Unit 4

Mass, Weight, and Density

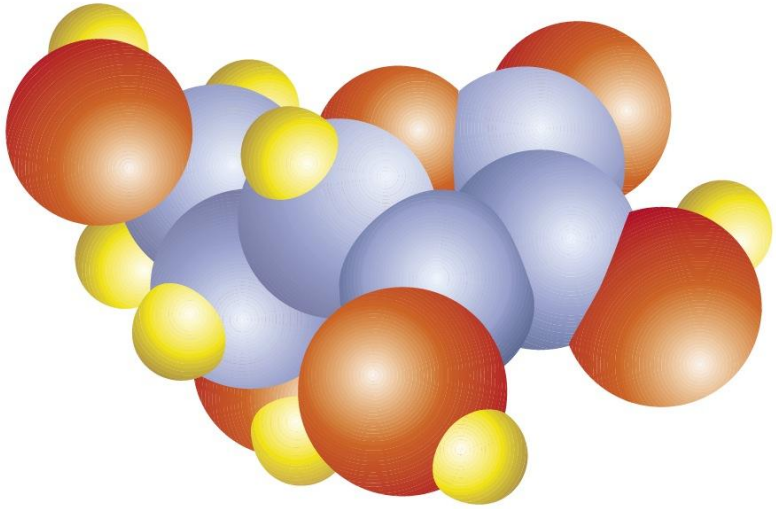
Lesson Objectives

- State that mass is a measure of the amount of substance in a body
- State that the mass of a body resists a change in the state of rest or motion of the body (inertia)
- State that a gravitational field is a region in which a mass experiences a force due to gravitational attraction
- Define gravitational field strength *g* as a gravitational force per unit mass.
- Recall and apply W = mg
- Distinguish between mass and weight.
- Recall and apply the relationship density = mass/volume.

Mass

The mass of a body is the amount of matter in the body.

It measures the inertia of the body.



The number and composition of atoms and molecules make up the mass of a body.

SI Unit for mass is kilogram (kg).

Mass

Mass depends on the number and size of particles which make up the substance.

It does not change from one location to another location.

e.g

The mass of an object on earth and on moon is the same.

Mass

- Large masses are measured in tonnes.

  (1 tonne = 1000 kg)
- Small masses are measured in grams and milligram.

  (1 gram = 0.001 kg)

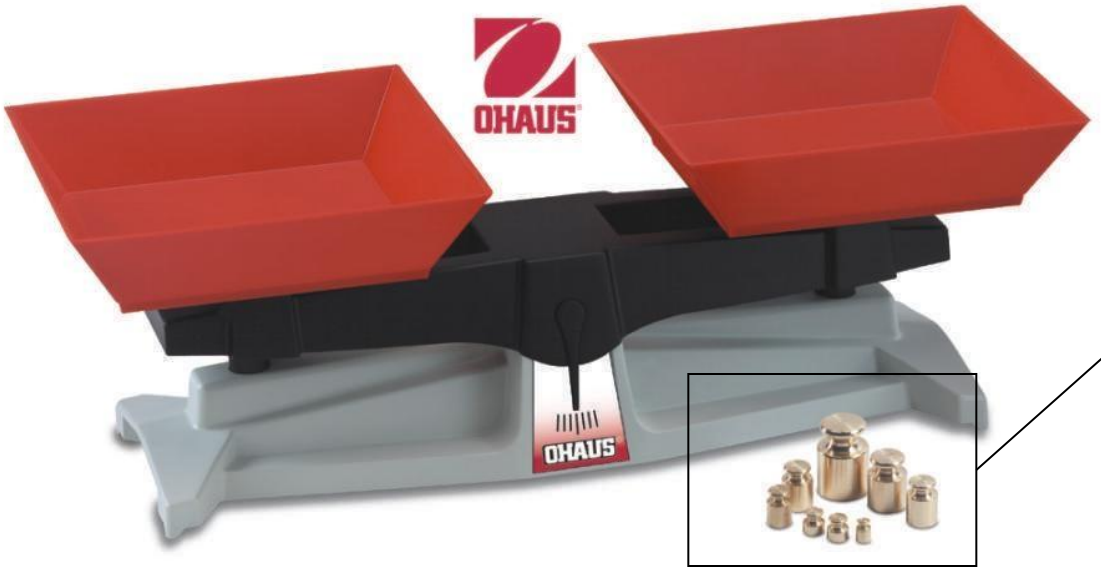
What are some objects that are measured in

- tonnes?
- kilograms?
- grams?
- milligrams?



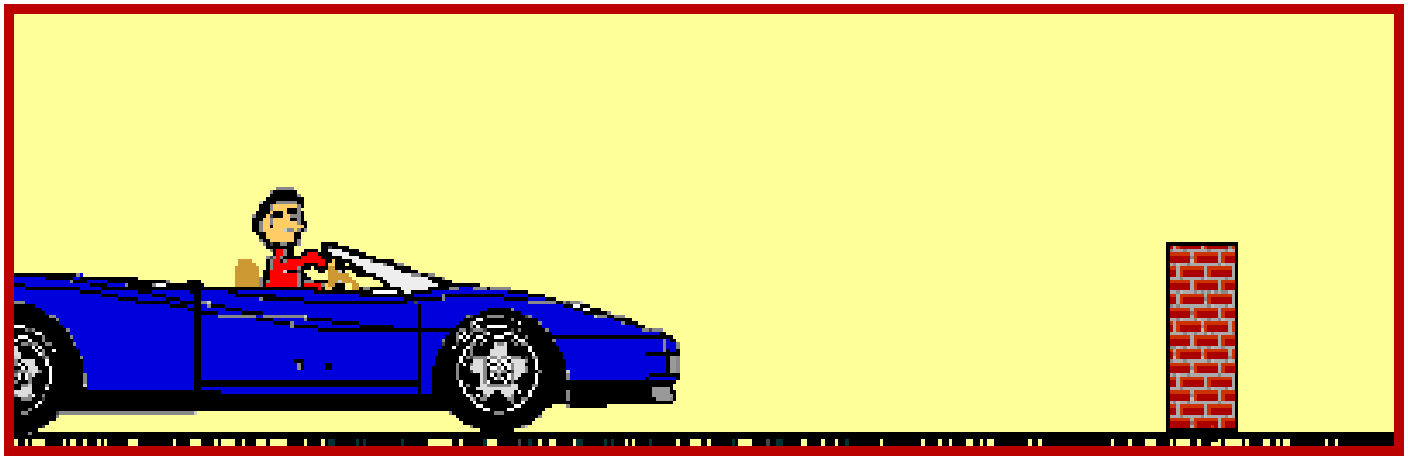

How to measure mass?

Instrument : beam balance



How to measure mass?

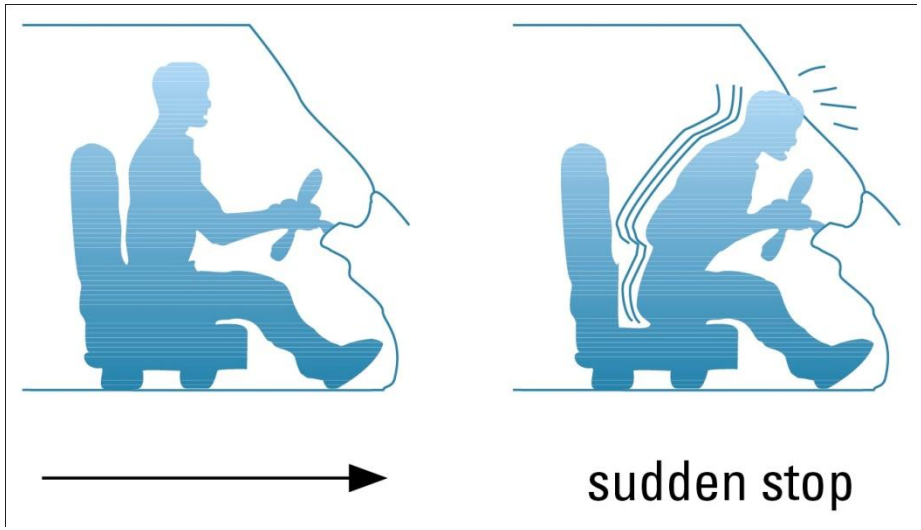
Instrument : electronic balance



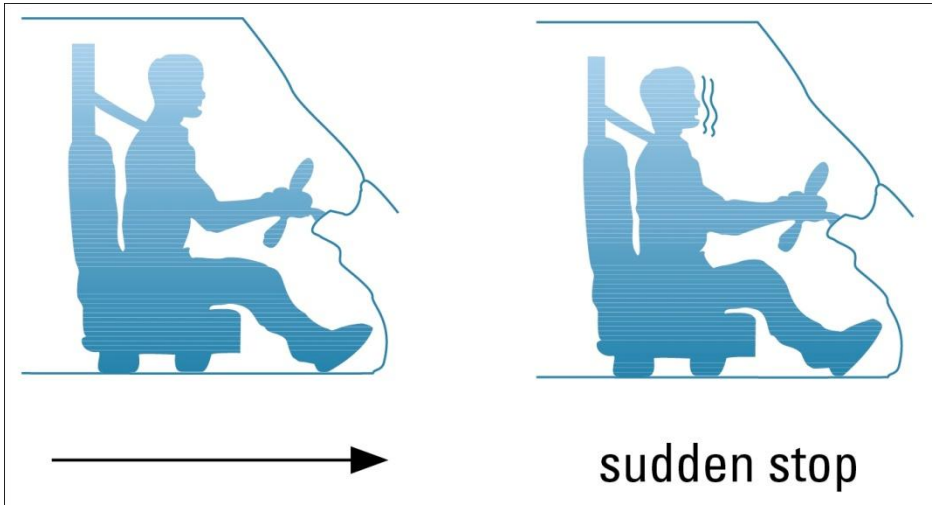
It is the natural tendency of objects to keep on doing what they're doing. All objects resist changes in their state of motion.

What is Inertia?

- Inertia of an object refers to the reluctance of the object to change its state of motion.
- The inertia of an object depends on its mass. An object with more mass has greater inertia.



Driver not wearing the seat belt.



Driver wearing the seat belt.

Inertia

A supertanker has high inertia because of its mass. It gains speed slowly and loses it slowly

Compare this with a speed boat?

Weight

- Weight is the gravitational force acting on a matter.

- Do you think that your weight on Earth is the same as that on the moon? Why?

- The Earth exerts a greater gravitational force than the moon. Thus, you will weigh heavier on Earth.

Weight

weight = mass x acceleration due to gravity

$$W = mg$$

where W is in N

m is in kg

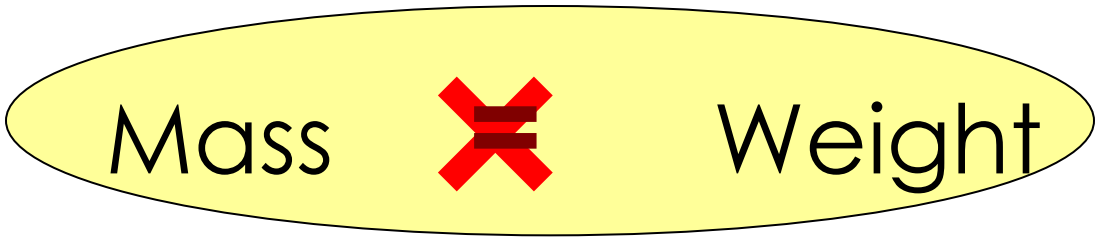
g = 10 m/s^2 (on earth)

How to measure weight of an object?

Use a spring balance! Scales measure the force of attraction between the object and the Earth. This force of attraction between the object and the Earth (or any other planet) is called the weight of the object.

SI unit : Newton, N (the unit for force)

Mass and Weight



Weight – the force that is acting on an object by gravity pull

Mass – the amount of matter in an object

Mass does not change from place to place whereas weight changes from place to place depending on the pull of gravity

Mass and Weight

Write down your mass in kg. After that, complete the table below:

Your mass, m = _____ kg

Planet	**g (m/s^2)**	**Mass (kg)**	**Weight = mg (N)**
Jupiter	22.88		
Earth	9.78		
Mars	3.72		

g values are obtained from:
http://www.solarviews.com/eng/homepage.htm

Mass and Weight

Mass	**Weight**
Is amount of substance in the body	Is the force of gravity acting on the body
Is constant at any location	Depends on acceleration due to gravity at the location
Is a scalar quantity	Is a vector quantity
Is measured in kg	Is measured in N
Is measured using a beam balance	Is measured using a spring balance
Can never be zero	Can be zero

Will regular Coke or diet Coke sink?

And why?

Coke vs Diet Coke

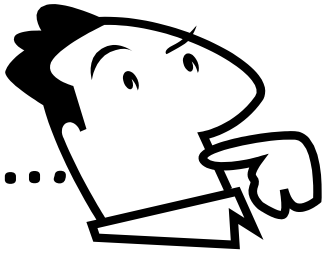
Density

- The density of a substance is the ratio between the mass and the volume of a substance.
- Before the density of a substance can be calculated, the mass and volume must be known.

$$Density = \frac{mass}{volume}$$

SI unit : kg/m^3 **other units : g/cm^3**

Food for thought…



- If I pack more mass into the same volume, what happens?

→It becomes denser!

- How about if I pack the same mass into a smaller volume?

→ It becomes denser!

- Does something with more mass imply that it has a greater density?

→ No!

Different ways of writing the density equation

$$Density = \frac{mass}{volume} \qquad Volume = \frac{Mass}{Density}$$

$$Mass = Density \times Volume$$

Worked Example 1

The density of gold is 19 g/cm^3 and the density of silver is 10 g/cm^3.
Jane has a ring with a mass of 380g and a volume of 30 cm^3.
Is the ring made of pure gold, pure silver or a mixture of both? How do you tell?

Solution

$$\text{Density of the ring} = \frac{\text{Mass}}{\text{Volume}} = \frac{380}{30}$$

$$= 12.7 \text{ g/cm}^3$$

Since the density is not the same as the density of gold and of silver, but the value lies in between, the ring should be a mixture of both.

Worked Example 2

Aluminium has a density of 2.7 g/cm^3. The mass of a block of aluminium was found to be 21.6 g. Find its volume.

Solution

Density of aluminium= 2.7 g/cm^3

Mass of a block of aluminium= 21.6 g

$$\text{Volume of the block} = \frac{\text{Mass}}{\text{Density}} = \frac{21.6}{2.7}$$

$$= 8 \text{ cm}^3$$

Try it Yourself

A metal of mass 135 g and density 9 g/cm^3 is lowered into a displacement can. How much water will be displaced by the metal?

A	9 mm^3
B	15 mm^3
C	9 cm^3
D	15 cm^3

Now for a harder one!

A piece of copper has a mass of 6.39 g and a density of 9 g/cm^3.

A piece of zinc has a mass of 504 g and a density of 7 g/cm^3.

The two are melted together to form an alloy. (An alloy is a mixture of two or more metals).

Find:

(a) The total volume of the alloy

(b) The density of the alloy

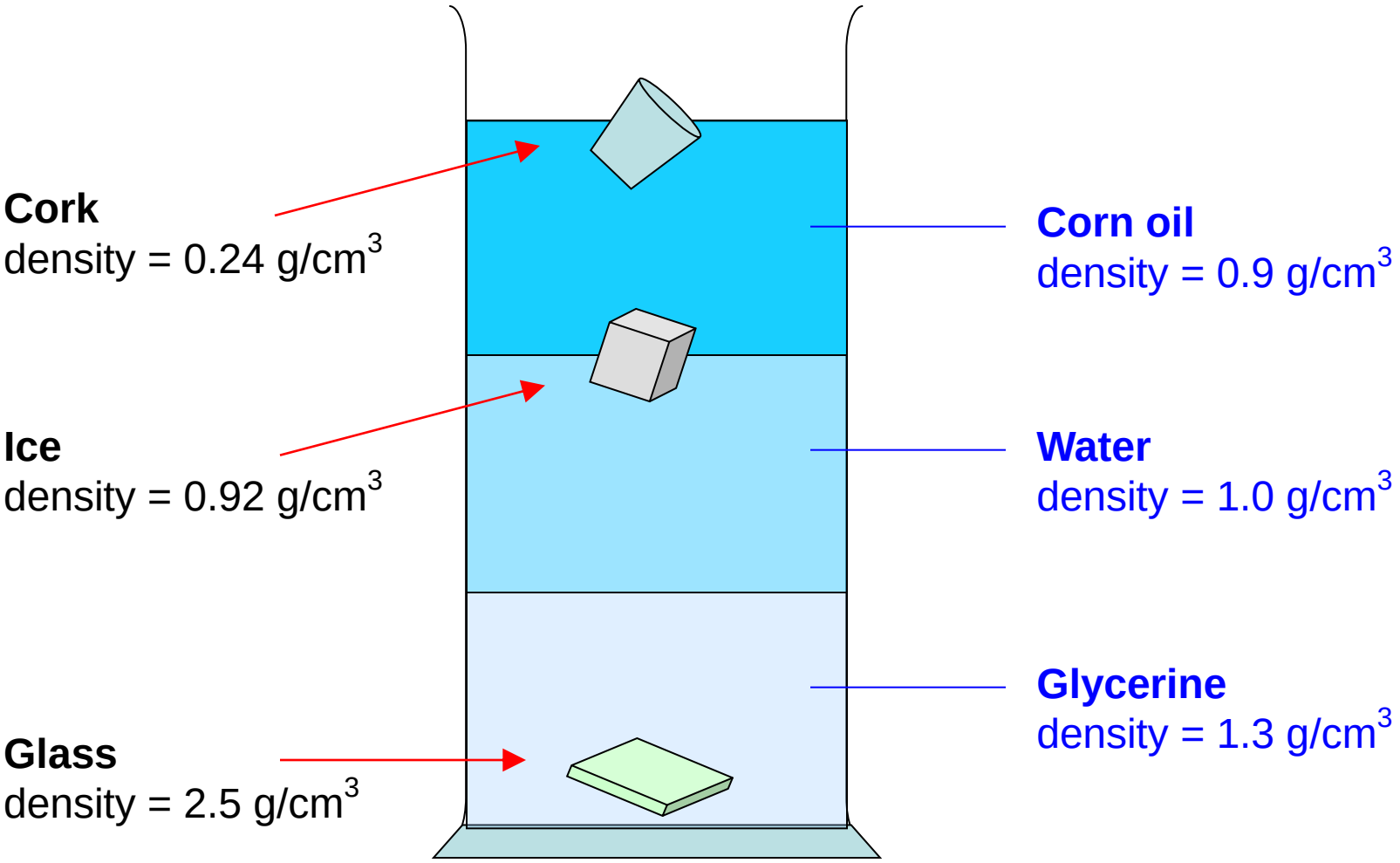
Floating and Sinking

- A substance floats if its density is less than that of the fluid around it.

- A substance sinks if its density is more than that of the fluid around it.

What happens to a solid placed in a liquid if the densities of the solid and liquid are the same?

Less dense – **Floats** , Denser - **Sinks**



http://www.explorelearning.com/index.cfm?method=cResource.dspView&ResourceID=17

Why do people float so effortlessly in the Dead Sea?

The Dead Sea has high salt content makes any plant and animal life impossible. The high concentration of salt is caused by the high evaporation rate, which has, over the years, led to the build up of salts.

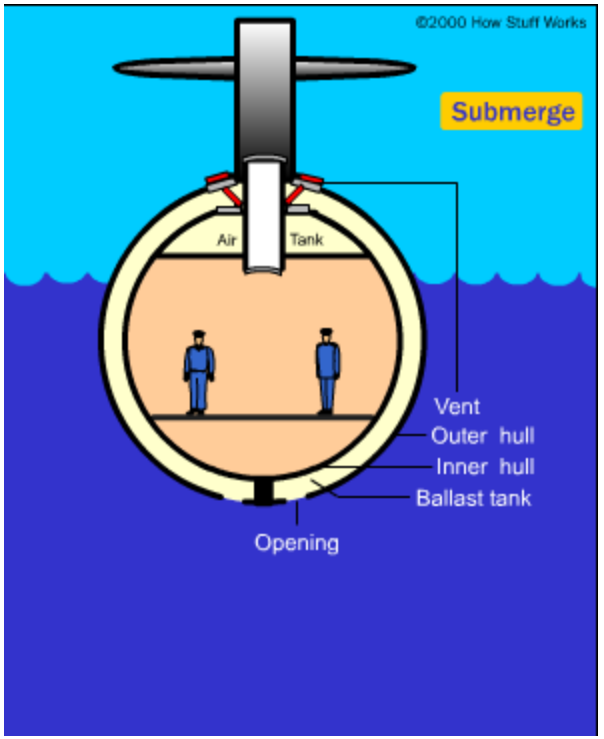
Buoyancy in a submarine

To dive:
Ballast tanks at the botton and the air valves at the top are open

- **Density increases**

To surface:
High-pressure air forces seawater out of the bottom of the tanks

- **Density decreases**



submarine http://science.howstuffworks.com/submarine1.htm