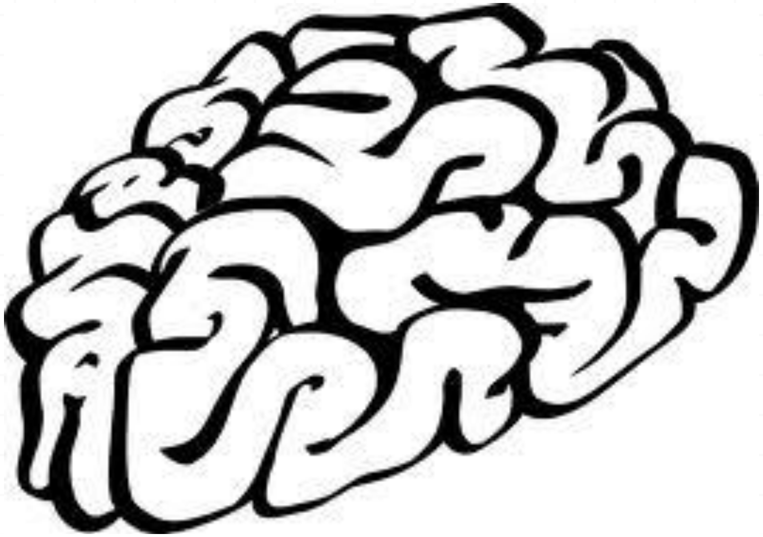
Measuring Mass

Exploring Diversity of Matter by Its Physical Properties

Mass

- Mass is the amount of matter in an object.
- SI unit: kilogram (kg)
- 1 kg = 1000 g

  1 g = 1000 mg



An adult brain: 1.3 ~1.4 kg

Beam Balance and Electronic Balance

Beam balance and electronic balance are used to give very accurate measurements.

Beam balance

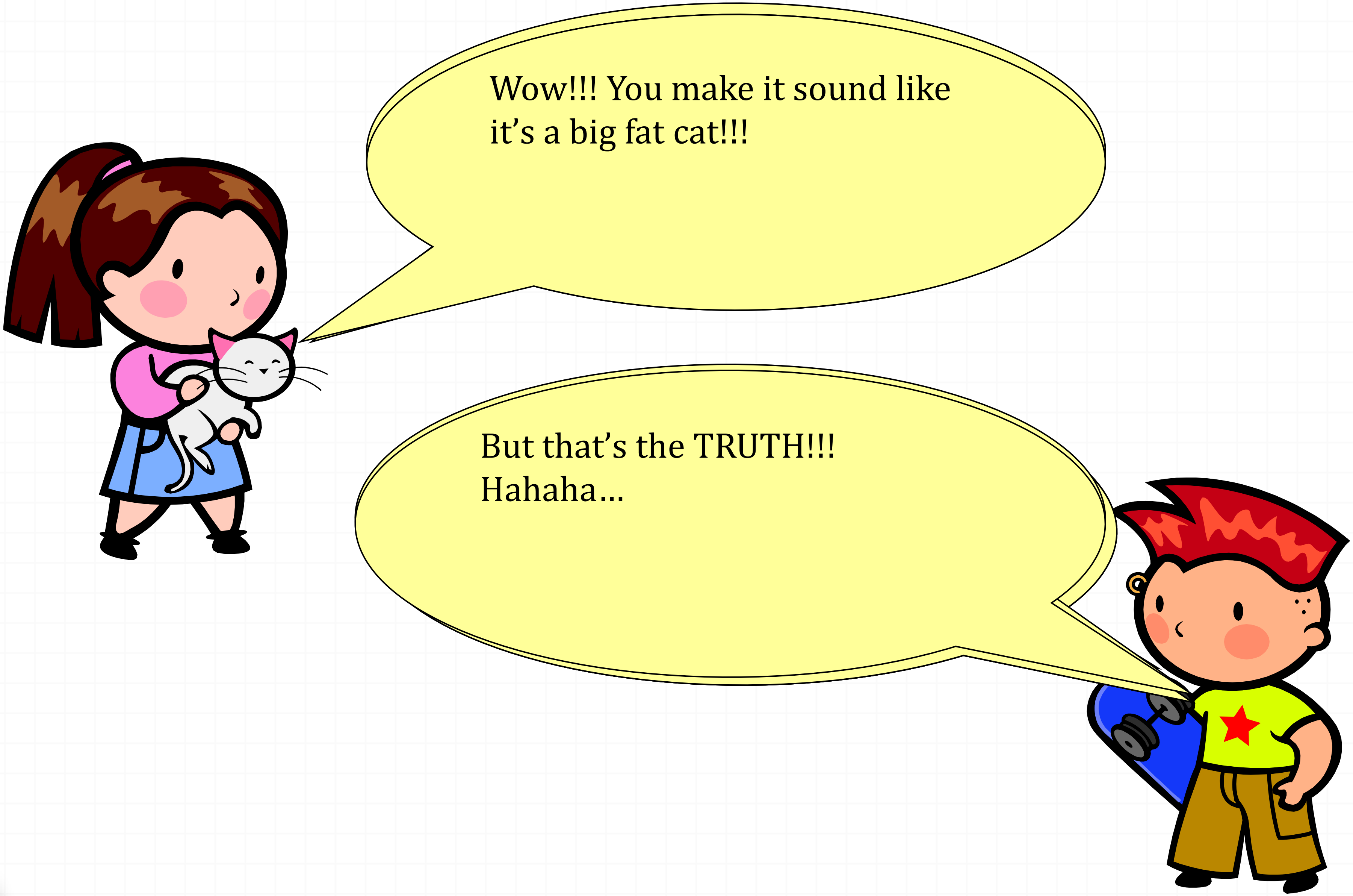
Electronic balance

Mass VS Weight

Mass should not be confused with weight.

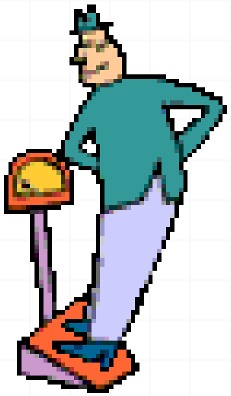
Mass	Weight
The amount of matter in an object.	The pull of gravity acting on an object.
Constant everywhere in the universe.	Changes from place to place.
Measured in kilograms (kg).	Measured in Newton (N).
Measured using beam balance.	Measured using spring balance.

Mass VS Weight



Weight

The gravitational force on Earth is 6 times greater than that on Moon. Thus an object weighs 6 times heavier on Earth than on Moon.



Calculate your weight on other planets

http://www.exploratorium.edu/ronh/weight/index.html

Temperature

Exploring Diversity of Matter by Its Physical Properties

Temperature

Temperature refers to the **degree of hotness and coldness.**

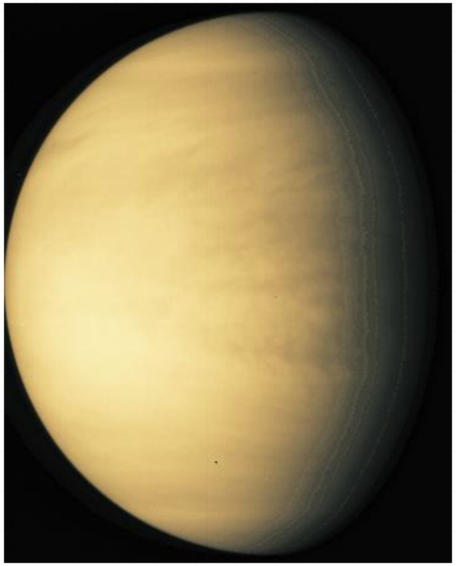
We are able to sense the hotness and coldness of an object by touching, but we are not able to tell the exact measurement of temperature.

Interesting Information

What do you think is the hottest planet?

Venus

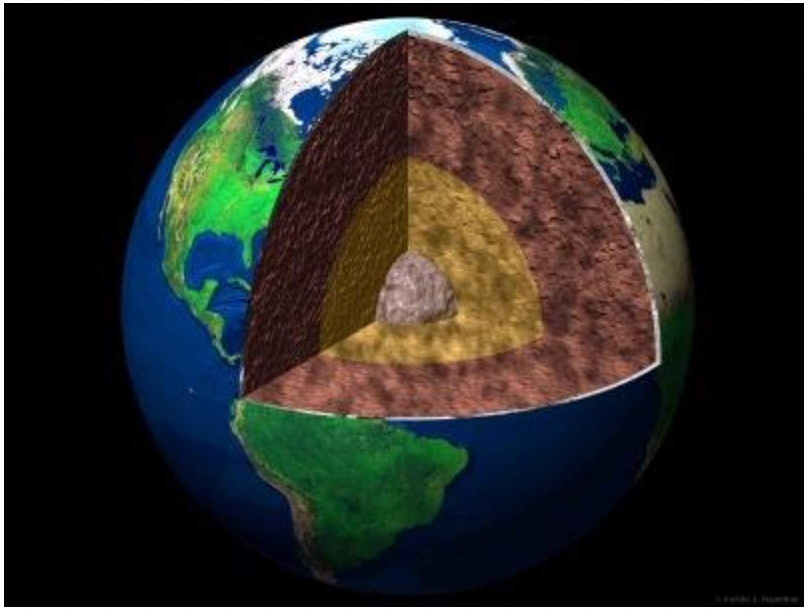
It has an average temperature of 400°C and it is hot enough to melt lead.



Interesting Information

What do you think is the temperature of the centre of the earth?

Approximately 5000°C which is approximately the same temperature as the sun.



Mercury Thermometer

Unit: Kelvin (K) (S.I. Unit)
Degree Celsius (°C)

Apparatus used for measuring temperature.

laboratory thermometer

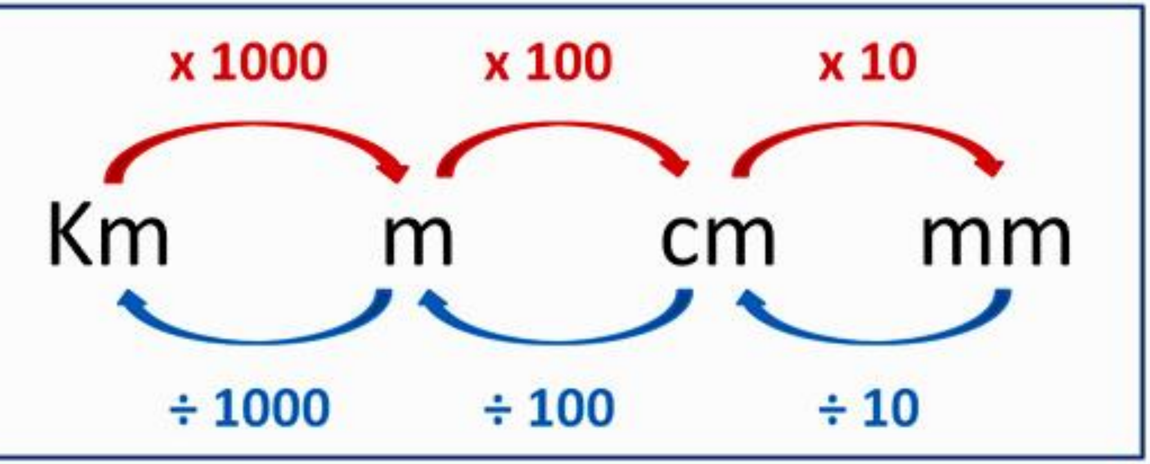
- mercury thermometer
- digital thermometer
- infrared thermometer

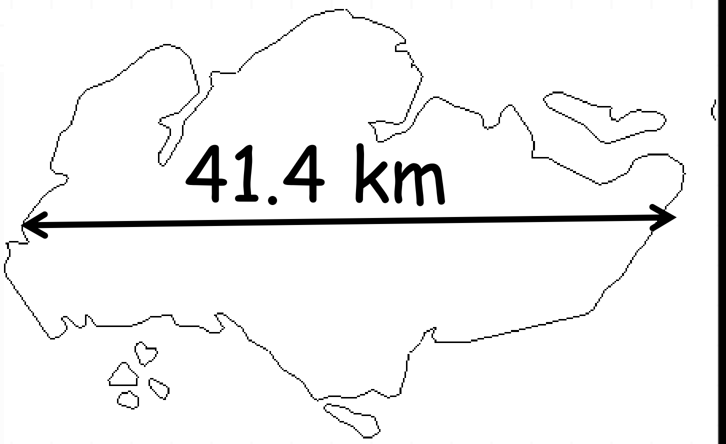
Measuring Length

Exploring Diversity of Matter by Its Physical Properties

Length

- Length is the distance between 2 points.
- SI unit: metre (m)



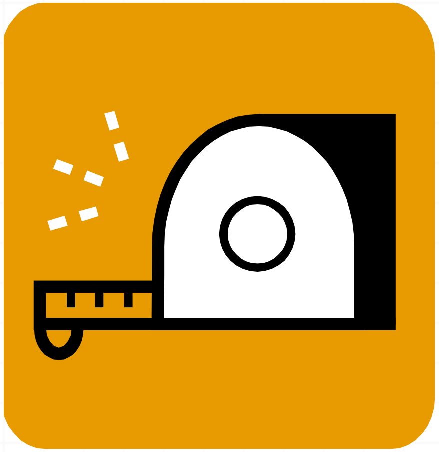


1 km = **<u>1000</u>** m = **<u>100,000</u>** cm = **<u>1,000,000</u>** mm

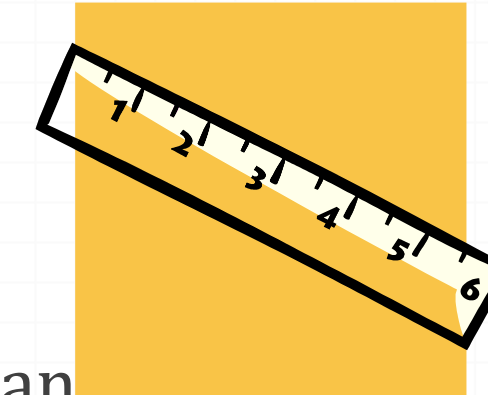
Range	Suitable Instruments	Accuracy of Instruments
Several metres (m)	Measuring Tape 	0.1 cm (or 1 mm)
Several centimetres (cm) to 1 m	 Metre Rule	0.1 cm (or 1 mm)
Between 1cm to 10cm	Vernier Calipers	0.01 cm (or 0.1 mm)
Less than 1 cm	Micrometer Screw Gauge	0.001 cm (or 0.01 mm)

Measuring Tape

- Can be used to measure distances of up to several hundred metres.
- Smallest division is **1 mm** or **0.1 cm.**
- A special property of the measuring tape is that it is soft and flexible, and are often used in measuring the diameters of round objects.

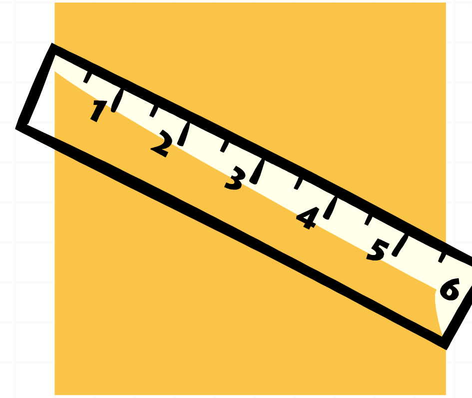


Metre Rule



- Measures length in **centimetres**, with an accuracy of **1 mm** or **0.1 cm**.
- To measure the length of an object using a metre rule, place one end of the object against the zero mark, and read off the mark on the rule at the other end of the object
- when taking a reading, **parallax** error may occur when it is not read at **eye** level.
- We can avoid parallax error by turning up the ruler instead of lying it flat.

Metre Rule



- when taking a reading, **parallax** error may occur when it is not read at **eye** level.
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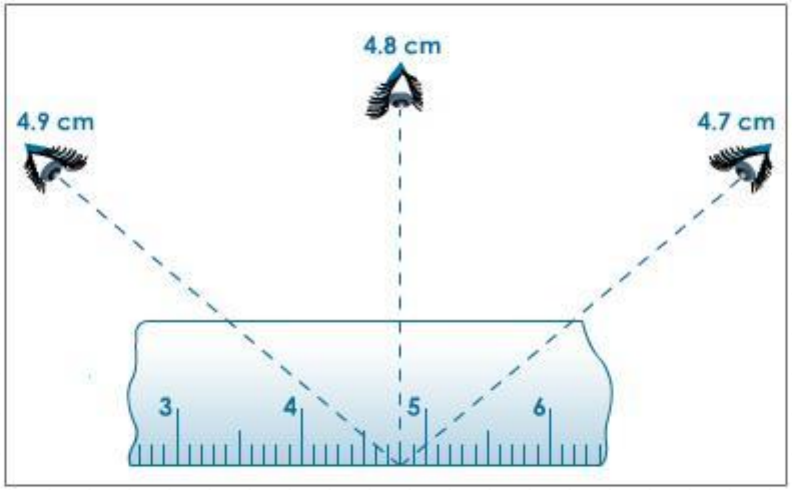
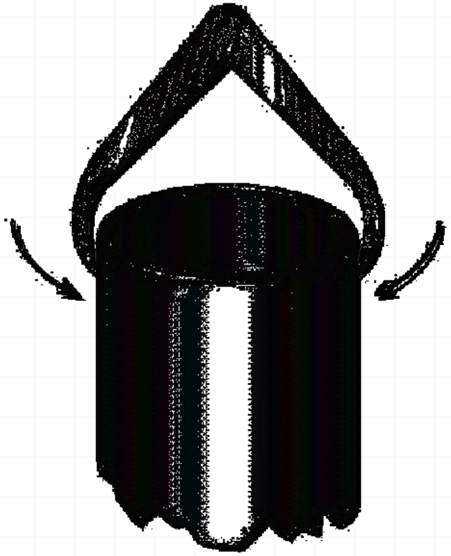
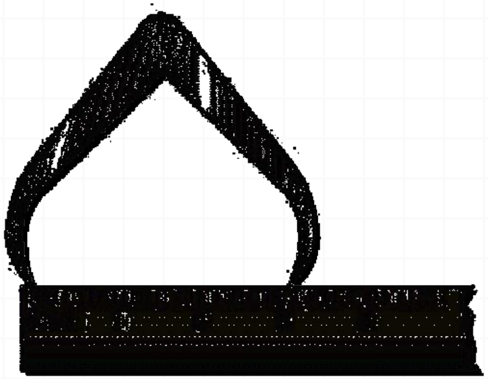


External Caliper

- Measures **external diameter** of objects.

External caliper

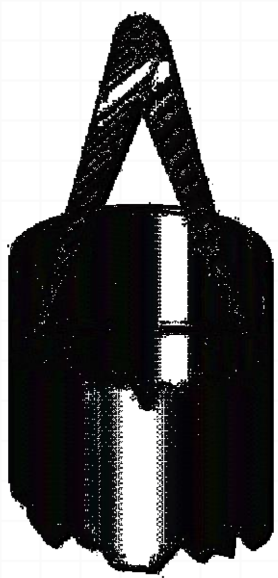


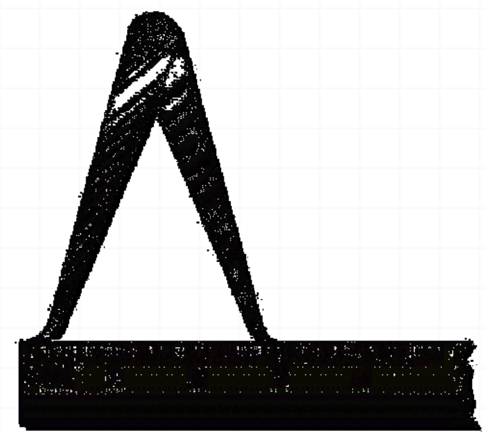


Internal Caliper

- Measures **internal diameter** of objects.

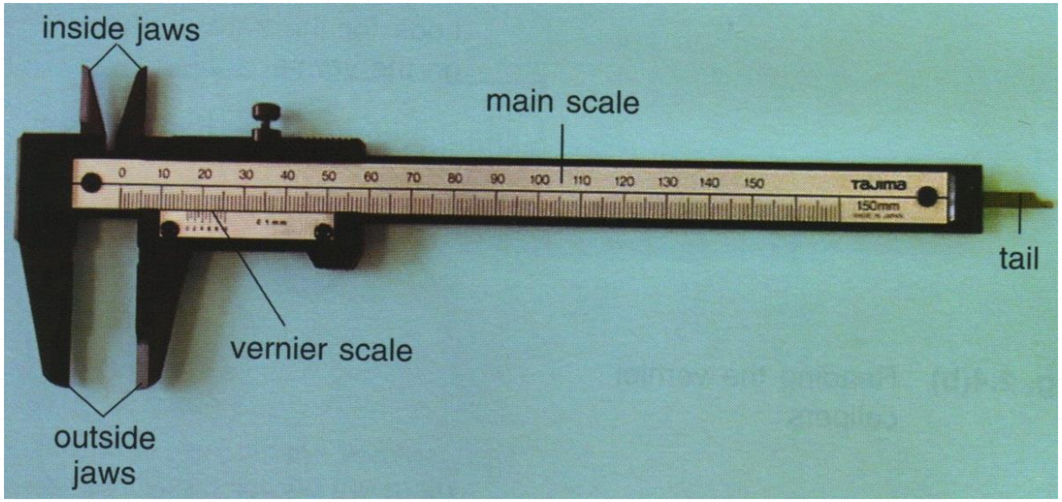
Internal caliper



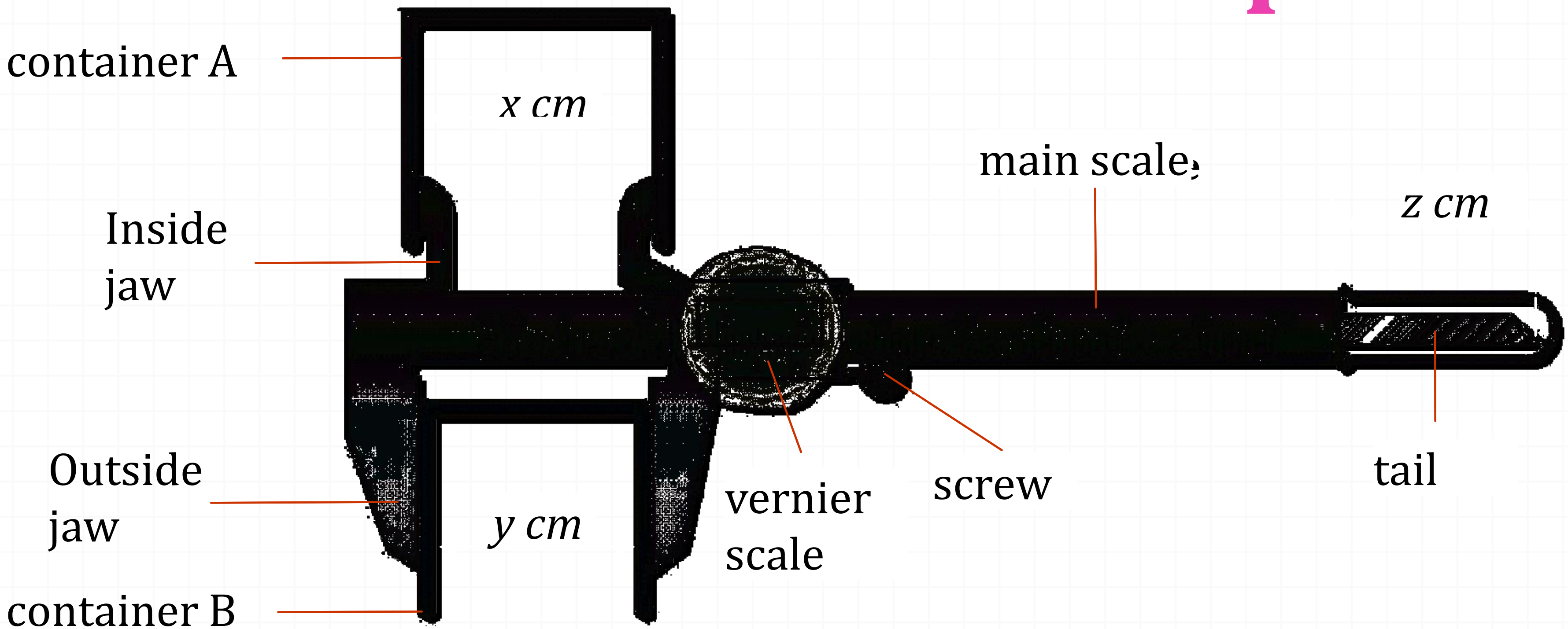


Vernier Caliper

- measure short lengths with accuracy of **0.1 mm** or **0.01 cm**.
- Each division on **main** scale: **1 mm**
- Each division on **vernier** scale: **0.1 mm**

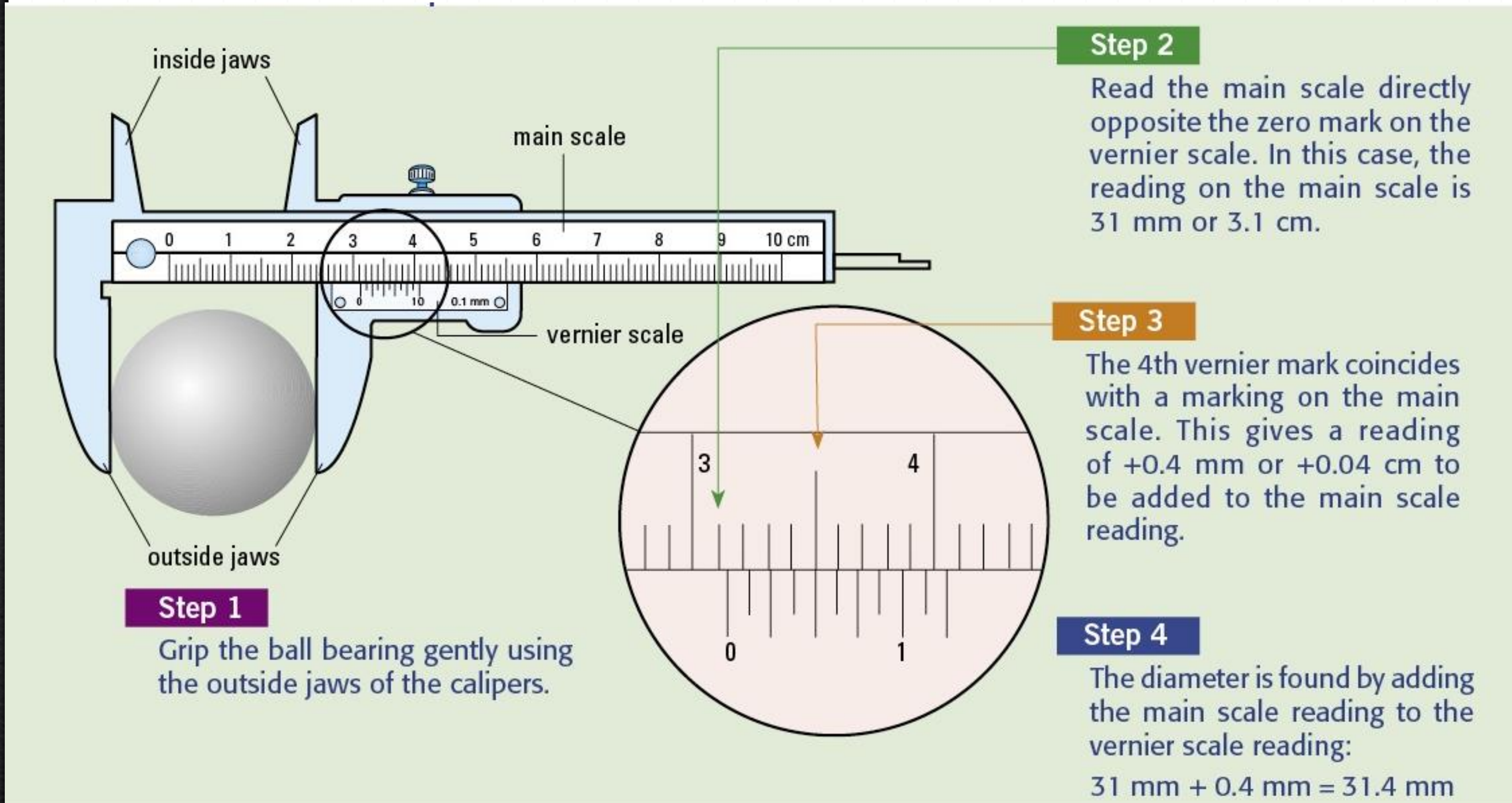


Parts of Vernier Caliper

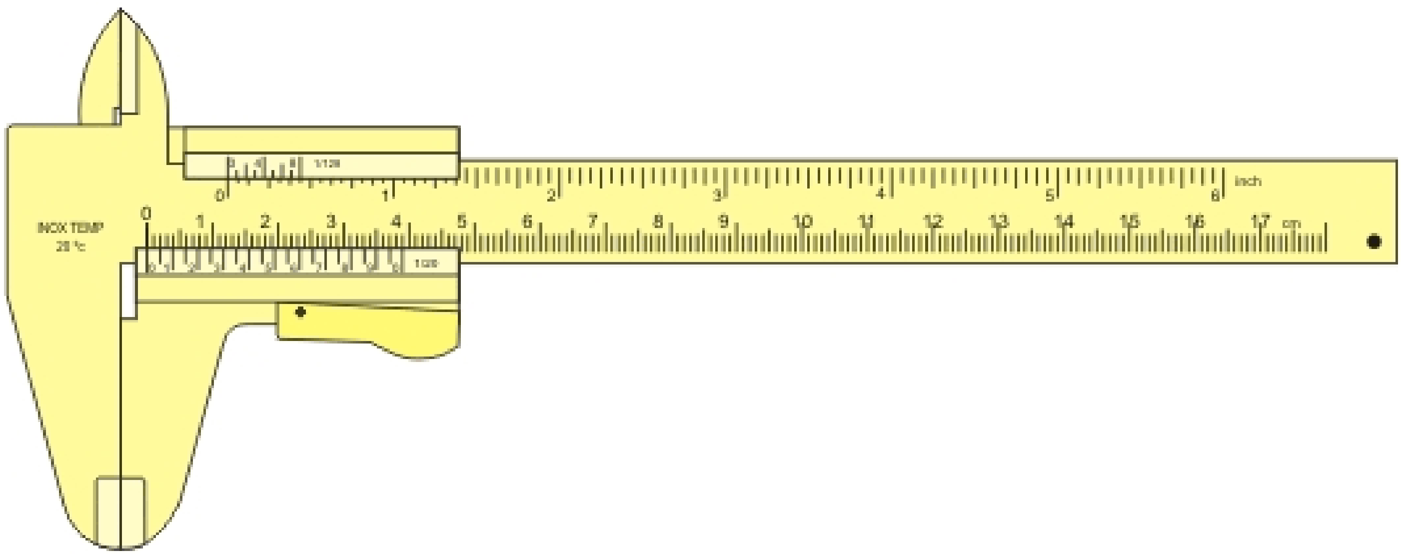


Parts	Functions
Inside jaws	To measure **internal** length
Outside jaws	To measure **external** length
Tail	To measure **depth**

Using the Vernier Caliper



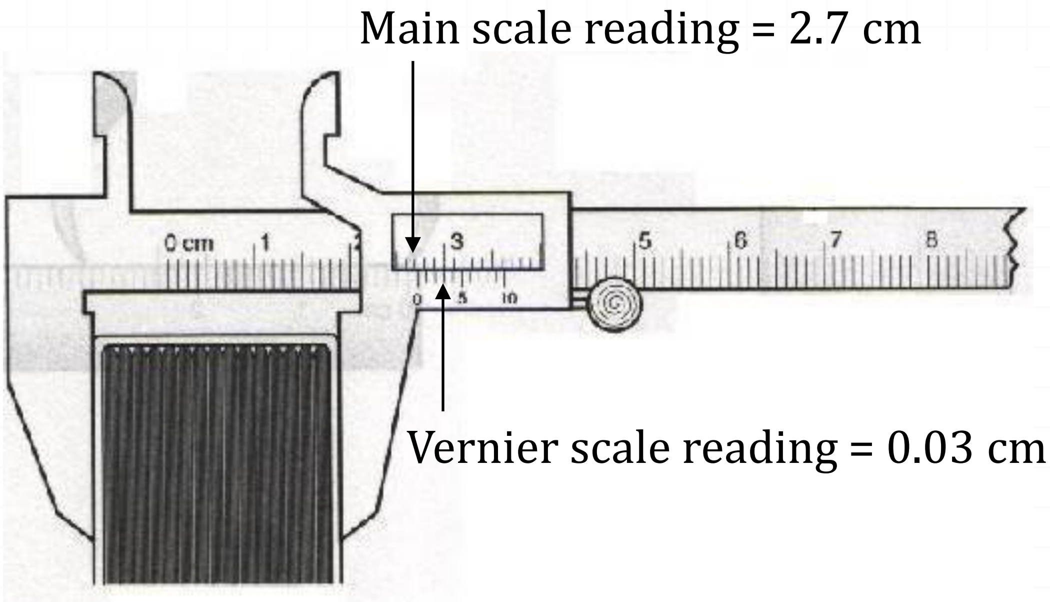
An animation on using the vernier calipers



•Right-click to pause the animation.
2nd External diameter animation
Internal diameter animation

Using the Vernier Caliper

Example: To measure the external length of a container



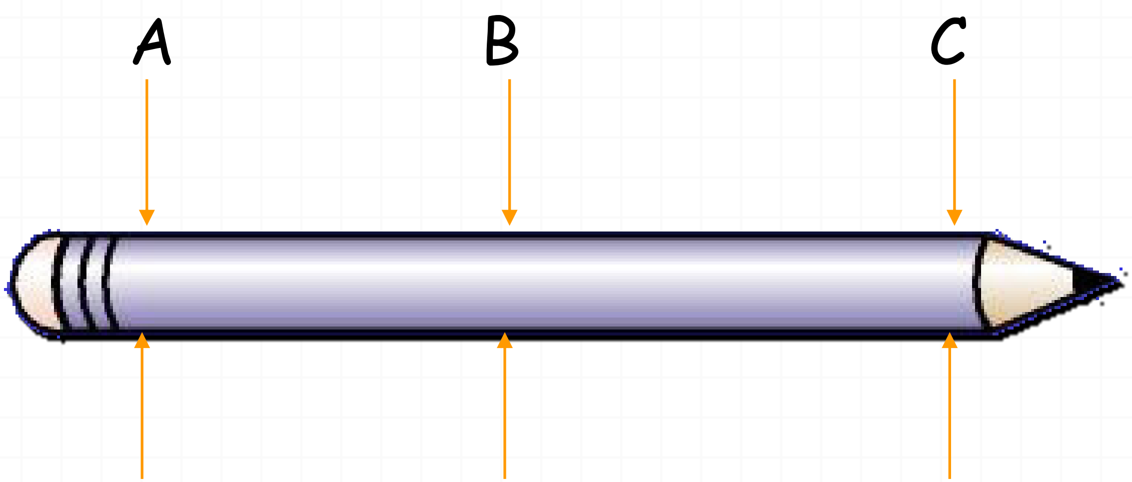
Main scale reading = 2.7 cm

Vernier scale – 3rd line is aligned with a line in the main scale = 0.03 cm

External length = 2.70 + 0.03 = 2.73 cm

Using the Vernier Caliper

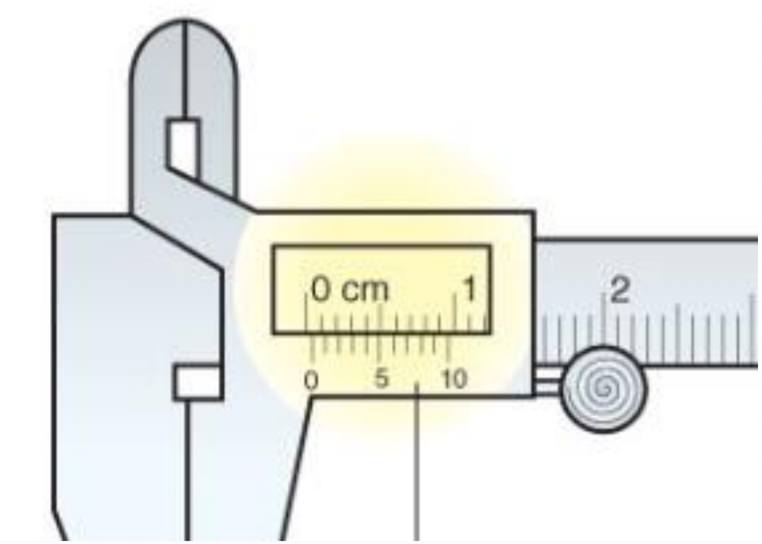
When finding the diameter of an object, take several measurements and use the **average.**



Zero Error

Zero error is a condition in which **zero marks on the two scales do not align** when the jaws are closed, resulting in inaccurate readings.

It is a condition where the initial reading at the start is not zero.



Correcting Zero Error

To correct the zero error, follow the steps below:

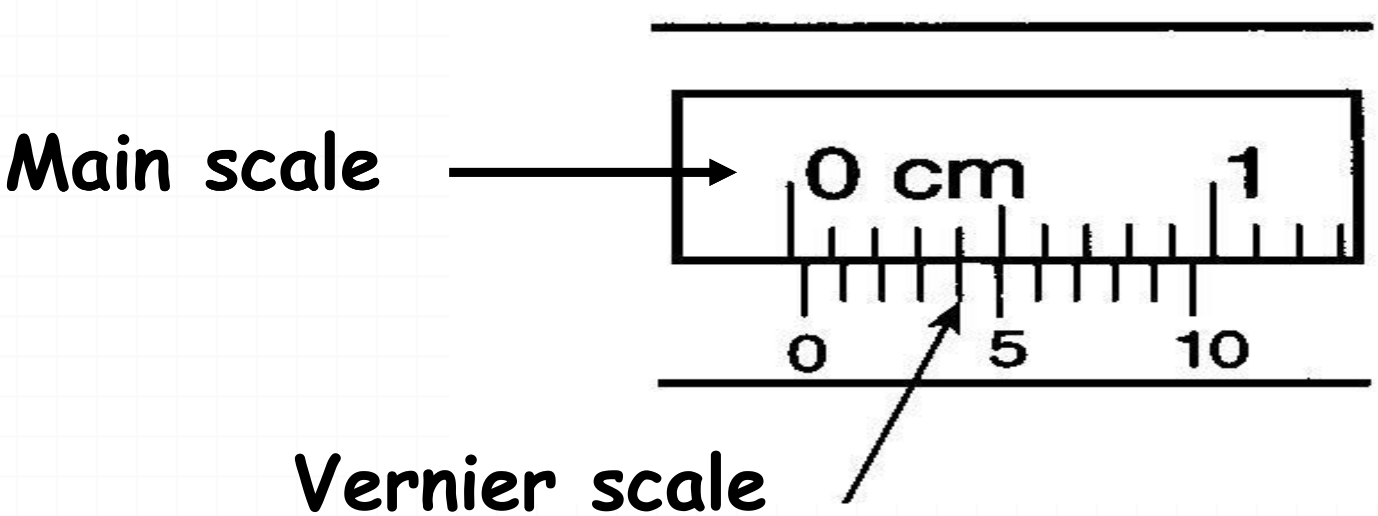
1. Note the position of the zero on the vernier and main scales.

2. Note the line on the vernier scale which aligns with one on the main scale.

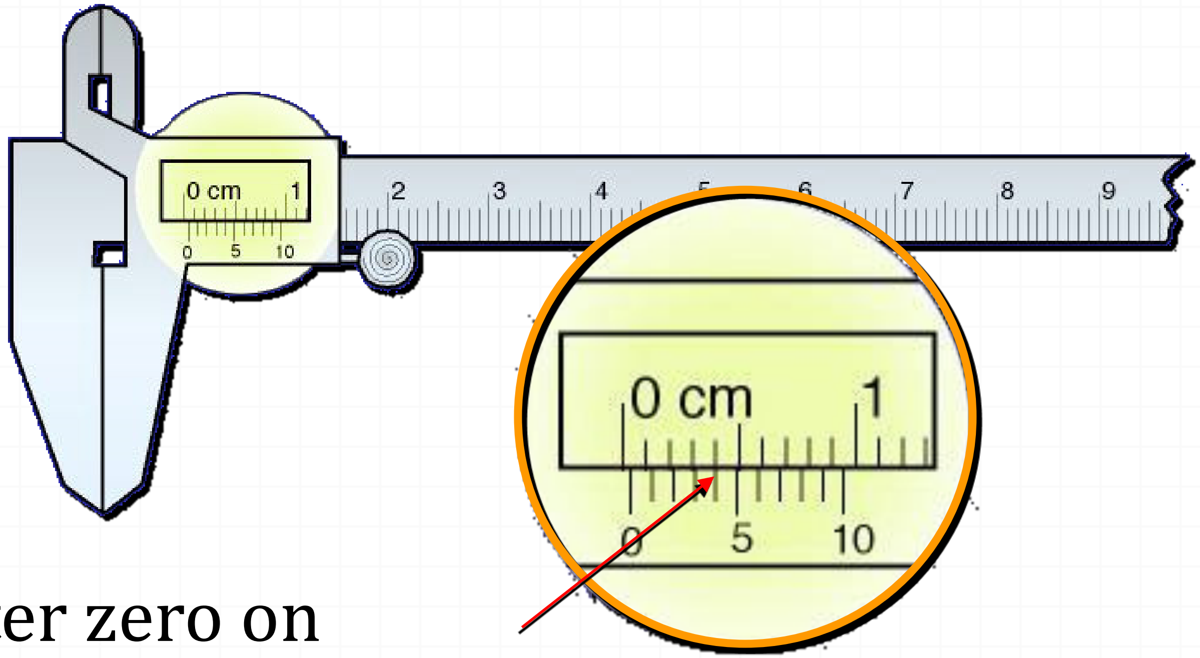
Corrected Reading = Measured Reading – Zero Error

Zero Error (Positive)

- Zero mark of the Vernier scale is to the **right** of the zero mark of the main scale.
- Measurements made are **greater than** the actual value by the value of the zero error.



Zero Error (Positive)



4th line after zero on vernier scale coincides with line on main scale; zero error = +0.04 cm

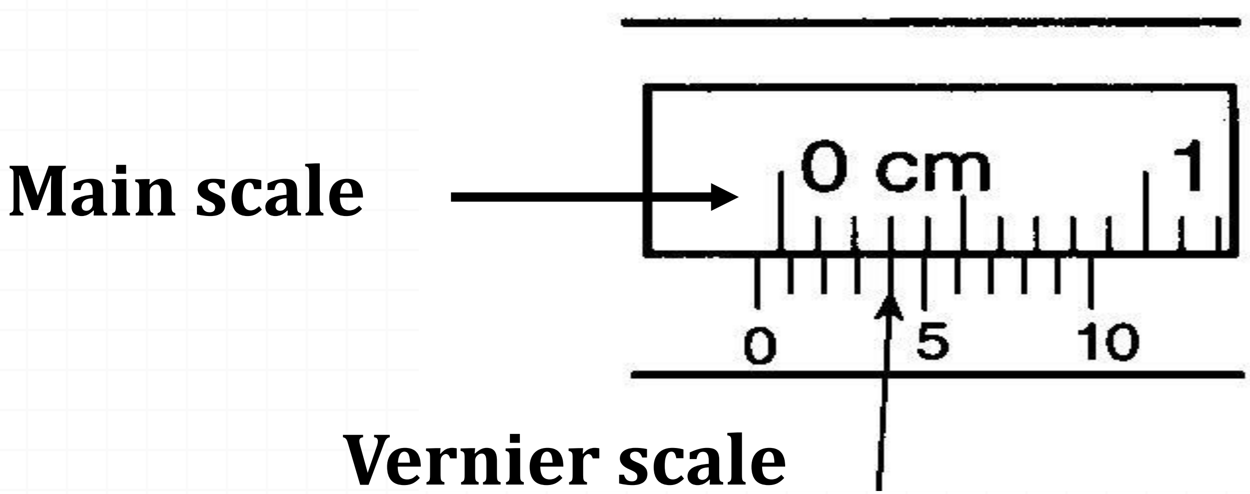
Zero error is subtracted from reading.

Correcting zero error animation

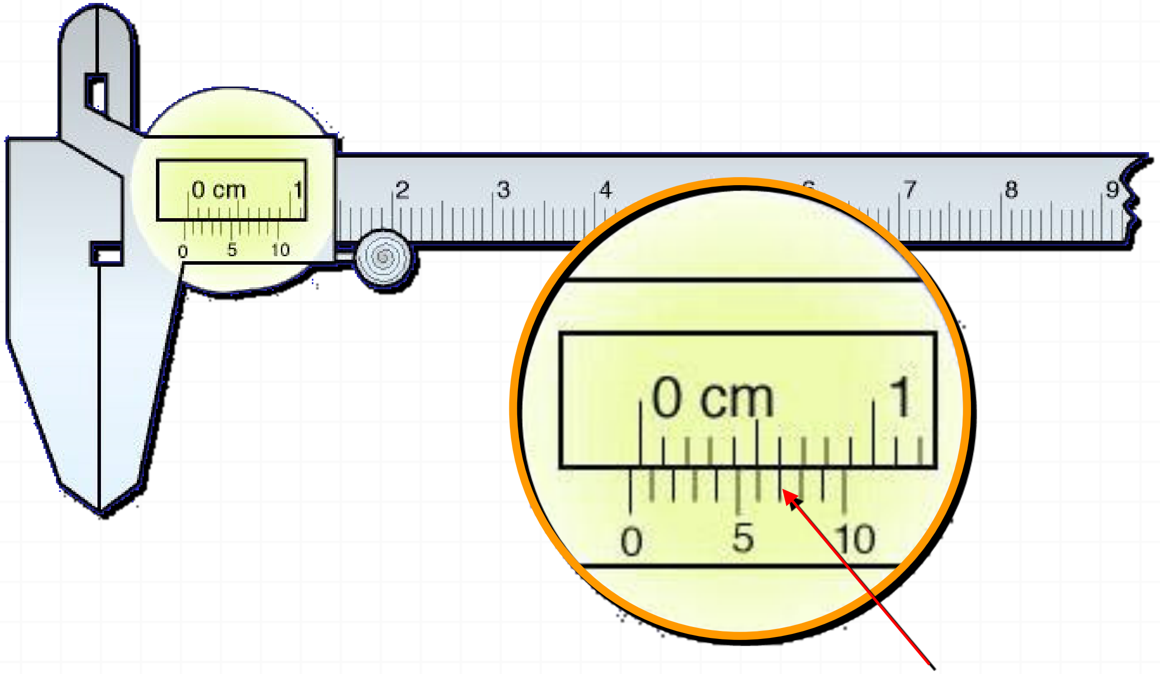
Zero Error (Negative)

- Zero mark of the Vernier scale is to the **left** of the zero mark of the main scale.

- Measurements taken are **less than** the actual value .



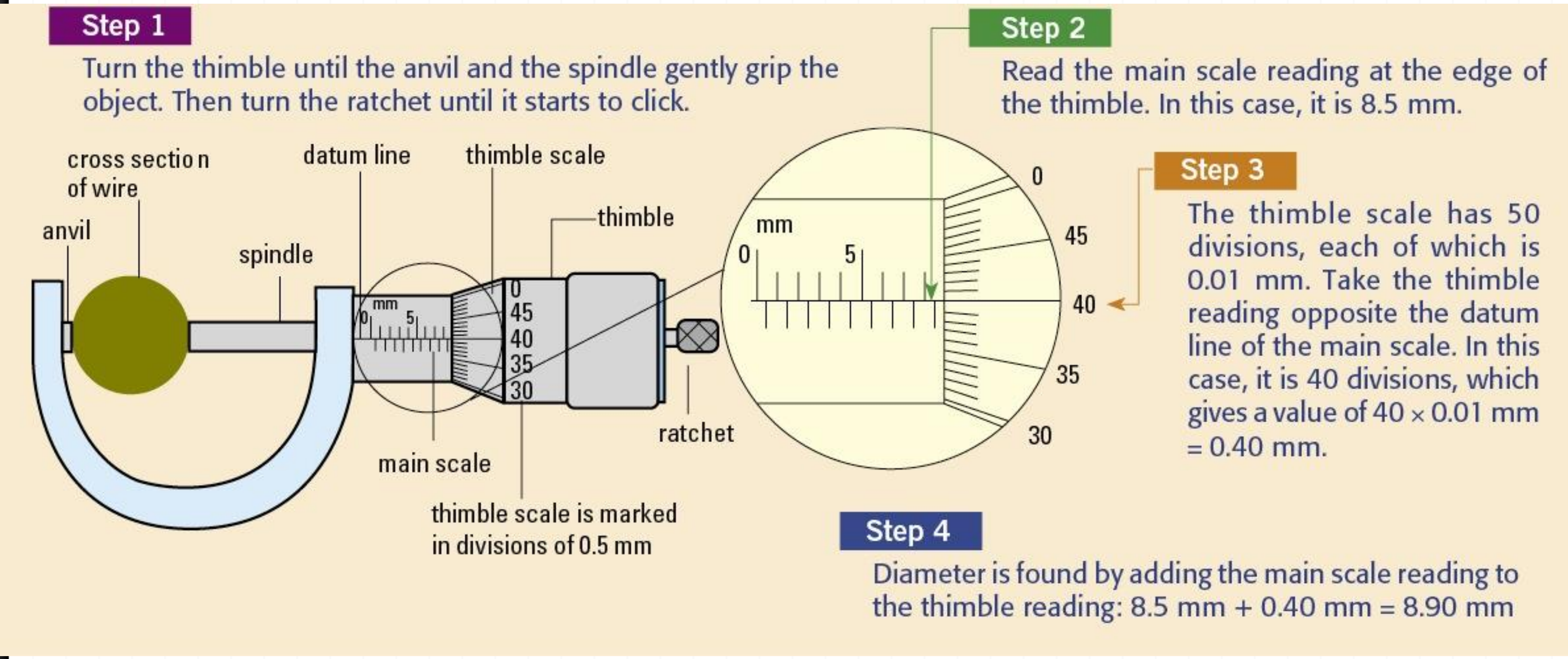
Zero Error (Negative)



7^{th} line after zero on vernier scale coincides with line on main scale; counting from the back zero error = -0.03 cm

Zero error is subtracted to the reading.

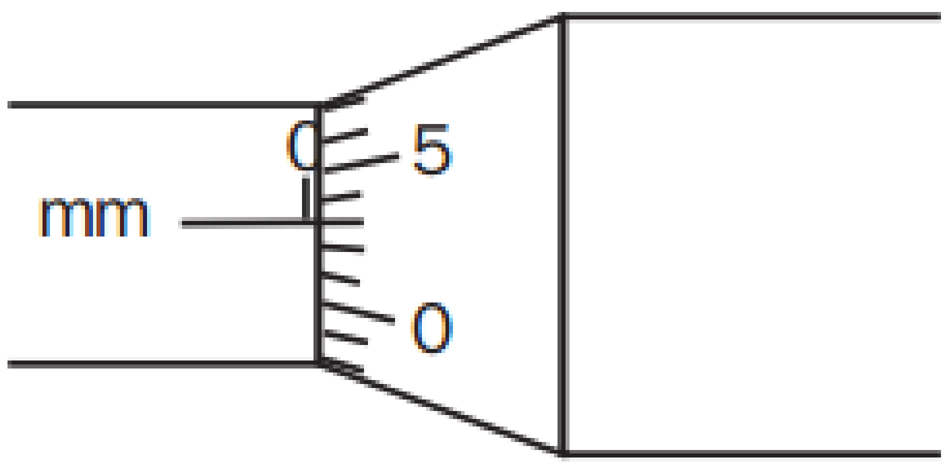
Using the Micrometer screw gauge



Smallest division is **0.01 mm** or **0.001 cm**.

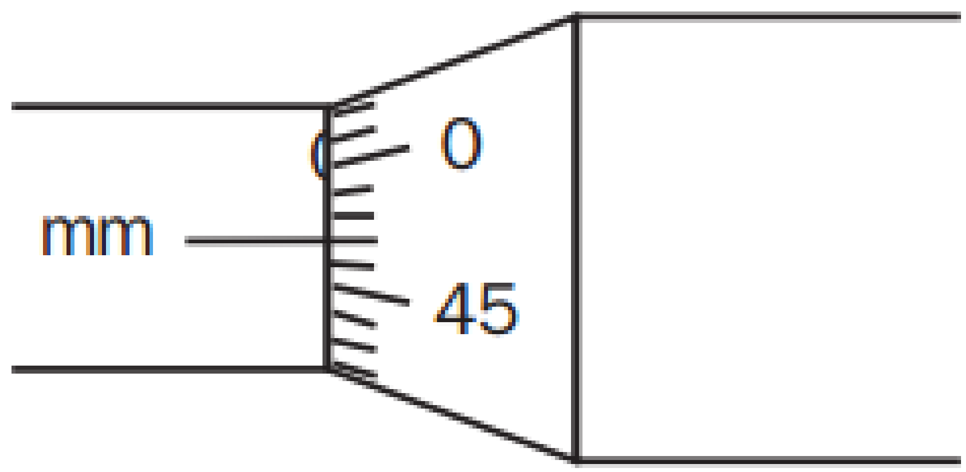
Zero Error (Positive)

- Datum line of the main scale is **higher** than the zero mark of the thimble scale.
- Measurements made are **greater than** the actual value by the value of the zero error.



Zero Error (Negative)

- Datum line of the main scale is **lower** than the zero mark of the thimble scale.
- Measurements made are **smaller than** the actual value by the value of the zero error.



Measuring Area

Exploring Diversity of Matter by Its Physical Properties

Area

- Area is the amount of space taken up by the surface of an object.
- SI unit: square metre (m^2)
  - $1\ m^2 = 100 \times 100\ cm^2$
  - $1\ cm^2 = 10 \times 10\ mm^2$
  - $1\ km^2 = 1000 \times 1000\ m^2$

Calculation Time!

Questions:

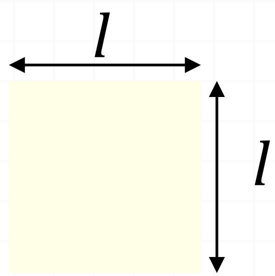
1) $100 \text{ m}^2 =$ ______cm^2
2) $5 \text{ cm}^2 =$ ______mm^2
3) $0.6 \text{ km}^2 =$ ______m^2
4) $80 \text{ cm}^2 =$ ______ m^2
5) $4000 \text{ mm}^2 =$ ___cm^2

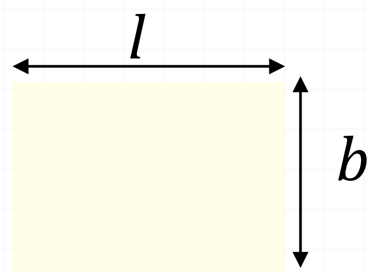
Answers:

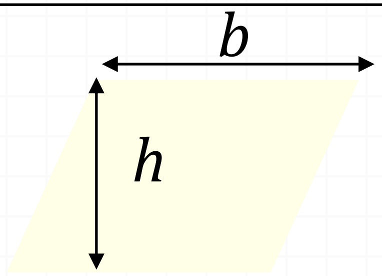
1) $1{,}000{,}000 \text{ cm}^2$
2) 500 mm^2
3) $600{,}000 \text{ m}^2$
4) 0.008 m^2
5) 40 cm^2

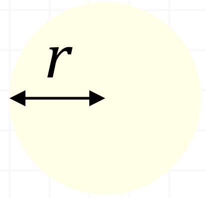
Areas of regular surfaces

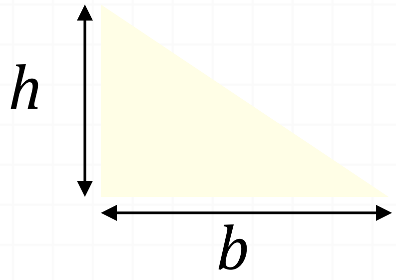
- Calculate from formulae.

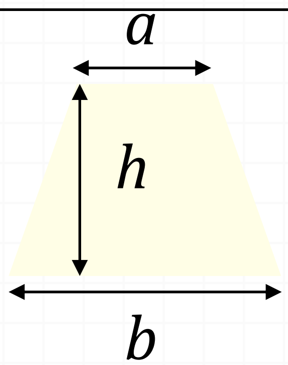
<table>
<tr><th>Square</th><th>Rectangle</th><th>Parallelogram</th></tr>
<tr>
<td>

$A = l \times l$</td>
<td>

$A = l \times b$</td>
<td>

$A = b \times h$</td>
</tr>
<tr><th>Circle</th><th>Triangle</th><th>Trapezium</th></tr>
<tr>
<td>

$A = \pi r^2$</td>
<td>

$A = ½b \times h$</td>
<td>

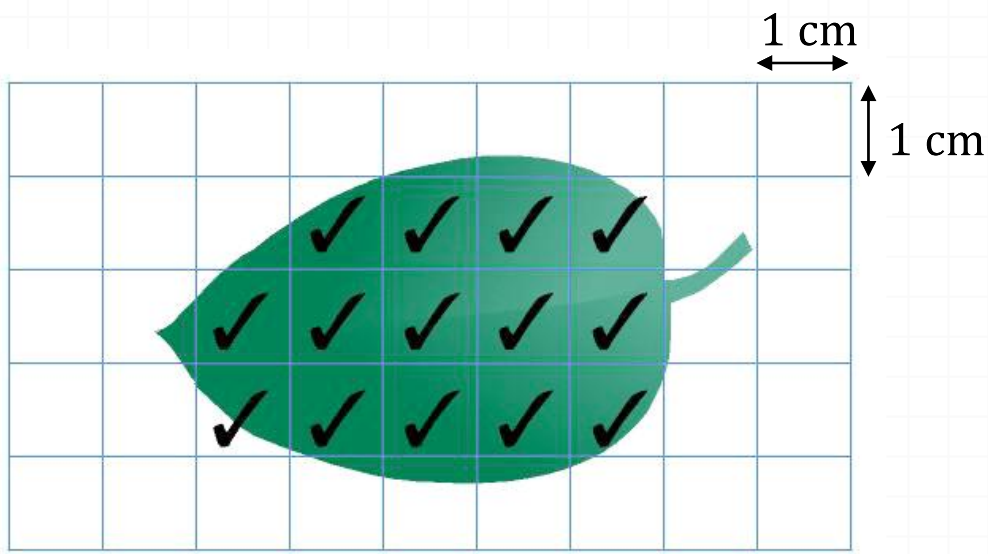
$A = ½(a+b) \times h$</td>
</tr>
</table>

Areas of Irregular Surfaces

- The areas of irregular surfaces can be estimated by first dividing them into **squares** and **counting** them.
- An incomplete square is counted as one if its area is **more than or equal to half** of the area of a unit square.
- If the areas of the incomplete square are **less than half**, then they are not counted.

Areas of Irregular Surfaces

Example:



Total number of squares ≈ **14**

Area of one square = 1 cm x 1 cm = 1 cm^2

Area of the irregular object ≈ 14 x 1 cm^2

≈ **14 cm^2**

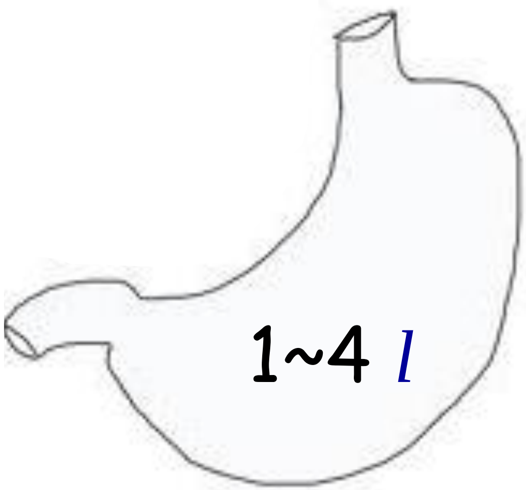
Measuring Volume

Exploring Diversity of Matter by Its Physical Properties

Volume

- Volume is the **amount of space a substance occupies.**
- SI unit: **cubic metre (m^3)**
  - **$1\ m^3 = 100 \times 100 \times 100\ cm^3$**
  - **1 *l* = 1000 m*l***
  - **1 m*l* = $1\ cm^3$**

335m*l*



Calculation Time!

Questions:

1) $10\ m^3 = \_\_\_\_\_\_ cm^3$

2) $7\ l = \_\_\_\_\_\_\ ml$

3) $2000\ ml = \_\_\_\_\_\_ cm^3$

4) $90{,}000\ cm^3 = \_\_\_ m^3$

Answers:

1) $10{,}000{,}000\ cm^3$

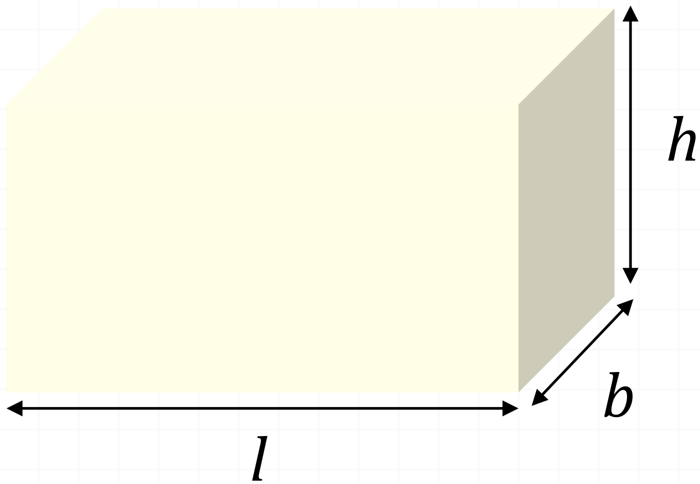
2) $7000\ ml$

3) $2000\ cm^3$

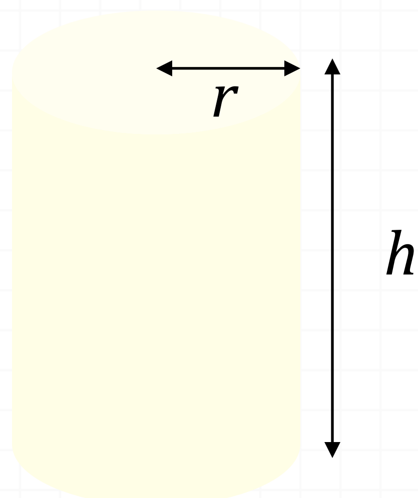
4) $0.09\ m^3$

Volume of Regular Solids

- Calculate from formulae.



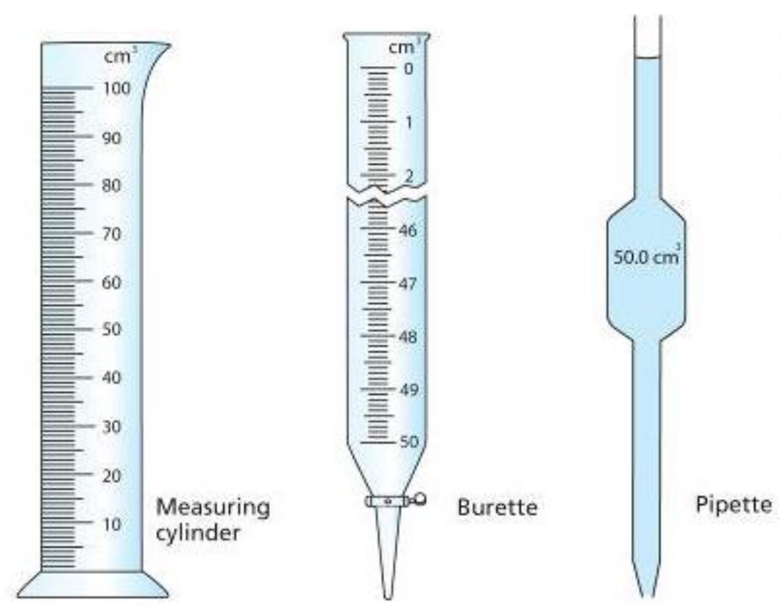
Cuboid: V = *l* x *b* x *h*



Cylinder: V = $\pi r^2 h$

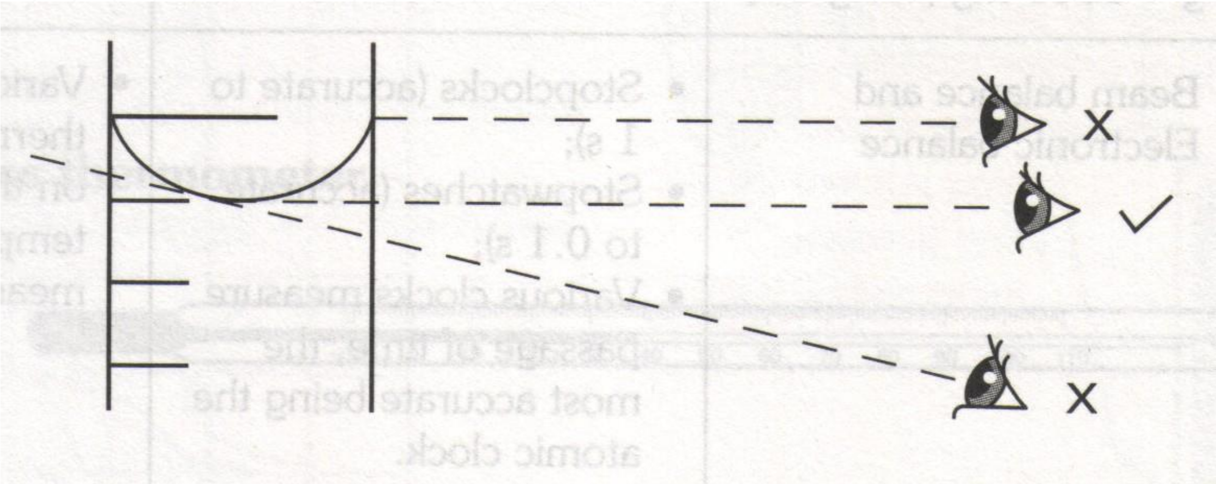
Volume of Liquids

- Instruments commonly used in the laboratory for measuring volumes of liquids include:
  - **Measuring cylinder**
  - **Burette**
  - **Pipette**
  - **Volumetric flask**



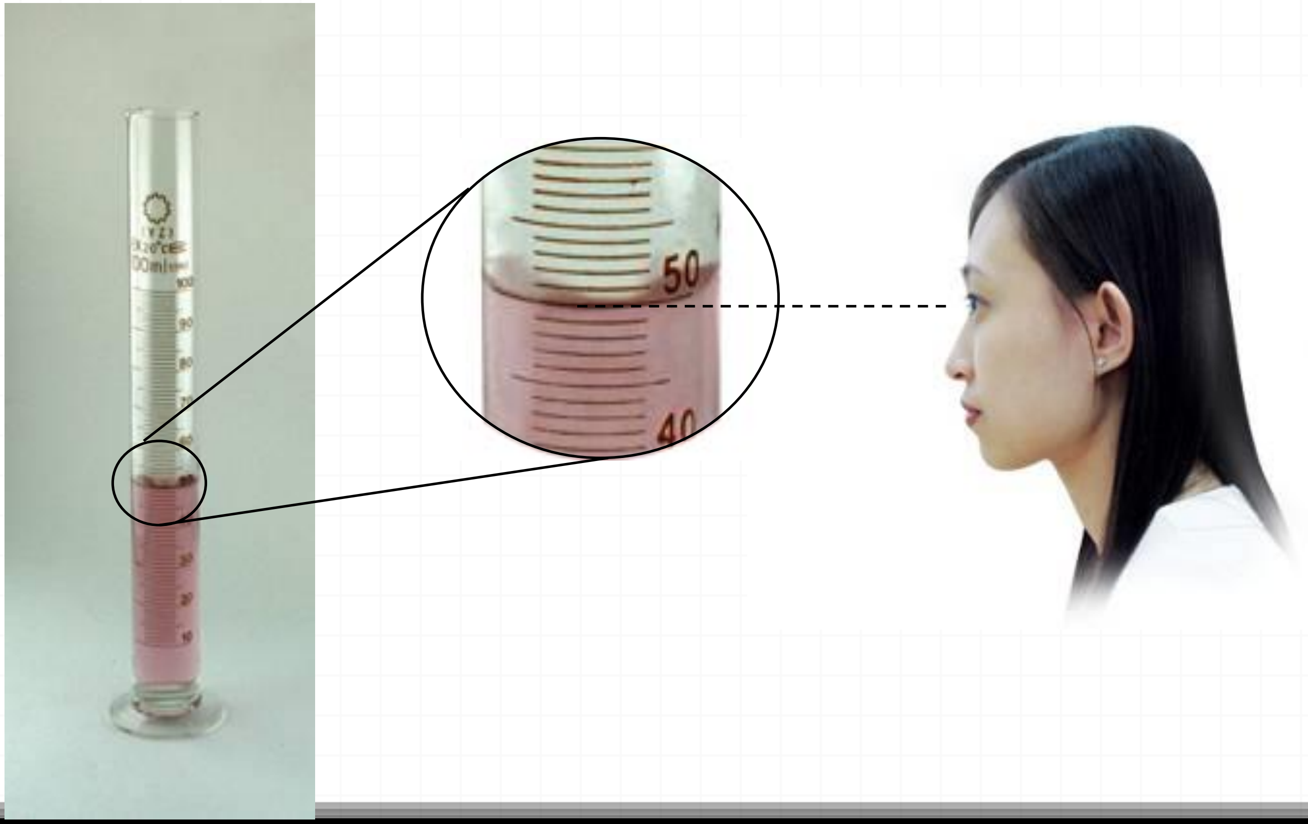
Meniscus Reading

- Note that the liquid in the measuring cylinder curves downwards as shown in the diagram below. This is known as the **meniscus**.
- The meniscus of most liquids curves downwards.



Meniscus Reading

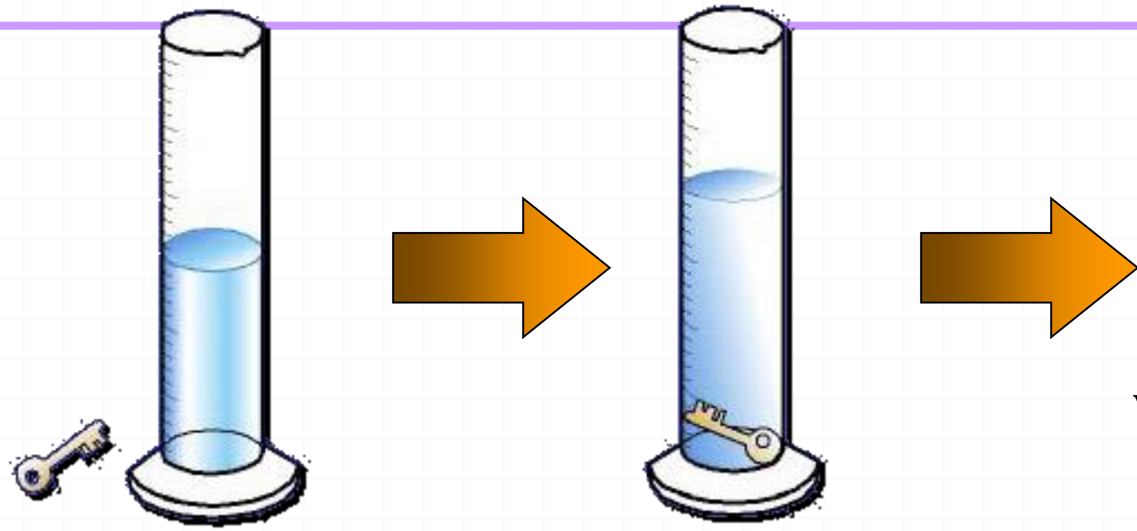
- The correct way to read the meniscus is to position the eye at the same level as the meniscus and take reading at the bottom of **the meniscus**.



Volume of Small Irregular Solids

For finding volumes of small irregular solids, place the object in a measuring cylinder containing water.

Volume of Water Displaced by Object = Volume of Object



volume of object
= $80 - 60\ cm^3$
= $20\ cm^3$

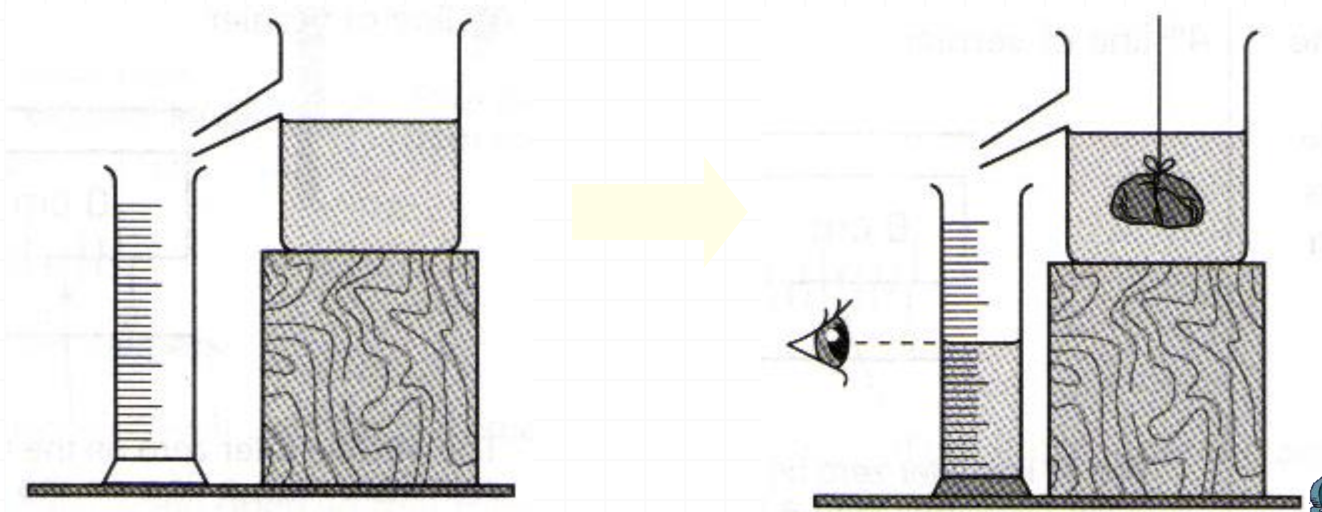
volume of water
= $60\ cm^3$

volume of water + object = $80\ cm^3$

Volume of Small Irregular Solids

For finding volumes of large irregular solids, place the object in a displacement or Eureka can. Then use a measuring cylinder to collect the displaced water.

Volume of Water Displaced by Object = Volume of Object



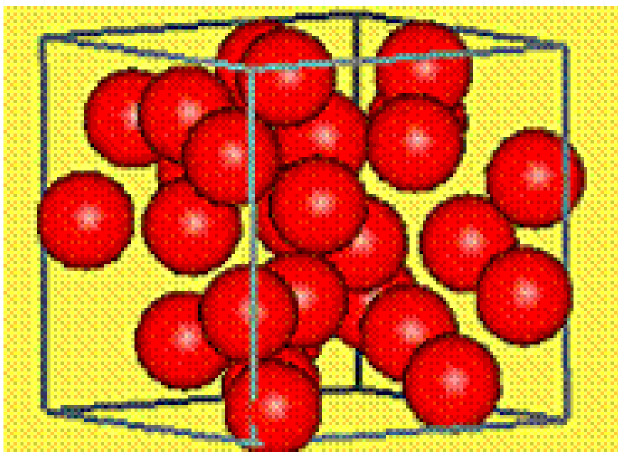
Animation

Density

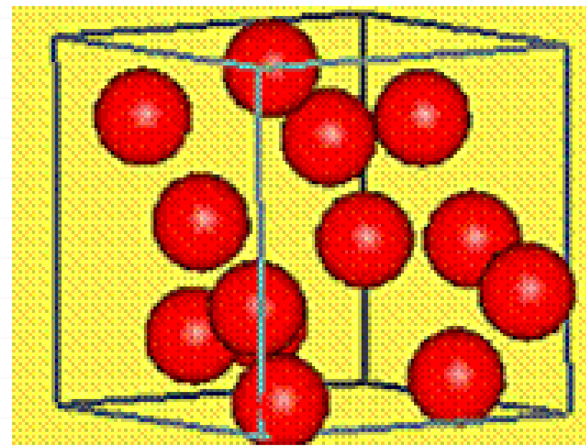
Exploring Diversity of Matter by Its Physical Properties

Density

Take a look at the two boxes below. Each box has the same volume.



Box A



Box B

If each ball has the same mass, which box would weigh more? Why?

Density

The box that has more balls has more **mass per unit of volume**. This property of matter is called density.

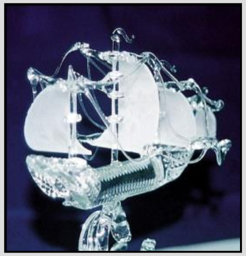
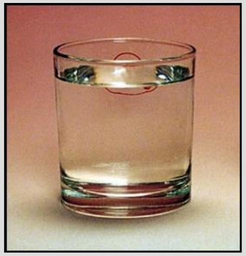
Density

- It is the **mass of the substance in a unit volume.**
- SI unit: kilogram per cubic metre (kg/m^3)
- Other units: g/cm^3
- Formula:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Density

Densities of gases are very low compared with those of solids and liquids.

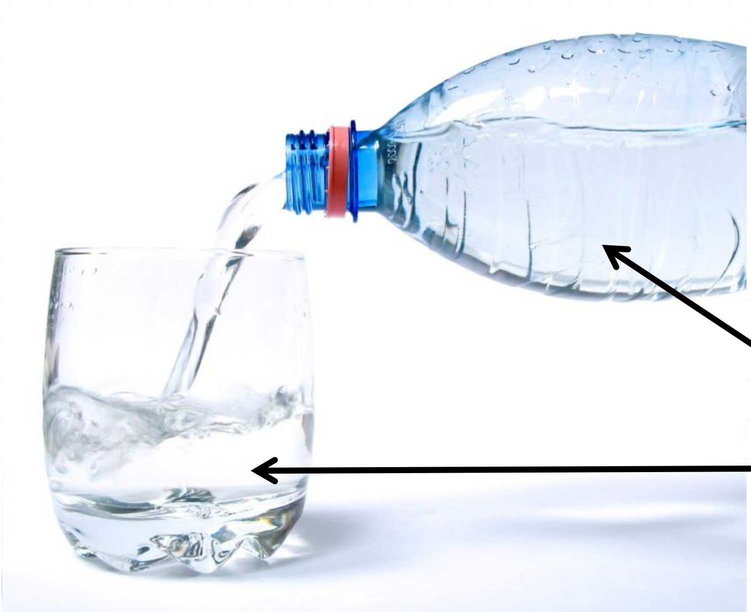
Substance	 gold	 glass	 mercury
Density	19.3 g/cm^3	2.5 g/cm^3	13.6 g/cm^3
Substance	 water	 cork	 air
Density	1.0 g/cm^3	0.25 g/cm^3	0.0013 g/cm^3

Density

All pieces of the same substances have the same density regardless of size and shape.

The density of a substance helps to distinguish it from other substances.

Mercury



Water in both the bottle and the glass have the same density.

Example

The mass of a stone is 180 g. Its volume is 50 cm^3. What is the density of the stone in g/cm^3?

Solution:

Density of the stone = Mass ÷ Volume

= 180 g ÷ 50 cm^3

= 3.60 g/cm^3

Test Yourself!!!

Osmium, the densest metal found, has a density of 22.6 g/cm^3. The mass of a block of osmium was found to be 113 g. Find its volume.

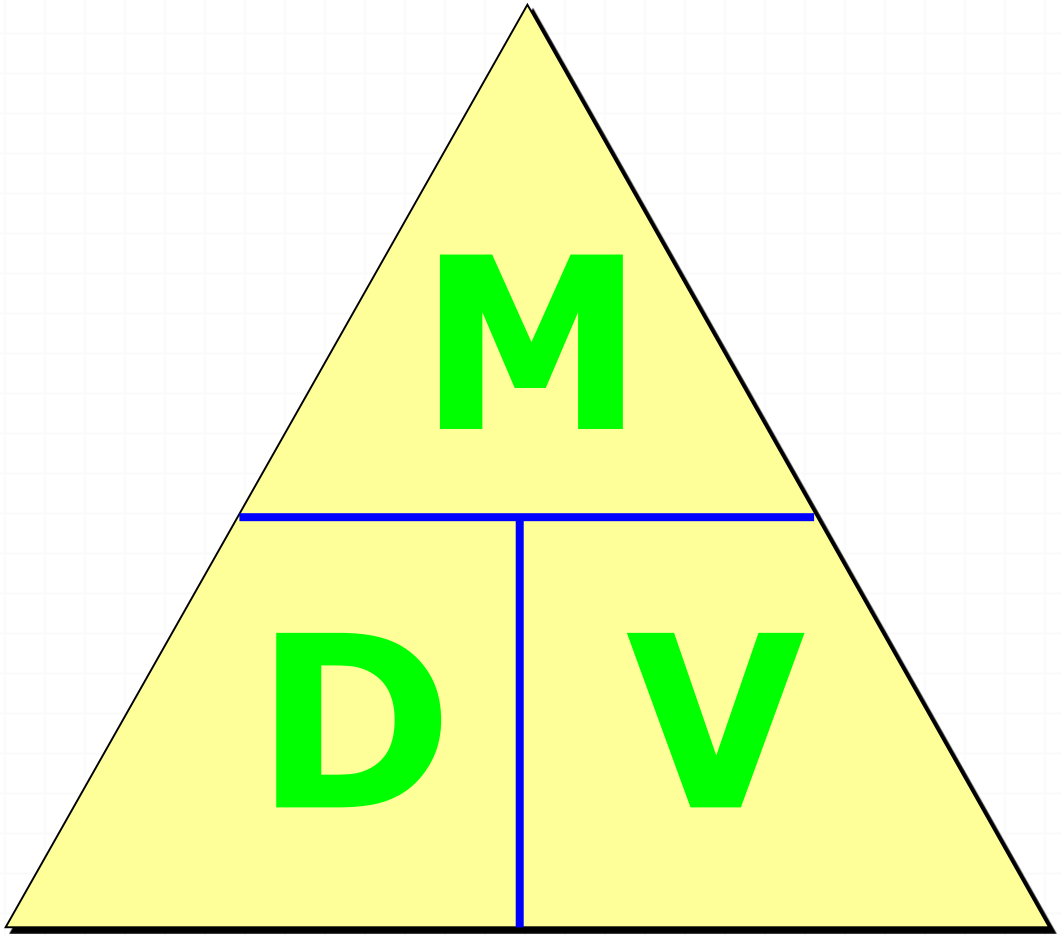
Solution:

Volume = Mass ÷ Density

= 113 g ÷ 22.6 g/cm3

= 5 cm^3

Density Equation



Measuring Density

Density of a substance can be found in 2 steps:

1) **Measure the mass and volume of the substance.**
2) **Divide the mass by its volume.**

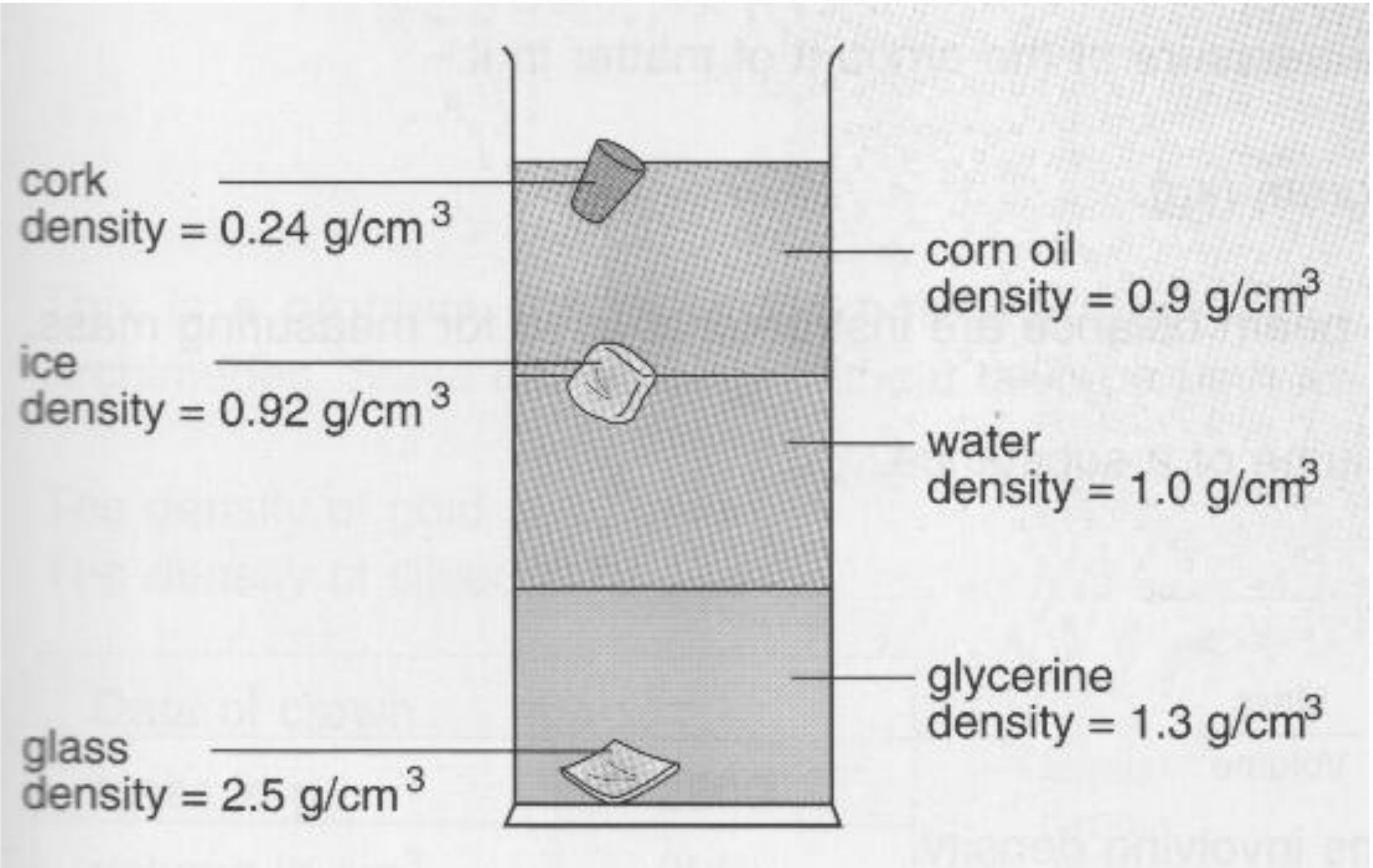
Density Floating Lab 101

http://www.sciencejoywagon.com/explrsci/media/density.htm

Floating and Sinking

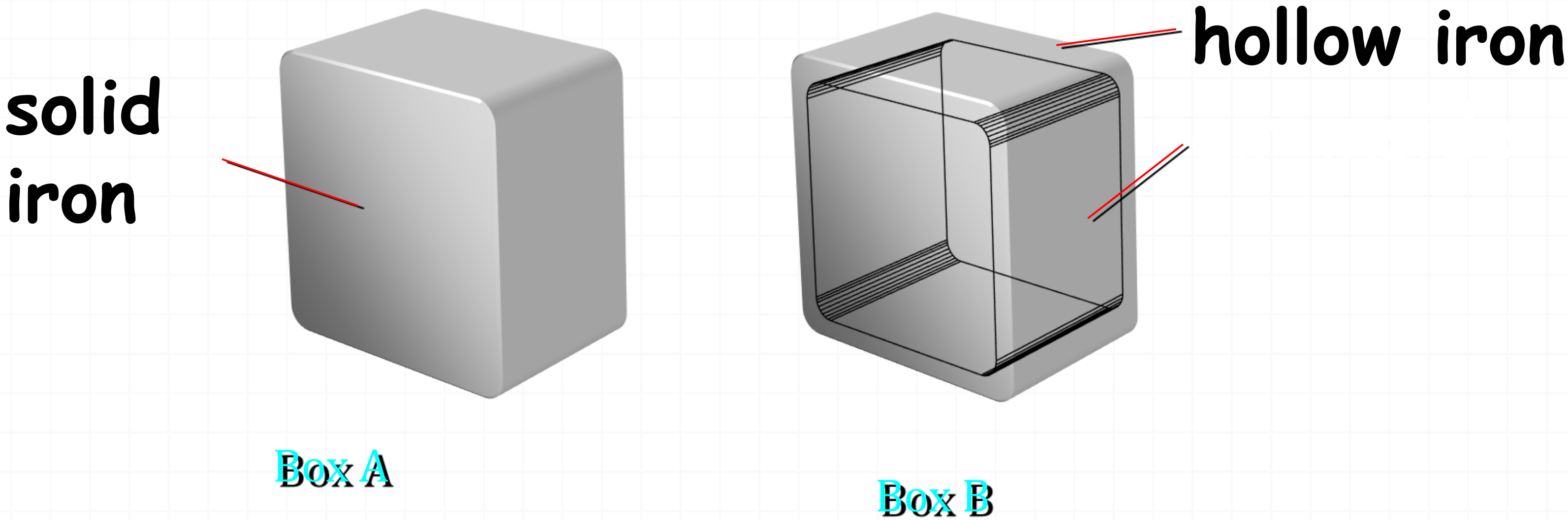
- The ability of an object to float or sink in a liquid depends on its **density**.
- Less dense substances **float** in denser liquids.
- Denser substances **sink** in less dense liquids.

Floating and Sinking



Why do Iron Ship Float

Iron is denser than water.



Why do Iron Ship Float?

Box A contains solid iron and therefore has a higher density. It sinks.

Box B is hollow and contains iron and a large volume of air. Therefore overall density is less than box A. It floats.