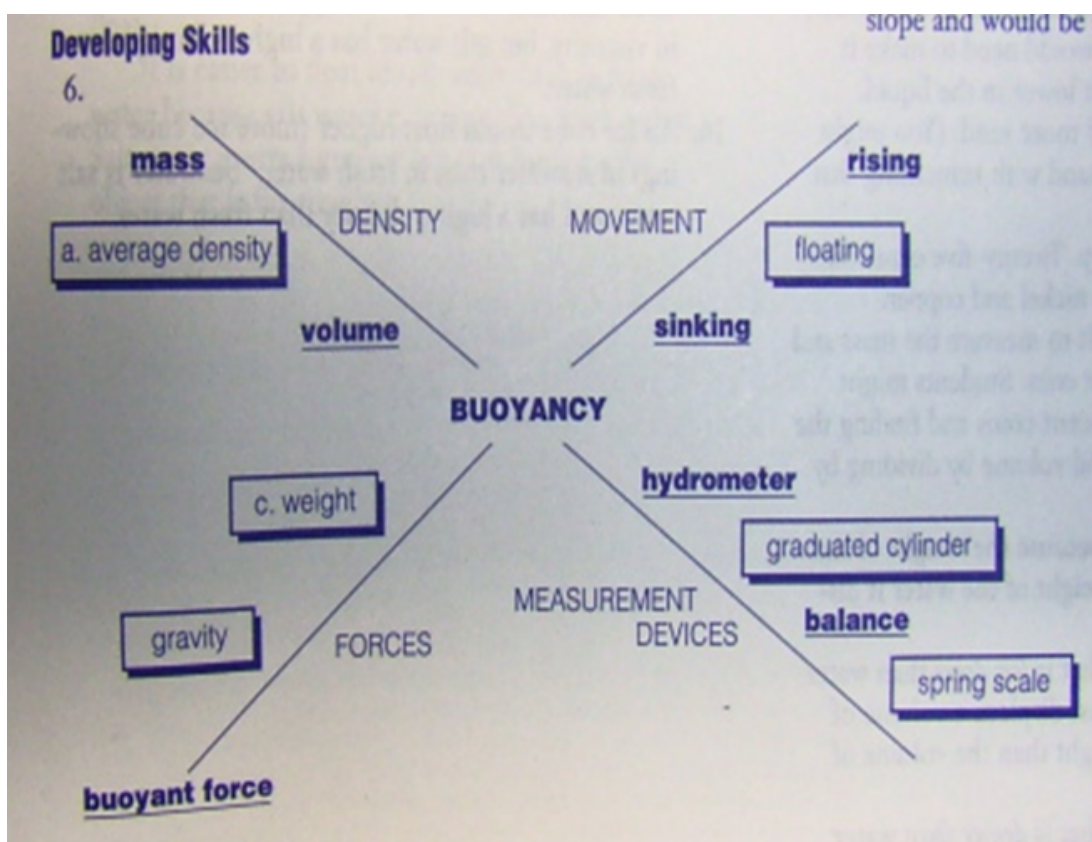
160 Buoyant Fluids

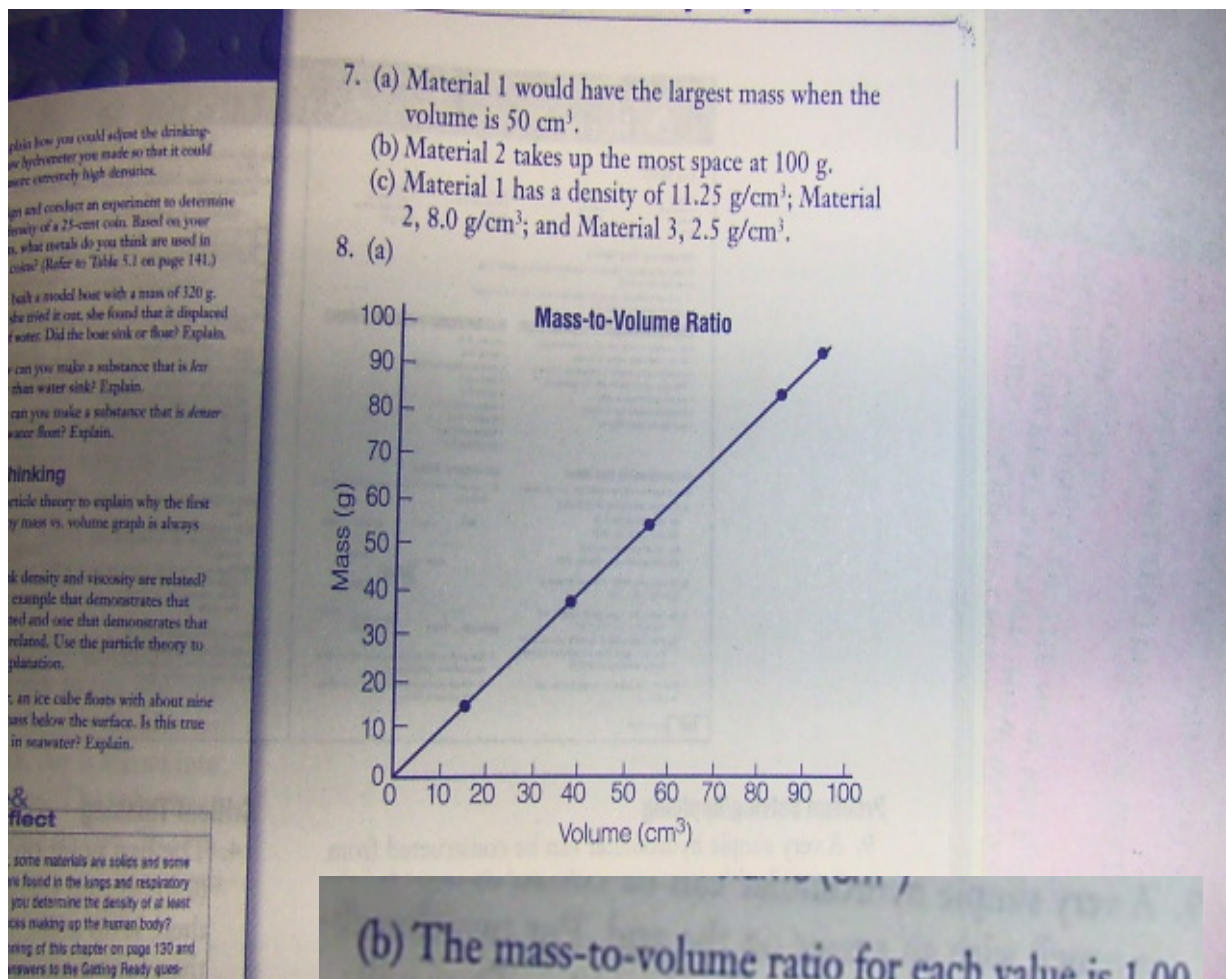
(d) The density of iron is 7.87 g/cm^3 . To make a ship with an iron hull float, you would include the total mass of the hull, including air, and divide by the total volume. Increasing the surface area decreases the average density, causing the ship to float.

4. (a) "Weight" refers to the pull of gravity acting on a specific mass. A "buoyant force" is the upward force exerted by a fluid on an object. A "buoyant force" acts against the force of gravity.

(b) If you were trying to remove rocks from a swimming area it would be much easier to move those rocks while they were under the surface of the water.

5. Students' answers will vary. Archimedes' principle states that an object placed in a fluid will displace volume of fluid equal to the volume of the object. The weight of this volume of fluid is equal to the buoyant force exerted by the fluid on the object.





- (b) The mass-to-volume ratio for each value is 1.00 g/mL .
 (c) According to the data in Table 5.1, the mystery substance is water.
 (d) A lower-density substance would have a shallow slope and would be under the line for water. A higher-density substance would have a steeper slope and would be above the line for water.

9. A very simple hydrometer can be constructed from a pencil with an eraser on the end. Put two thumb-tacks into the eraser on opposite sides. They will act as a weight for the pencil so that it does not float. They will also help to keep the pencil sitting more upright in the liquids. Place the pencil, eraser-end first, into the fluid. The relative densities can be marked on the pencil.
10. In order to use the straw hydrometer for extremely high-density liquids, you would need to make it heavier so that it would sit lower in the liquid. Therefore, you would add more sand. (You might even want to replace the sand with something that is heavier.)
11. Students' answers will vary. Twenty-five cent coins in Canada are made from nickel and copper.
(Note: It could be difficult to measure the mass and volume of a single 25-cent coin. Students might consider using several 25-cent coins and finding the average values for mass and volume by dividing by the number of coins.)
12. Cassie's boat would sink because the weight of the boat is greater than the weight of the water it displaces.
13. (a) To make a substance that is *less dense* than water sink, the substance must displace a volume of water that has less weight than the volume of the substance.
(b) To make a substance that is *denser* than water float, you would have to decrease the average density of the substance. The substance must displace a volume of water that has more weight than the same volume of the substance.
14. The first point on a mass vs. volume graph is always (0,0) because there is no mass or volume. When there is no mass, there is no matter to occupy space, therefore there is no volume.
15. In most cases, an item that is very dense also has a high viscosity. Mercury is very dense (13.55 g/mL) but has a lower viscosity than lead, which has a density of 11.34 g/mL, and does not flow at all. Fresh water and salt water have no appreciable difference in viscosity, but salt water has a higher density than fresh water.
16. An ice cube would float higher (more ice cube showing) in seawater than in fresh water. Seawater is salt water and has a higher density than fresh water.

Attachments

Archimedes story.docx

Chapter 5 Review Questions Pg 160.docx