

# LESSON 1: MEASUREMENT PHYSICS

## Lesson objectives

At the end of the lesson, I will be able to:

Measurement of physical quantities is an essential part of physics.

For measurement to make sense we require a system of units. If I walk into the room and say 20, you'll all think I've lost it. The number 20 simply means figure 20 until a unit is tagged on to it e.g. 20kg. Now we know we mean **mass**. What do mean by 1 metre or 1 kilogram? **Length** or **Mass**. How did we come up with what a metre or a kilogram is?

Well this is how...scientists from all over the world got together and decided on a standard. The Systeme Internationale or THE SI UNIT is a system of measurement that has been agreed on internationally. It defines 7 fundamental quantities and units.

### TAKING MEASUREMENTS

Without measurements, they'll be no Physics. So how do we take measurements? Although measurements cannot be perfectly accurate, we take certain steps to increase precision. We note the **Reading Accuracy** of the instrument and record the measurement in the **Correct Number of Significant Figure**. To increase accuracy of measurements, we take them multiple times and find the average value. Every instrument is calibrated or graduated using small lines. The smallest graduation i.e. the distance between two lines directly following each other is known as the Reading Accuracy. The reading accuracy is the smallest possible accurate measurement you can take using an instrument.

We record the result stating the precision or **Estimated Uncertainty**. Example: a measurement of  $5.07 \text{ g} \pm 0.02 \text{ g}$  means that the experimenter is confident that the actual value for the quantity being measured lies between 5.09 g and 5.05 g. 0.02 here is the uncertainty in the measurement. The uncertainty is the experimenter's best estimate of how far an experimental quantity might be from the "true value."

### Measuring Length

What instrument would you use to measure the length of your book? **Meter rule**. Other instruments for measuring length are callipers, vernier callipers and a micrometer screw guage.

How do we know when to use each instrument?

Every object that you want to measure must be larger than the reading accuracy of the instrument you are using.

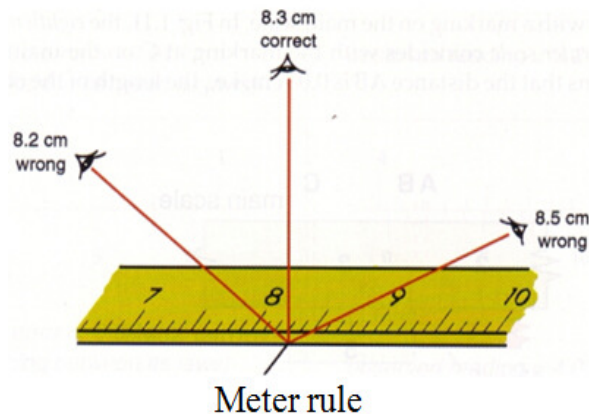
Other factors to consider are shape of the object to be measured. If an object is circular, a straight instrument wouldn't work very well. When using a metre rule, look vertically downwards at the markings to avoid parallax errors. Parallax error is the apparent displacement of an object caused by a change in the position from which it is viewed.

Instrument	Reading Accuracy	Uncertainty	What to measure
The Metre Rule	0.1 cm		Large distances e.g the length of a notebook, the length pf a field etc
Vernier Callipers	0.01 cm		Small lengths e.g the thickness of a metre rule, internal and external diameters of a tube, diameter of a rod etc
Micrometer Screw Guage	0.001 cm		Smaller lengths e.g the diameter of a wire, the diameter of a small ball etc

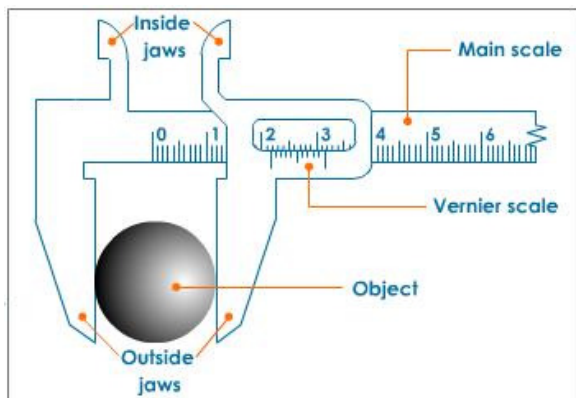
**Meter rule and Measuring Tape**

- A meter rule is used to measure medium lengths i.e. 0 to 1m. It has an accuracy of 0.1cm.
- A measuring tape is used to measure long lengths i.e. 0 to 100m . It has an accuracy of 0.1 cm

Reading both tape and rule is very simple and easy. Parallax error is the main type of error asked about in the exams. Parallax error is the error caused due to noting the reading from the side of the Tape or the Rule. The reading should always be taken by keeping your eye perpendicular and directly above the reading.

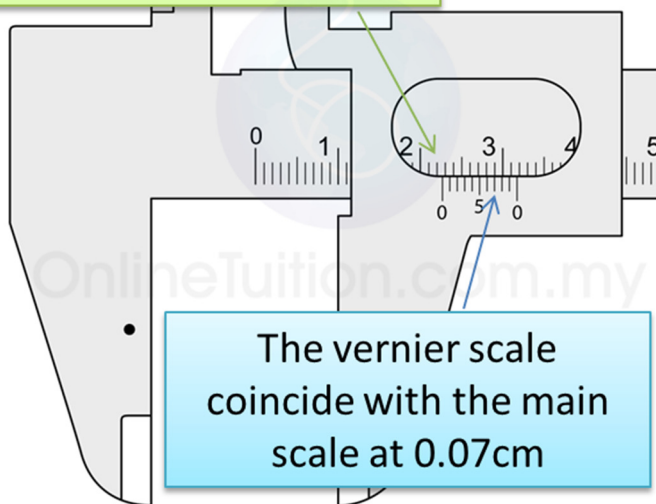


Vernier caliper is used to measure short lengths i.e. 0 to 15 cm. It is accurate to 0.01 cm. A pair of vernier calipers consists of a Main Scale and a Vernier Scale as shown in the diagram below.



Reading of main scale = 2.2cm  
 Reading of vernier scale = 0.07cm  
 Reading of the vernier caliper = 2.27cm

At zero mark, the reading of the main scale = 2.2cm

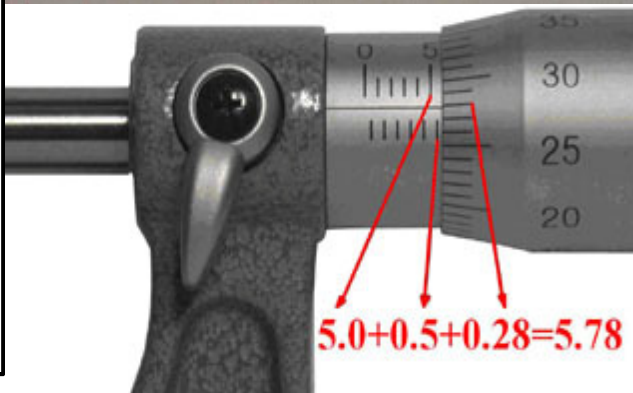
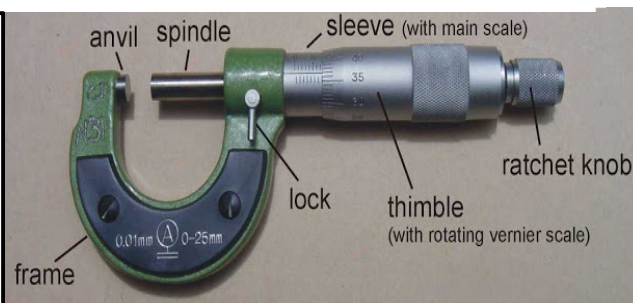


**Micrometer**

Micrometer is used to measure very short readings i.e. 0 to 2.5cm. it has an accuracy of 0.001cm or .01 mm. Micrometer has two scales, main scale (on the sleeve) and the circular scale (on the thimble ). Each division on the main scale represents 1 mm while each division on the thimble represents a distance of 0.01mm.

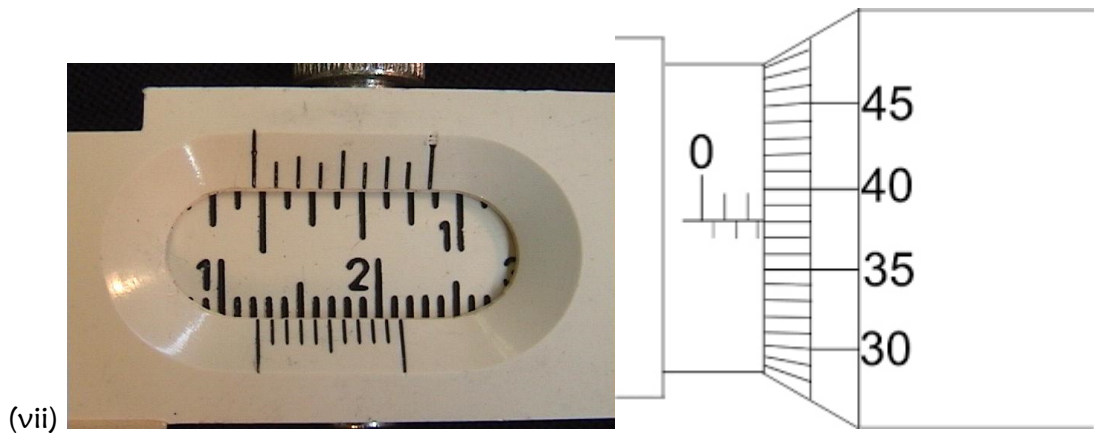
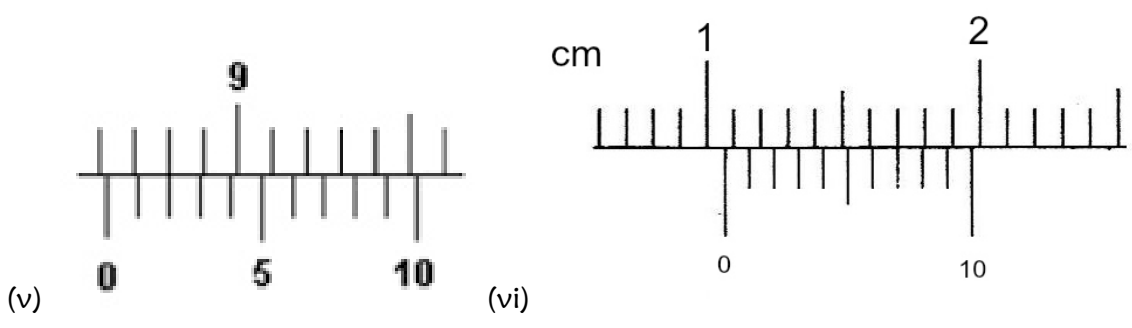
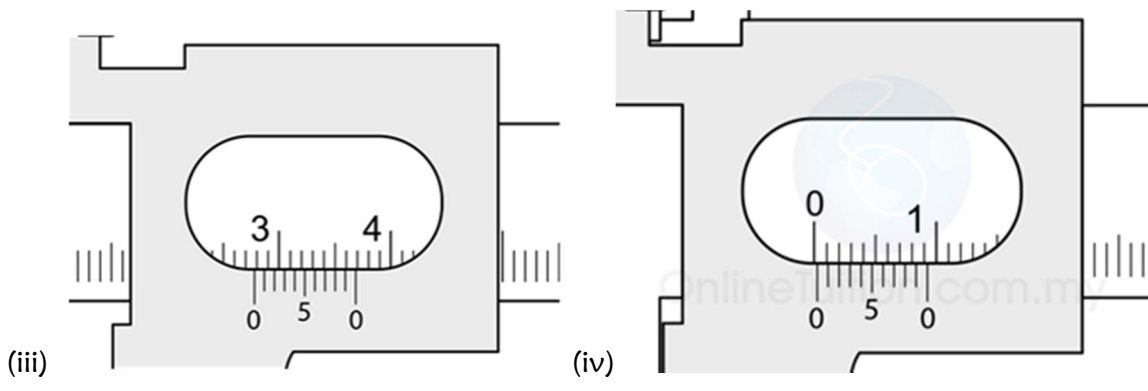
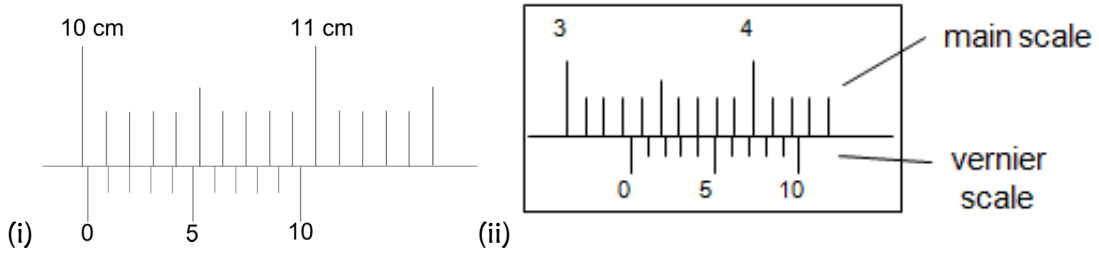
**How to take reading**

- Turn the thimble until the object is gripped gently.
- Read the main scale on the sleeve. This reading would be in millimeters. In the diagram below, the reading is 5.5mm
- Then read the line on the circular scale that coincides with the line on the main scale. In the diagram below, the 28th line on the circular scale coincides with the line. So, the reading would be 0.28mm.
- Then add 5.5 with 0.28 and you will obtain your answer in millimeters



Summary Exercise

1. What do you understand by the reading accuracy of a measuring instrument? \_\_\_\_\_
2. Write down the reading accuracies of the following: Micrometer Screw Gauge \_\_\_\_\_, Metre rule \_\_\_\_\_, vernier caliper \_\_\_\_\_.
3. What the reading on the following instruments;



# LESSON 2: MEASUREMENT PHYSICS

## Lesson objectives

At the end of the lesson, I will be able to:

### Measuring Volume

Volume measures how much space an object occupies. Sometimes you might hear questions like "what is the capacity of a box?" or "how much can the box hold?" You can assume that these questions will need a volume to be calculated. Units commonly used to measure the volume of objects include, litres(L), millilitres (mL), cubic metres (m<sup>3</sup>), cubic millimetres (mm<sup>3</sup>) and cubic centimetres(cm<sup>3</sup>).

### Measuring Volume

Volume to be measured	How to measure
Rectangular Block	Measure the length, breadth and height and multiply
Irregular Solid	Immerse completely in a measuring cylinder containing a liquid. The volume of the liquid displaced is the volume of solid
A sphere	Measure the diameter with a micrometer screw gauge and obtain the volume by volume = $(4/3)\pi(d/2)^3$
Cylindrical wire	We measure the length of the wire using a metre rule and the diameter of the wire at different points using a micrometer screw gauge. <b>Volume = <math>\pi r^2 l</math></b>

### Finding Volume of a regular Solid

Object	Length	Width	Height	Diameter	Volume
Specimen A					
Specimen B					
Specimen C					

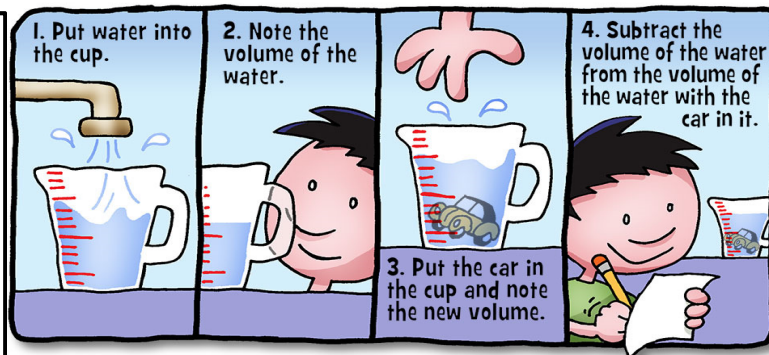
### Finding Volume of an irregular Solid

Find the volume of Specimen D

Initial volume of water: \_\_\_\_\_

Final volume of water with object: \_\_\_\_\_

Difference in volume: \_\_\_\_\_



### Measuring Mass and Weight

Mass is the amount of matter contained in a body. Mass is measured in kilograms.

Weight is the force of gravity pulling you towards the earth's centre. Mass is measured with a beam or chemical balance or lever balance and weight is measured with a spring balance.

The reading accuracy of the beam balance is 0.001g and uses the principle of moments. The spring balance uses Hooke's law.

**Measuring Time**

Time is a dimension in which events can be ordered from the past through the present to the future. Time has various units some of which are the solar day, hours, minutes, seconds etc. Time is measured with stop watches and clocks. The accuracy of a stop watch is 0.1 seconds.

*Google the history of Time Measurement. List 2 sites you visited*

*What is Sidereal Time?*

**Class Activity**

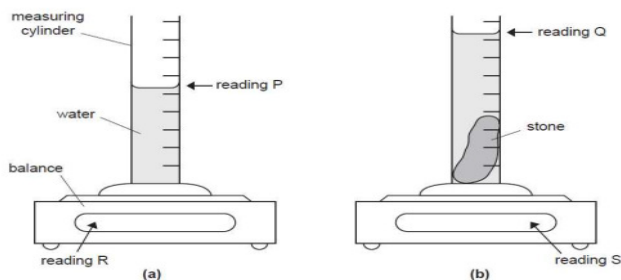
You are provided with the following specimens; Candy, Pringle, chocolate and gala. Measure the thickness, length and mass of the specimens using the instruments given to you. Also time yourself using stop watch. This is the interesting part of it, if you get the measurement correctly they are all yours.

Specimen	Length	Thickness	Mass	Time
Candy				
Pringle				
Chocolate				

**Summary Exercise**

Fig. 3.1(a) shows a measuring cylinder, containing some water, on a balance.

Fig. 3.1(b) shows the same arrangement with a stone added to the water.



(1) Which two readings should be subtracted to give the volume of the stone?

reading \_\_\_\_\_ and reading \_\_\_\_\_

(2) Which two readings should be subtracted to give the mass of the stone?

reading \_\_\_\_\_ and reading \_\_\_\_\_

(3) In a certain experiment,

mass of stone = 57.5 g,

volume of stone = 25 cm<sup>3</sup>.

(4) Write down the equation linking density, mass and volume.

(5) Calculate the density of the stone.

density of stone = \_\_\_\_\_

## Measurements physics Prep Questions

Fill in the blanks

What are the reading accuracies of the following?

1. Micrometer Screw gauge \_\_\_\_\_
2. Stop Watch \_\_\_\_\_
3. Vernier Callipers \_\_\_\_\_
4. Metre rule \_\_\_\_\_

How many seconds are there in

5. 1 year \_\_\_\_\_
6. 2 days \_\_\_\_\_
7. Month of March \_\_\_\_\_
8. What instrument is used for measuring mass? \_\_\_\_\_
9. What instrument is used for measuring weight? \_\_\_\_\_

## Accelerated Questions

(1) Name the instruments that can be used to measure the following:

- (i) time
- (ii) weight of an object
- (iii) length
- (iv) mass of an object