Chapter Ten: Properties of Matter

- 10.1 Density
- 10.2 Properties of Solids
- 10.3 Properties of Fluids
- 10.4 Buoyancy

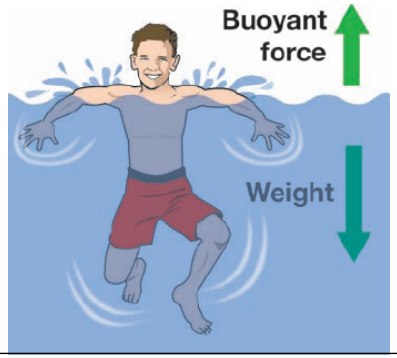
Chapter 10.4 Learning Goals

- Define buoyancy.
- Explain the relationship between density and buoyancy.
- Discuss applications of Archimedes' principle.
- Apply Charles's law to relate the temperature and volume of a gas.

10.4 Buoyancy is a force

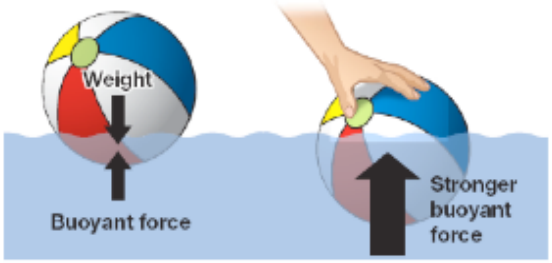
- **Buoyancy is a measure of the upward force a fluid exerts on an object that is submerged.**

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



10.4 Volume and buoyancy

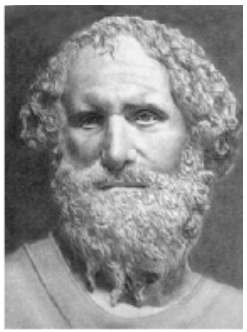
- The strength of the buoyant force on an object in water depends on the volume of the object that is underwater.



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

10.4 Archimedes' Principal

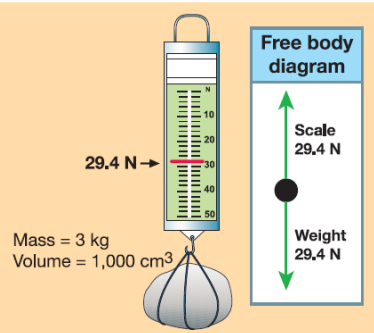
- In the third century BC, a Greek mathematician named Archimedes realized that buoyant force is equal to the weight of fluid displaced by an object.



- A simple experiment can be done to measure the buoyant force on a rock with a spring scale when it is immersed in water.

10.4 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.

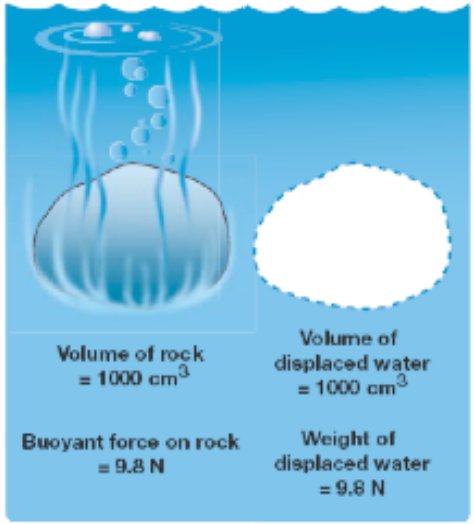


What is the rock's weight?

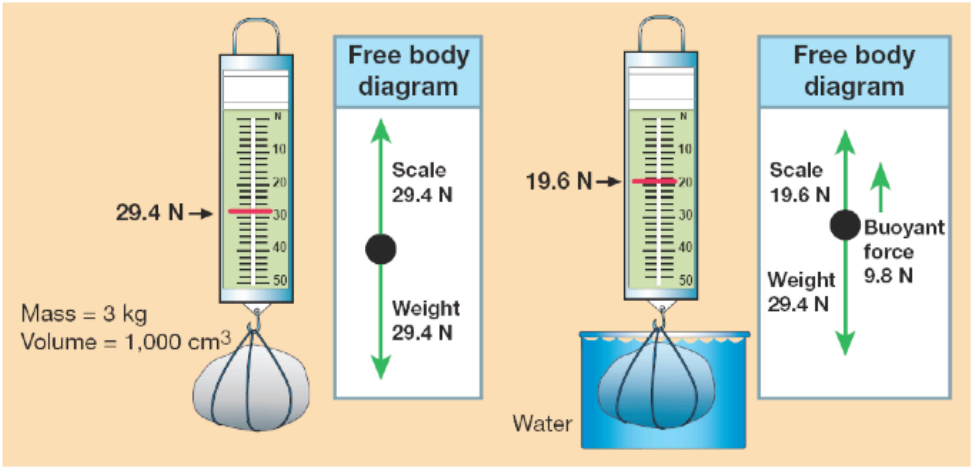
What is the rock's mass?

10.4 Sinking and floating

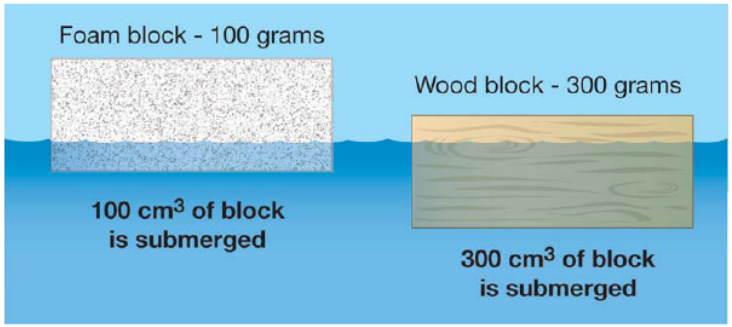
- In air the buoyant force on the rock is 29.4 N.
- When the rock was submerged, the scale read 19.6 N.
- The difference is a force of 9.8 N, exactly the amount of force the displaced water exerts.



Archimedes' Principle



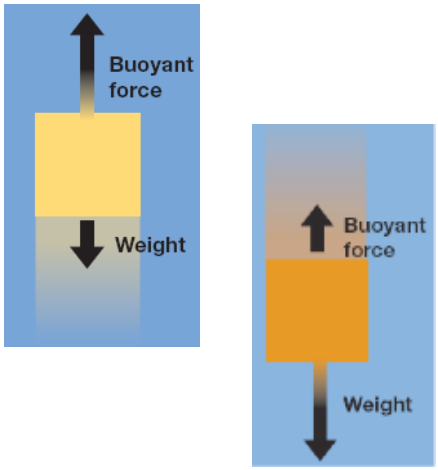
10.4 Sinking and floating



These blocks are the same total volume.
Which block has more buoyant force acting on it?
Which block weighs more in air?

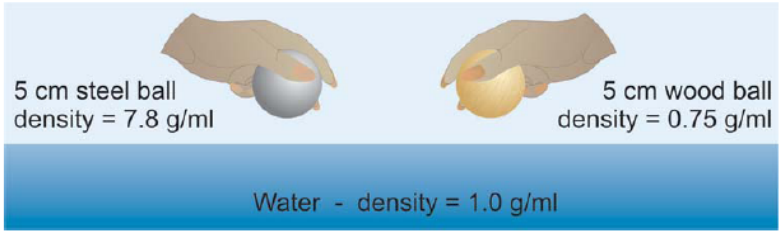
10.4 Sinking and floating

- 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.



10.4 Density and buoyancy

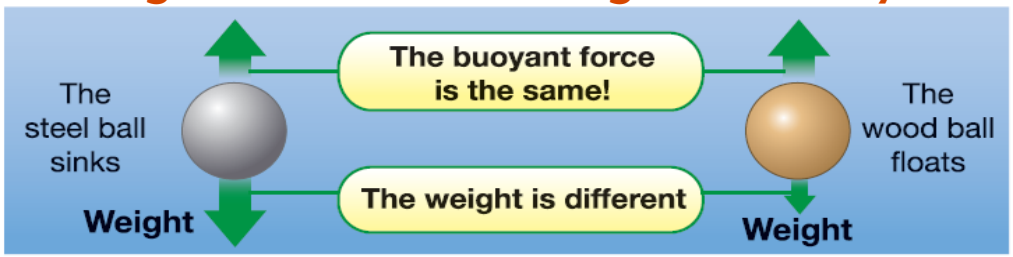
- If you know an object's density you can quickly predict whether it will sink or float.



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

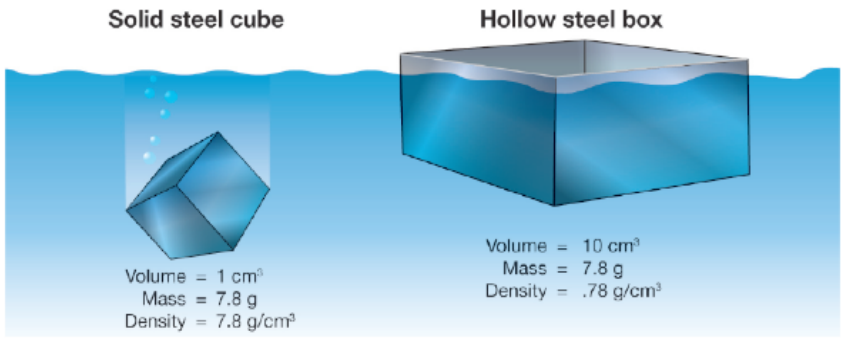
10.4 Density and buoyancy

- When they are completely underwater, both balls have the same buoyant force because they displace the same volume of water.
- However, the steel ball has more weight since it has a higher density.



10.4 Boats and apparent density

- Apparent density determines whether an object sinks or floats.



10.4 Apparent Density

- **An object with an apparent density GREATER than the density of water will sink.**
- **An object with an apparent density LESS than the density of water will float.**

Apparent Density

Apparent density is the total mass divided by the total volume.

Solid steel ball
volume = 25 mL
mass = 195 g

$$\text{App. Density} = \frac{195\ \text{g}}{25\ \text{mL}}$$

App. Density = 7.8 g/mL
SINKS!

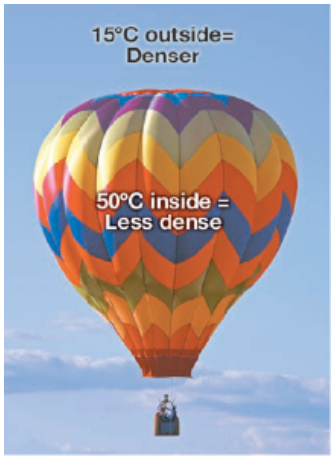
Hollow steel ball
volume = 25 mL
mass = 20 g

$$\text{App. Density} = \frac{20\ \text{g}}{25\ \text{mL}}$$

App. Density = 0.8 g/mL
FLOATS!

10.4 Buoyancy, volume, temperature, and pressure of

- A hot-air balloon floats because the air inside is less dense than the air outside.
- The balloon example illustrates an important relationship, known as Charles's law, discovered by Jacques Charles in 1787.



10.4 Charles' Law

- According to Charles' law, the volume of a gas increases with increasing temperature.
- Volume decreases with decreasing temperature.

CHARLES' LAW

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

V_1: Initial volume — T_1: Initial temperature (K)

V_2: New volume — T_2: New temperature (K)

Pressure and mass constant

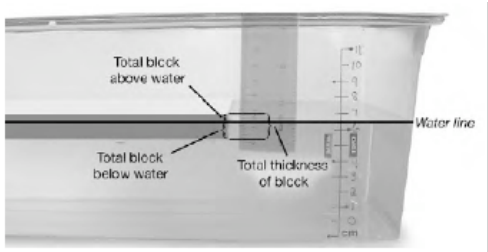
10.4 Pressure–Temperature Relationship

- The pressure of a gas is also affected by temperature changes.
- If the mass and volume are kept constant, the pressure goes up when the temperature goes up, and the pressure goes down when the temperature goes down.

Investigation 10C

Mountains and Earth's Crust

- **Key Question:**
  How can mountains float?



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.