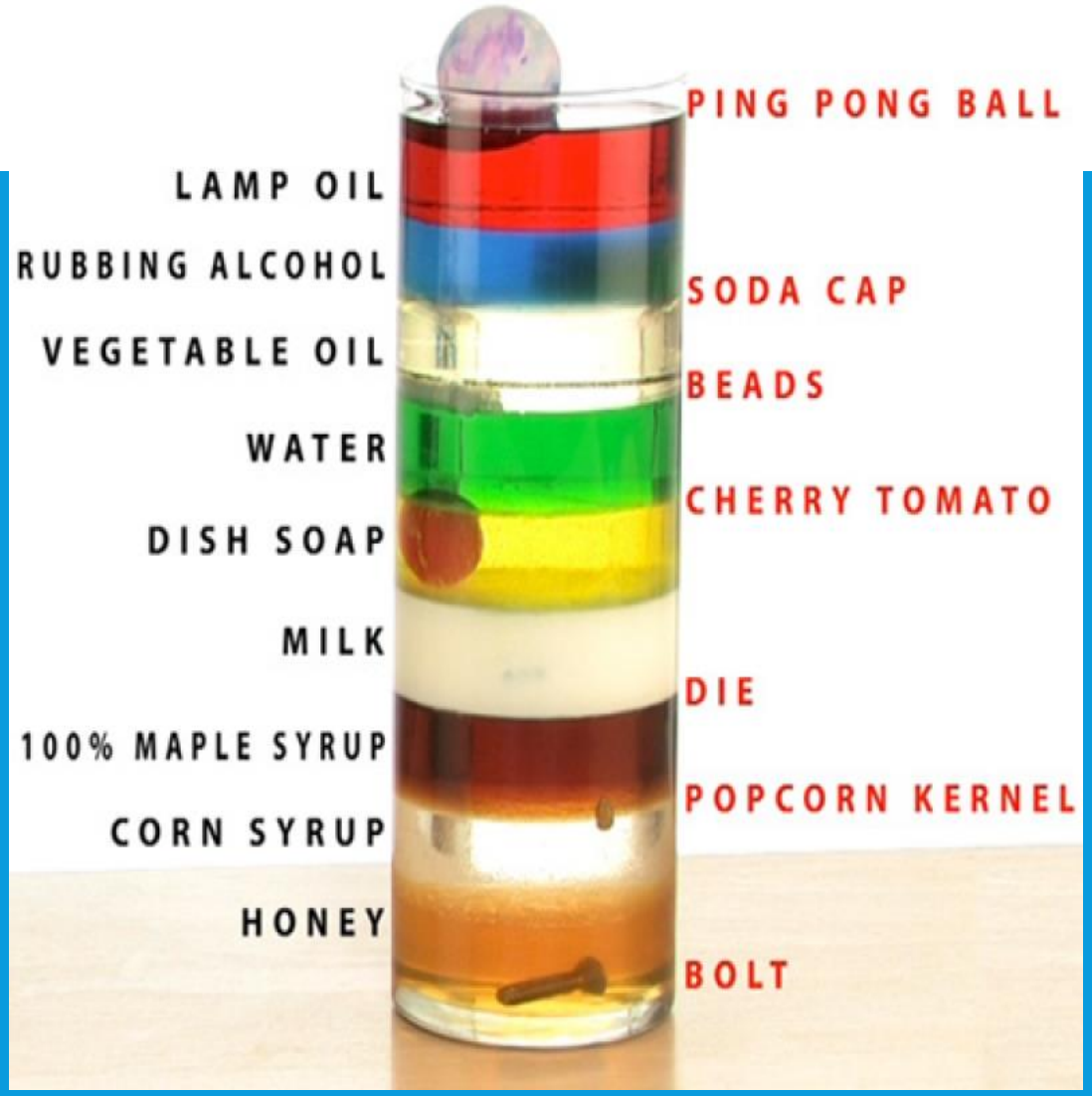
DENSITY AND BUOYANCY

DENSITY - RECAP

- What is DENSITY?
- The amount of MASS contained in a given VOLUME
- Density describes how closely packed together the particles are in a substance



Density Experiment

SINK OR FLOAT?

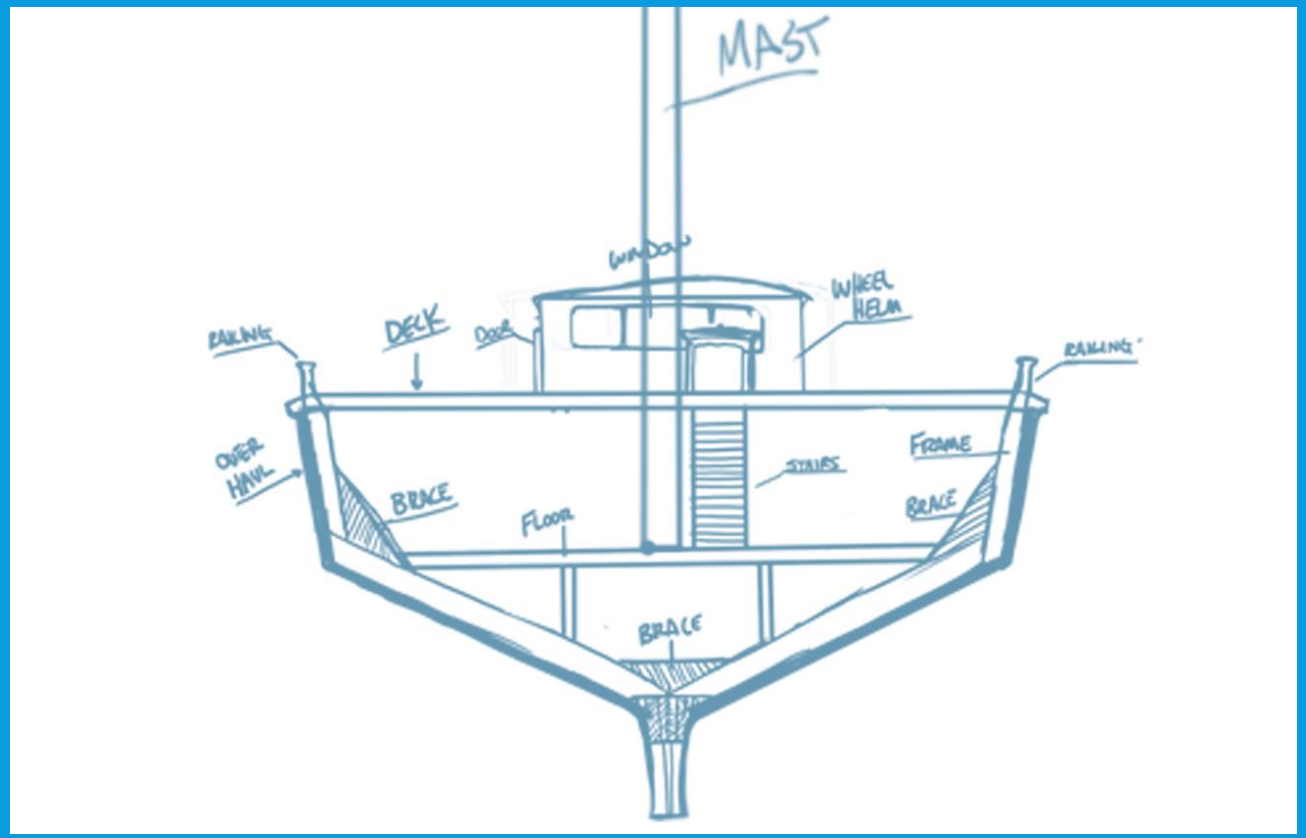
- If the density of a substance/object is GREATER than the density of the fluid, the substance will SINK
- If the density of a substance/object is LESS than the density of the fluid, the substance will FLOAT
- If the density of the substance is the EQUAL TO the density of the fluid, the substance will "HOVER" in place

SINK OR FLOAT?

- If all metals have a greater density than water, how is it possible for metal boats to float on water?

- How do submarines float and sink when they want to?

BOATS



How boats float

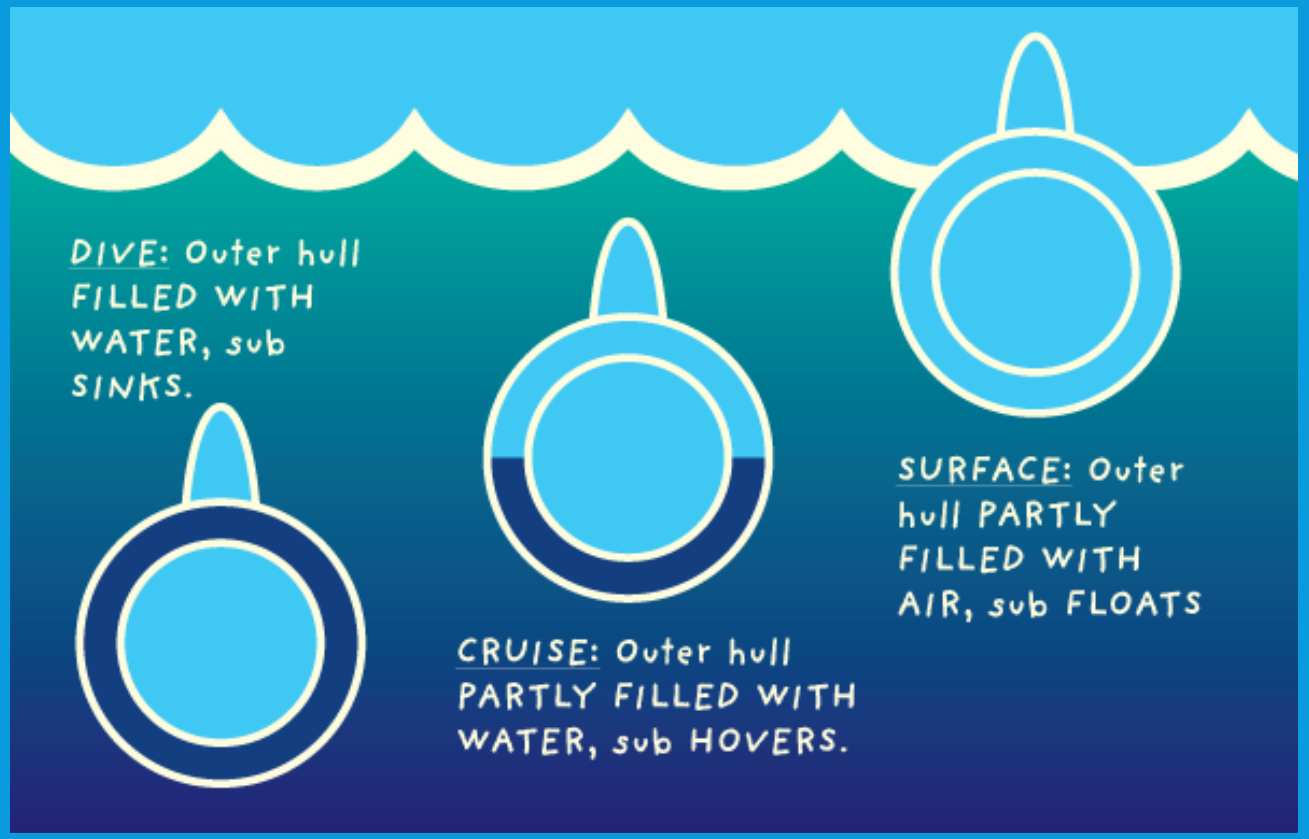
Boats consist of more than just metal.

You must consider the density of the air inside the boat, as well as the objects in the boat, and the density of the boat itself

The average density of the boat is less than the average density of the water

SO IT FLOATS

SUBMARINES



Submarines have ballast tanks that they can fill with water in order to make the average density of the submarine more than that of the surrounding water This will make them SINK

In order to FLOAT again, the ballast tanks are emptied so the average density of the submarine is less than that of the water

DENSITY AND STATE

- The state of a substance affects its density
- The solid state of a substance is usually more dense than the liquid state
  - Can you think of the one example where the solid state of something is less dense than its liquid state?
    - ICE
- The liquid state of a substance is more dense than the gas state

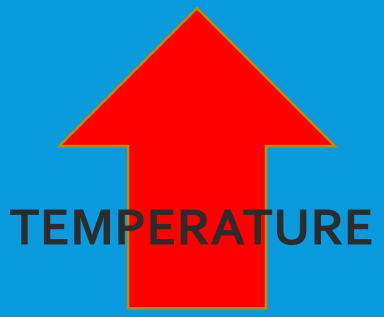
DENSITY AND TEMPERATURE

- A substance can have different densities, depending on its temperature
  - Example: Water
    - Have you been swimming in a lake on a hot summer day? What do you notice about the temperature of the water?
    - The water on the surface is noticeably warmer than the water below it. Why?
    - The warm water floats on top of the colder water because it has a lower density than the colder water.
- Can you think of any other examples?

DENSITY AND TEMPERATURE

NOW WITH MORE PARTICLE THEORY!

- What happens when you add heat/energy to a substance?
  - The particles begin to move more quickly, as they move faster and faster, they move farther and farther apart.
  - This causes an increase in volume, even though the number of particles remains the same.
  - An increase in volume with the same amount of particles results in the density decreasing



CALCULATING DENSITY

- Density is a ratio of mass to volume

$$Density\ (d) = \frac{\text{mass}\ (m)}{\text{volume}\ (V)}$$

Sample problem: A 25.0 mL sample of oil has a mass of 21.20g. What is its density?

$$d = \frac{m}{V} \qquad = \frac{21.20g}{25.0mL} \qquad \textbf{= 0.848 g/mL}$$

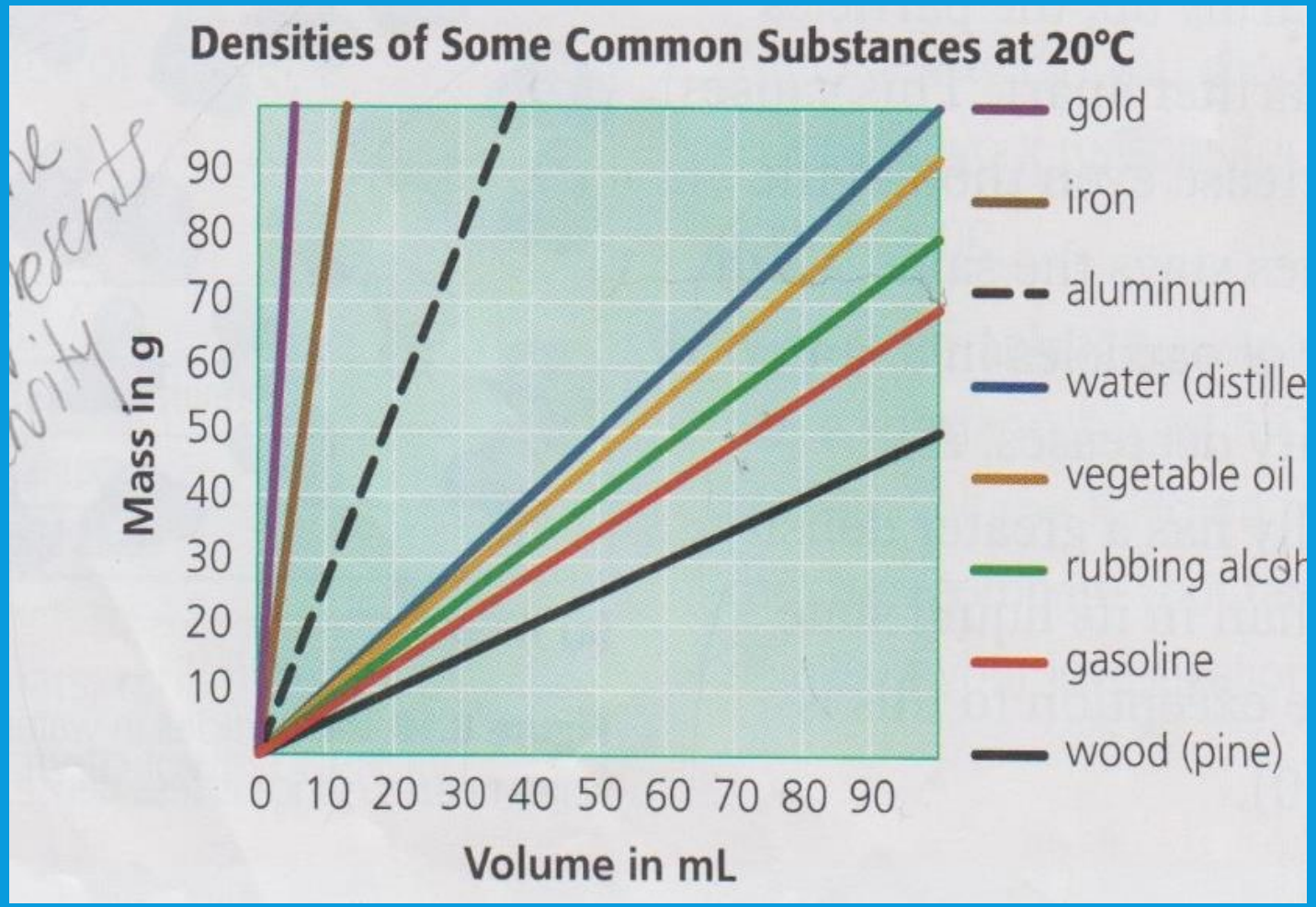
PRACTICE PROBLEMS

- A 15 mL sample of gasoline has a mass of 11g. What is the density of the gasoline?

- What is the density of a 2.5 cm^3 glass marble that has a mass of 7.5 g?

- The mass of 5.0 mL of rubbing alcohol is 4.0g. The mass of an 8.0.cm^3 block of wood is 5.6 g. Which of these materials has the greater density?

Practice Problems Continued



- Which substances have a lower density than rubbing alcohol?
- If gasoline and vegetable oil were poured into the same container, which substance would be on top?
- What is the mass of 30 mL of aluminum?

The lines represent density

FORCES IN FLUIDS

- A FORCE is a push or a pull that acts on an object
  - Example: Gravity
    - Weight is the downward pull of an object due to the force of gravity
- Buoyancy is the tendency of an object in a fluid to rise or sink due to density differences
- Buoyant force is the force that a fluid exerts pushing matter upward

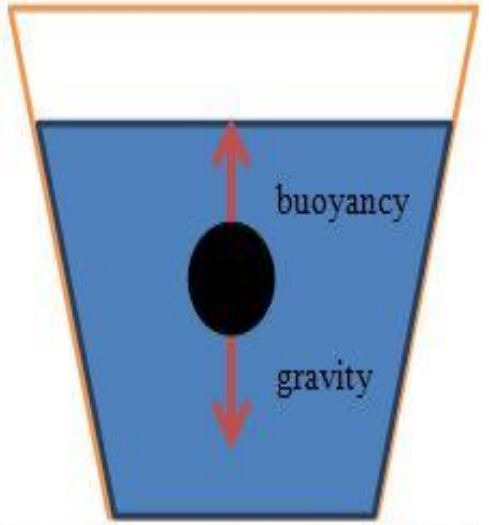


Figure 1: Forces acting on a floating object

BUOYANCY AND GRAVITY

- An object will **rise** in a fluid when:
  - If the density of the object is ***less*** than the density of the fluid
  - The buoyancy force on the object is ***greater*** than the force of gravity on the object

- Examples:
- A submarine with empty ballast tanks
- A surfacing whale
- Can you think of other examples?

BUOYANCY AND GRAVITY

- An object will ***sink*** in a fluid when:
  - If the density of the object is ***greater*** than the density of the fluid
  - The buoyancy force on the object is ***less*** than the force of gravity on the object

  - Examples:
  - A submarine with full ballast tanks
  - An anchor
  - Can you think of other examples?

Buoyant Force

Gravity

BUOYANCY AND GRAVITY

- An object will **float** in a fluid when:
  - If the density of the object is ***equal*** than the density of the fluid
  - The buoyancy force on the object is ***equal*** than the force of gravity on the object

  - Examples:
  - A submarine with partially filled ballast tanks
  - Can you think of other examples?

ARCHIMEDES' PRINCIPLE

- Archimede's Principle
- Force on an object is equal to the weight of the fluid displaced by the object
- An example: Two identical pieces of aluminum foil. If you crumple up one piece tightly and place it in the water, it will sink. However, if you fold the second piece into the shape of a boat, it will float.
- Even though they have the same mass, the piece shaped like a boat takes up a much greater volume and displaces more fluid, increasing the buoyant force pushing upward on the boat