DEPARTMENT OF EDUCATION

GRADE 11

PHYSICS

MODULE 1

MEASUREMENT

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GRADE 11

PHYSICS

MODULE 1

MEASUREMENT

IN THIS MODULE YOU WILL LEARN ABOUT:

11.1.1: QUANTITIES AND UNITS

11.1.2: DIMENSIONAL ANALYSIS

11.1.3: ERROR ANALYSIS

11.1.4: GRAPHS

Acknowledgement

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DIANA TEIT AKIS
Principal-FODE

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SECRETARY'S MESSAGE

Achieving a better future by individual students, their families, communities or the nation as a whole, depends on the kind of curriculum and the way it is delivered.

This course is part of the new Flexible, Open and Distance Education curriculum. The learning outcomes are student-centred and allows for them to be demonstrated and assessed.

It maintains the rationale, goals, aims and principles of the National Curriculum and identifies the knowledge, skills, attitudes and values that students should achieve.

This is a provision by Flexible, Open and Distance Education as an alternative pathway of formal education.

The Course promotes Papua New Guinea values and beliefs which are found in our constitution, Government policies and reports. It is developed in line with the National Education Plan (2005 – 2014) and addresses an increase in the number of school leavers affected by lack of access into secondary and higher educational institutions.

Flexible, Open and Distance Education is guided by the Department of Education's Mission which is fivefold;

- To develop and encourage an education system which satisfies the requirements of Papua New Guinea and its people
- To establish, preserve, and improve standards of education throughout Papua New Guinea
- To make the benefits of such education available as widely as possible to all of the people
- To make education accessible to the physically, mentally and socially handicapped as well as to those who are educationally disadvantaged

The College is enhanced to provide alternative and comparable path ways for students and adults to complete their education, through one system, two path ways and same learning outcomes.

It is our vision that Papua New Guineans harness all appropriate and affordable technologies to pursue this program.

I commend all those teachers, curriculum writers, university lecturers and many others who have contributed so much in developing this course.

UKE KOMBRA, PhD
Secretary for Education

MODULE 11.1 MEASUREMENT

Introduction

Measurements play a very important role in the investigation of physics. It is defined as the act of finding the size of physical quantity such as height, length, width, time, mass, volume, density, force, speed and acceleration and so on. We use measurement daily such as the food we eat, the clothes we wear, the work we do and the sports we play.

Values of an object are made by quantifying into specific units. Measurements act as labels which make those values more useful in terms of details. For example, instead of saying that someone is tall, we can specify its measurement and say that the individual is 2 metre tall.

Accurate measurement and observation is important to the development of any scientific investigation. The traditional way of measurement does not give an accurate value so scientists all over the world come up with a standard measurement we call it the International System of Units (SI).

In this unit we will discuss SI unit and its conversion. But how sure are we, that, what we measure is accurate? When we measure, there is some degree of error or uncertainty. A measurement is only an estimation of the true value. A factor that causes this error in measurement is also discussed in this unit.

You will also learn here how to measure length, mass, and time as an example of a physical quantity. Different physical quantities have different SI units. For example, the SI units of length are metres (m) time is seconds(s) and so on.

In many experiments, the aim is to find a relationship between two or more variables that are measured. Thus, dimensional analysis is covered in the module that will bring ideas to the student on how equations are built. Also relationship can be done by drawing a graph of the values of one variable against the values of another variable and then comparing the shape of the graph against known graphs in order to determine the form of the relationship is likewise discussed here.

Therefore, learning outcomes are covered in the study of the following topics: Fundamental and derived units, Using the SI system and changing from one unit to another, Scientific notation and significant figures, Dimensional analysis, and Graphing.

Learning Outcomes

After going through this module, you are expected to:

- recognize the four principles applied to the study of physics.
- appreciate the importance of measurement in describing quantities.
- define and explain measurement and quantity.
- name the seven quantities classified as basic or fundamental quantities.
- give the other quantities that can be derived from the basic quantities.
- identify the units and symbols of the basic and derived quantities.
- recognize the metric system as the system of measurement that is best suited to scientific purposes.
- identify the SI unit used for measuring the different quantities.
- convert one metric unit to another.
- define length and name some instruments used to measure it.
- identify some quantities that are derived from the units of length.
- interpret diagrams and read scales correctly.
- solve conversion problems.
- define mass and name instruments used to measure mass.
- recognize density as quantity derived from mass.
- briefly explain the reason why some objects float or sinks.
- define time and name some instruments used to measure time.
- define significant figures and scientific notation.
- use significant figures to indicate accuracy of a quantity.
- observe rules when adding, subtracting, multiplying and dividing significant figures.
- express quantities in standard form.
- write the order of magnitude of a number.
- define vector and scalar quantities.
- represent and draw vectors.
- use dimensional analysis to perform mathematical operations and obtain derives units.
- give examples of quantities and their dimensions.
- define and classify error in measurement.
- realize that errors occur and can be minimized.
- analyze errors by performing calculations.
- present data in a graphical form.
- differentiate independent and dependent variables.
- interpolate and extrapolate graphs.
- describe graphs of important relationship.
- mentally check measurements to see if they make sense.

Time Frame

Suggested allotment time: **8 weeks**

This module should be completed within 8 weeks.

If you set an average of 3 hours per day, you should be able to complete the module comfortably by the end of the assigned week.

Try to do all the learning activities and compare your answers with the ones provided at the end of the module. If you do not get a particular question right in the first attempt, you should not get discouraged but instead, go back and attempt it again. If you still do not get it right after several attempts then you should seek help from your friend or even your tutor.

DO NOT LEAVE ANY QUESTION UNANSWERED.

11.1.1 Quantities and Units

Quantity is a definite or indefinite amount of a specified magnitude or size. It is also related to how much there are of something that we can quantify known as physical quantity. A physical quantity is measured by defining its units of measurement or using a measuring instrument.

Many investigations in physics will involve taking measurements of quantities and calculating some results. For measurement and calculations to be meaningful, units must be introduced. A quantity without units is of no use to anyone. Measurement involves two parts: the numerical value representing the size and the units of that measurement.

Investigations in physics typically involve four important principles:

- **Experimentation**
  To test whether a hypothesis will agree with actual experiences, experiments must be performed. Scientists often perform many experiments to test the reliability of their hypothesis. They may have to repeat and sometimes modify experiments until they are convinced that their proposed hypothesis is correct.

- **Observation**
  We observe things and events every day, and we base our actions on these observation. We become skilled at associating different observations, and using our past observations to predict future events. For example, when crossing the road we observe the position of cars, trucks, and so on. We estimate their speed, and then judge whether it is safe to cross the road.

- **Description**
  Shows the result of how the experiment and the data is processed.

- **Measuring**
  The measurement of any observable event is made in terms of units of some agreed standard. The unit of length maybe feet, inches, metres, centimetres or millimetres. For example, we can talk of the length of a pencil as being 0.33 feet, 4.0 inches, or 10.0 centimetres long. To specify length as 10.0 without giving the units is confusing and meaningless.

Fundamental and Derived Units

A physical quantity is anything that can be measured and are expressed in terms of a numerical value or magnitude and a unit. Examples are area and the unit is square metre (m^2), and speed which is expressed in a unit metre per second (m/s).

Non-physical quantities (qualitative) such as love, hate, fear and hope cannot be measured. Each of the quantities used by scientists and non-scientists alike is measured in a particular unit.

The table below lists the seven base units of the SI system.

Base quantity	Name of unit	Symbol for unit
length	metre	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
Temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

Table 1 Seven base (or fundamental) units of the SI system.

Some symbols given above are written in capital letter because it represents the surname of the scientists who discovered the unit.

Using the base units, it is possible to derive a system of units which can be used to measure other quantities. **Derived quantities** are formed from basic quantities. **Derived units** are made by a combination of two or more of the fundamental units. A simple example is the unit of area, the square metre (m^2).

Other examples are given in the table below.

Derived quantity	Unit	Symbol
Area	square meter	m^2
Volume	cubic meter	m^3
Frequency	Hertz	Hz
Density	kilogram per cubic metre	kg/m^3
Force	Newton	N
Work, energy	Joule	J
Power	Watt	W
Velocity (speed)	metre per second	m/s

Table 2 Some SI Derived Units

Some derived quantities have been given specific names, such as Newton, Watt and Joule. This combination of basic unit can be replaced by the Newton (N), Joule (J), and Watts (W).
1 Newton = 1 kilograms metre per second squared ($1N = 1kgms^{-2}$), 1 Joule = 1 Newton metre (1J= 1Nm), 1 Watt = 1 Joule per second (1W=1J/s).

International System of Units

An internationally agreed system of units is necessary to standardize measurement of these quantities, and such a system is now in general use. In 1960 the international authority on units agreed to adopt the Systeme Internationale d'Unites, or the International System of Units. The abbreviation of which is SI in all languages. The SI is a set of metric units. It is a decimal system in which units are divided or multiplied by 10 to give smaller or larger units.

Examples

1. It would be difficult to give the length of a rugby field in millimetres. The length of the rugby field is 100 000mm which is equivalent to 100m. Giving it in a more appropriate unit that is metres, would give people a far better idea of the actual length of the field.

2. It would be equally inappropriate to give the thickness of a human hair in kilometres. The thickness of a human hair is 0.000 000 1km which is equal to 1 millimetre giving it in a more appropriate unit that is millimetres, would give people a far better idea of the actual thickness of the hair.

Parts of words like kilo- and milli- that are used above are called **prefixes**. In science, we use prefixes like these to represent multiples or sub-multiples of a more basic unit. The table below is presented for easy understanding.

Prefix	Value	Symbol
mega	1 000 000 x 10^{6}	M
kilo	1 000 x 10^{3}	k
hecto	1 00 x 10^{2}	h
centi	0.01 x 10^{-2}	c
milli	0.001 x 10^{-3}	m
micro	0.000001 x 10^{-6}	µ
nano	0.000000001 x 10^{-9}	n

Table 3 Unit of multiple and submultiple for conversion.

Examples of using prefixes with units:

Kilo- means 1000 times of a meter
Therefore 1 kilometre is 1000 times a metre
Milli- means a one thousandth of a metre
Therefore 1 millimetre is 0.001 metre

Significant Figures and Scientific Notation

Significant figures (sig. figs) are those digits in a number or measurement that are not being used and considered as place-values. Zeroes are not significant if they are used only to indicate the position of the decimal point. For example, if the length of a computer desk, as measured by a ruler graduated in millimetres, was found to be 1564.3mm, the measurement has five significant figures.

Here are the Rules for Significant Figures which will help you to understand them better.

a. All non-zero figures are significant: 25.4 has three significant figures.
b. All zeros between non-zeros are significant: 30.08 has four significant figures.
c. Zeros to the right of a non-zero figure but to the left of the decimal point are not significant (unless specified with a bar): 109 000 has three significant figures.
d. Zeros to the right of a decimal point but to the left of a non-zero figure are not significant: 0.050, only the last zero is significant; the first zero merely calls attention to the decimal point.
e. Zeros to the right of the decimal point and following a non-zero figure are significant: 304.50 have five significant figures.

Two significant figure	Three significant figure	Four significant figure
21000	3250000	42210000
0.0012	469	1786
1.0	0.00843	508.6
0.18	0.234	0.6780
67	65.0	5.060

Table 4 Significant figures position

When performing calculations we must consider the significant figures. When adding, subtracting, multiplying or dividing numbers, the answer should contain only as many significant figures as the number involved in the operation that has the least number of significant figures.

For example

1) 264.68 – 2.4711 = 262.2089 = 262.21. In this operation, the least number of significant figures in the operation is five so the final answer must have five significant figures.

2) 2.345 x 3.56 = 8.3482= 8.35. The final answer has three significant figures because the least number of significant figures in the operation is three that is 3.56.

3) The following values are part of a set of experimental data: 618.5 cm and 1450.6mm. Write the sum of these values correct to the right number of significant figures.

Solution
First, we need to convert 1450.6mm to centimetres.
Take note that you cannot add the two values if they are of different units, so you have to convert. Remember your previous topic on conversion that is, 1cm= 10mm. So to convert smaller to a bigger value, we divide 1450.6/10 = 145.06cm. Now that they are of the same unit, you can now add them.

618.5cm + 145.06cm = 763.56cm

The least number of significant figures in the original values is 4, so write the answer to this significance. The sum is written as 763.6cm.

Now check what you have just learnt by trying out the learning activity below!

Learning Activity 1

20 minutes

Answer the given problem below. Show all your working out where necessary.

1. Give the number of significant figures in each of the following numbers:

   (a) 4.02 ______________________________
   (b) 0.008 ______________________________
   (c) 8600 ______________________________
   (d) 1049 ______________________________
   (e) 0.0002 ______________________________
   (f) 52.07 ______________________________
   (g) 0.60 ______________________________

---

2. The following values are part of a set of experimental data: 34.7cm and 19.65mm. How many significant figures would be present in the sum of these two figures?

---

3. Given that the definition of area is Area= length x width, determine the basic or fundamental unit form of the unit of the area.

Thank you for completing learning activity 1. Now check your work. Answers are at the end of the module.

What is scientific notation?

Scientific notation or standard index notation is a way of writing any number between 1 and 10 multiplied by an appropriate power of 10 notations. It is a shorthand method of writing numbers that are very large or very small.

Let us take for example 1 and 2

1. The distance from the earth to the nearest star is about 39 900 000 000 000 000m.
   In scientific notation it is written as 3.99×10^{16}m. The exponent tells you how many times to multiply by 10.

2. The mass of hydrogen atom is 0.000 000 000 000 000 000 000 000 001 7 kilograms.
   In scientific notation it is written as 1.7×10^{-27}kg. In this case, the exponent tells you how many times to divide by 10.

Scientific notation involves writing the number in the form $M \times 10^{n}$, where M is a number between 1 and 10 but not 10, and n is an integer.

NOTE: Integer is a positive and negative whole number.

Given below are examples on how to change numbers into scientific notation:

1. 24 700
   To change this number into scientific notation, first put the decimal point to the right of the last digit.

   Now count how many numbers to move the decimal point to a position where the number is now between 1 and 10. You had to move the decimal point 4 places to the left. The result is 2, 4700.

   Now write the number in scientific notation as: 2.47×10^{4}, where m = 2.47
   N = 4 shows that the decimal point was moved 4 places to the left.

2. 0.0032
   To change this number into scientific notation, from where the decimal point is, count how many numbers you are to move the decimal point to a position where the number is now between 1 and 10;
   You have to move the decimal point three places to the right, as 3 and 2 are in between 1 to 10.

   Now write the number in scientific notation as 3.2×10^{-3}.
   The -3 shows that the decimal points have to move three places to the right.

3. Write the following numbers in scientific notation.
   (a) $3270 = 3.27 \times 10^{3}$
   (b) $0.128 = 1.28 \times 10^{-1}$
   (c) $654\ 000 = 6.54 \times 10^{5}$

NOTE: In general if the number is greater than one, the sign of the index is positive. And if the number is less than one, the sign of the index is negative.

Now check what you have just learnt by trying out the learning activity below!

Learning Activity 2

30 minutes

Read and answer each question. All working out must be shown where necessary.

1. Convert the following numbers into scientific notation:

(a) 27 000 000 = ____________________

(b) 0.000 007 12 = ____________________

(c) 821 = ____________________

(d) 0.000 101 = ____________________

(e) 81 250 000 000 = ____________________

(f) 0.000 000 002 05 = ____________________

2. Change the following numbers into normal notation:

(a) 5.80×10^{6} = ____________________

(b) 6.32×10^{-5} = ____________________

(c) 8.56×10^{4} = ____________________

(d) 2.52×10^{-3} = ____________________

(e) 2.30×10^{10} = ____________________

(f) 6.10×10^{-11} = ____________________

3. Rewrite 2800 in scientific notation having 2 significant figures to be consistent with uncertainty 2800 ± 10.

4. Write the standard form.

(a) Speed of light in a vacuum = 298 000 000km/s ____________________

(b) One light year = 10 000 000 000 000km ____________________

Thank you for completing learning activity 2. Now check your work. Answers are at the end of the module.

Converting from one unit to another
In science, it is important that the standard unit is used. You must be able to convert from one form of a unit to another.

Example:
Change 5m into centimetres.

You know that there are 100cm in a metre and, therefore, to change metres into centimetres you must multiply by 100 that is:

5m= 5 x 100cm = 500cm

Steps

1. First decide if you are converting from a bigger to a smaller unit or if you are converting from a smaller to a larger unit.

   Case I – Bigger to Smaller

   If you are converting from a bigger to a smaller unit (example mega to kilo), then you **multiply**.

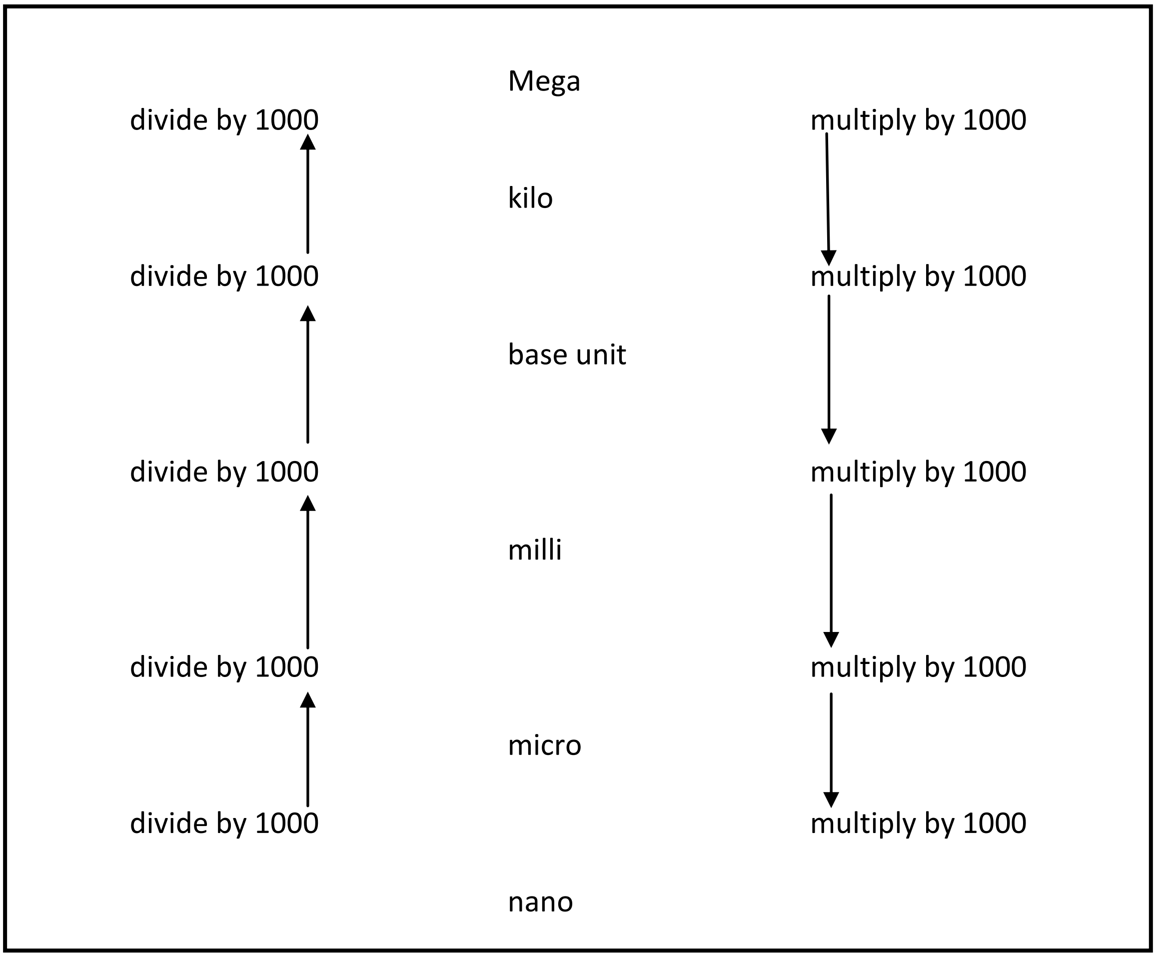
   Case II – Smaller to Bigger

   If you are converting from a smaller to a bigger unit (example micro to milli), then you **divide.**

2. Then find the factor that you are going to multiply or divide by to make the conversion. If you are moving one step up or down the chart, then the factor is 1000 (or 10^3). If you are moving two steps up or down the chart, then the factor is 1000 000 (or 10^6) etc.

3. Then multiply or divide your number by the appropriate factor.

Study the chart on the next page to help you convert units.



Example 1
Convert 6.8km to mm

Step 1
Decide if you are changing from a bigger unit to a smaller one. As kilo is above milli in the chart, you are going to change from a **bigger unit** to a **smaller unit** and therefore you **multiply**.

Step 2
You are going two (2) steps down the chart, therefore the factor is 1000x1000 = 1 000 000 or 10^6

Step 3
Multiply by 1 000 000
6.8km = 6.8 x 1 000 000mm
6.8km = 6800000 or 6.8 x 10^6mm

Example 2
Convert 5.8µA to A (µ is read as micro)

Step 1
You are changing from a smaller unit to a bigger unit and therefore you will divide.

Step 2
You are moving two steps in the table and therefore the factor is 1000 x 1000= 1 000 000.

Step 3
Divide by 1000 000
5.8µA = 5.8/1000 000 = 0.000005.8A

Now check what you have just learnt by trying out the learning activity below!

Learning Activity 3

20 minutes

Answer the following questions on the spaces provided.

1. Fill in the blanks with the correct words.

   a. All physical quantities consist of a __________ and __________.

   b. A __________ unit is made up of one or more SI units.

   c. We use __________ to indicate multiples of units.

---

2. Fill in the table below.

Base quantity	Name of base unit	Symbol quantities
Length		
Mass		
Time		
Electric current		
Temperature		
Luminous intensity	candela	Cd
Amount of substance	Mole	mol

3. Convert the following values to the indicated units

(a) 330mA = ___________ A

(b) 6.3km = ___________ m

(c) 2MJ = ___________ J

(d) 18mg = ___________ g

(e) 2000g = ___________ kg

(f) 18km = ___________ m

---

4. An electric current measures 2 milli-amperes. What is the current in kilo-amperes?

---

5. What is the equivalent of 0.0345mW when changed to MW?

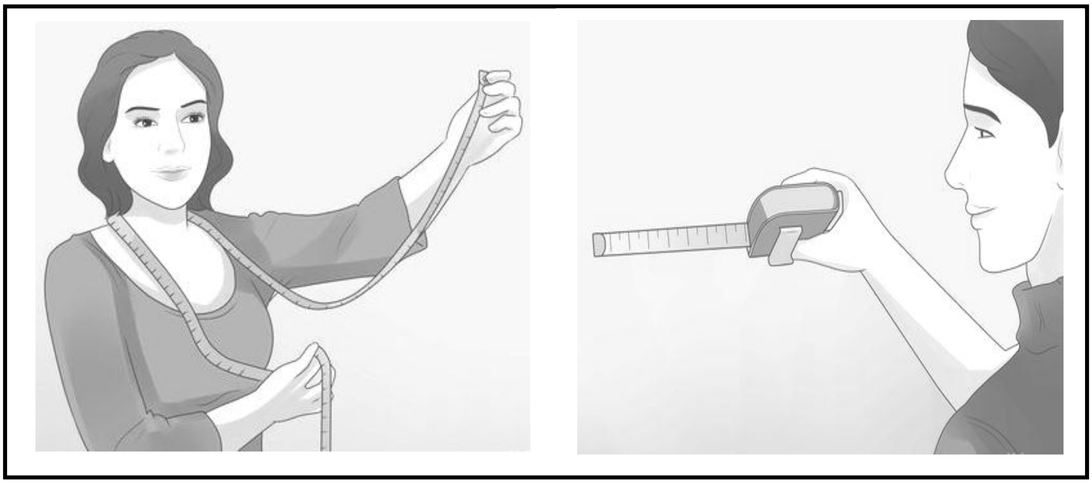
Thank you for completing learning activity 3. Now check your work. Answers are at the end of the module.

Measurement of Length

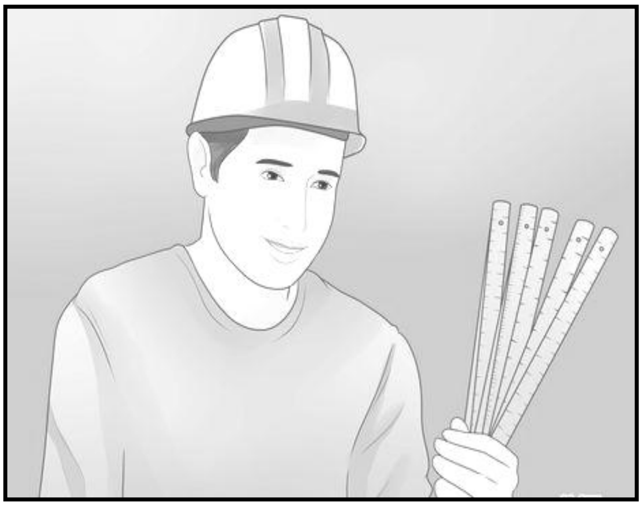
Length is simply defined as the measurement or extent of something from end to end.
The following are instruments used for measuring length.

1. A **ruler** is a measuring stick marked with units for measuring distance or to rule straight lines. These can be made of plastic, cardboard, metal or fabric.

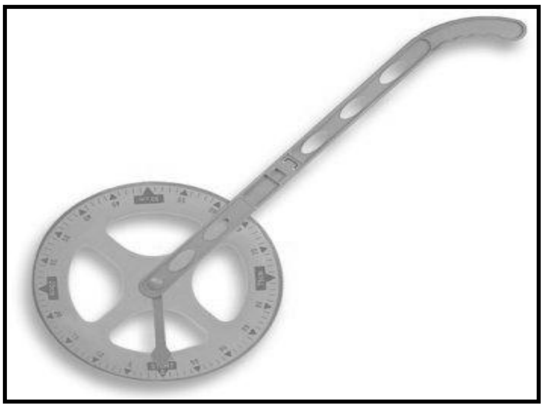
2. A **tape measure or measuring tape** is a flexible ruler made of flexible cloth or metal tape. It is marked with numbers representing inches or centimetres.



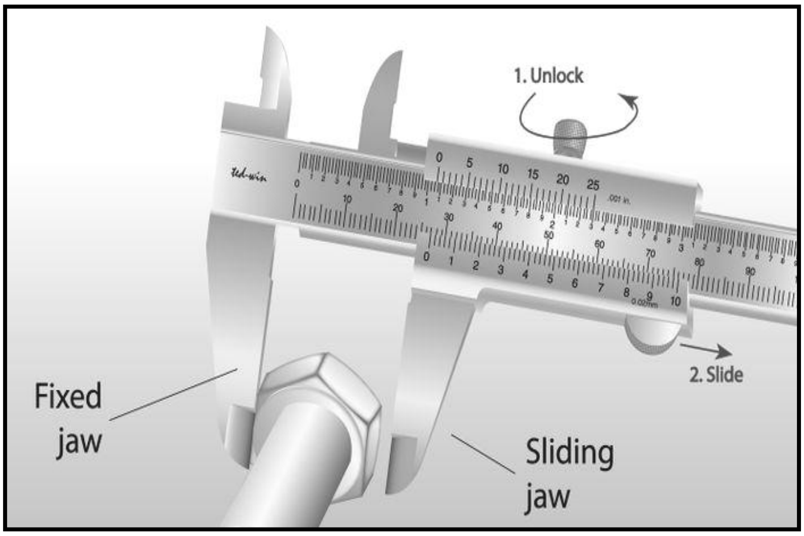
3. A **carpenter's ruler** is about 6 feet long and can be folded to fit into a tool pouch or pocket. Typically these rulers are made up of 8 inch segments. They are scaled in metric units where measurements are in foot and inches.



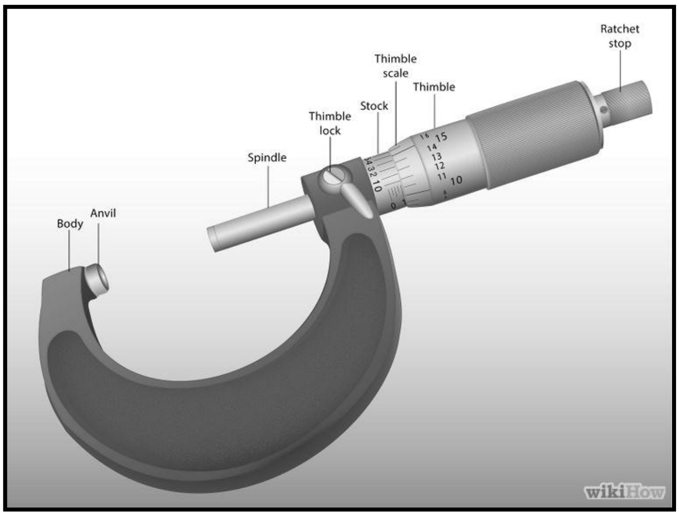
4. **Trundle wheel** is used to measure distance of great length.



5. Vernier caliper are used to measure length to an accuracy of 0.01cm



6. A micrometer is used to measure accurately small sizes.



In the metric system, the SI unit of length is the metre (**m**). For some purposes, the metre is a large unit and therefore it is converted into smaller units as follows:

1 metre (m) = 10 decimetres (dm)

= 100 centimetres (cm)

= 1000 millimetre (mm)

In dealing with large distances, the kilometre is used such that 1 kilometre (km) = 1000 metres (m). The conversion in the metric system is essentially a decimal system and it is easy to convert from one unit to another.

Worked Example

(a) Convert 38m into mm

1m = 1000mm
You will be converting from a bigger to smaller unit so you have to multiply by 1000
So 38m= (38 x 1000) mm = 38 000mm

(b) Convert 297mm into cm

In 1cm = 10mm
You will be converting from a smaller to a bigger unit so you divide by 10.
297mm = (297 ÷ 10) cm = 29.7cm

The instruments you use to measure length depends very much on how large or small the length or distance is.

For an accurate measurement, the eye must always be placed vertically above the mark being read.

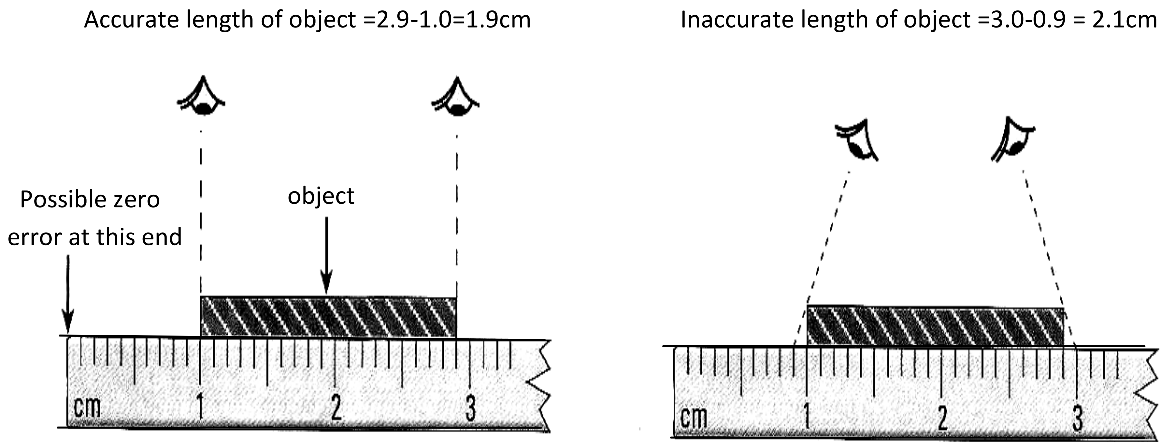


Figure 1.1 (a) accurate measurement with no parallax errors

Figure 1.1 (b) inaccurate measurements due to parallax errors

Figure 1 Measuring accurately with a ruler

Application of measurements

The skill of measuring lengths is the basis of finding other measurements such as the measurements of area and volume.

Measuring Area

The amount of space covered by a body in two dimensions is called area. The standard unit of area measurement is the square metre (m^2). Large areas use measurement in square kilometres (km^2) or hectares (ha), while smaller areas are usually measured in square centimeters (cm^2).

The following table shows the common units of area measurement.

Unit name	Symbol	Size (m^2)
Square centimetre	cm^2	10^{-4}
Square metre	m^2	1
hectare	ha	10^4
Square kilometre	km^2	10^6

Table 5 Common Units of Area Measurements

Example 1

The area of a square or rectangle in a formula, is **area = length x width**. The SI unit of area is the square metre (m^2) which is the area of a square with sides 1m long. Note that by conversion, $1cm^2$ is equal to $0.0001m^2$ as shown below.

$$1cm^2 = \frac{1}{100}m \text{ X } \frac{1}{100}m$$
$$= \frac{1}{1000}m^2$$
$$= 0.00010m^2$$

Sometimes we need to know the area of a triangle. It is given by:

Area of triangle $= \frac{1}{2}$ x base x height

For example as shown in the figure

Area ΔABC $= \frac{1}{2}$ x AB x AC

$= \frac{1}{2}$ x 4cm x 6cm

$= 12cm^2$

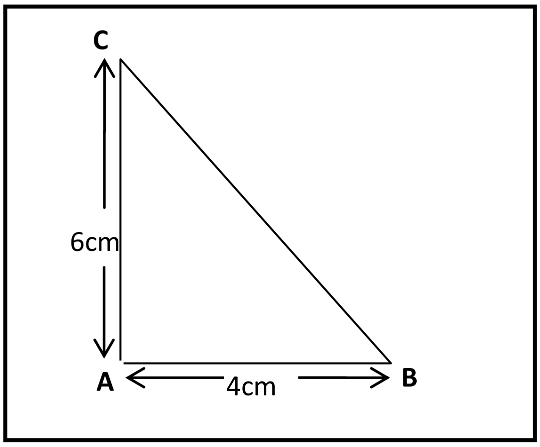


Figure 2 Triangle ABC

Order of magnitude

The order of magnitude of a number is the value of the number rounded to the nearest power of ten (no significant figures). It is used if you need to give only an indication of how large or small a number is, and only the power of ten is given. It also indicates that the accuracy of the measurement is limited.

For example

1) The velocity of light is 3.0 x 10^8 metres per second. The order of magnitude of this velocity is 10^8.

2) The order of magnitude of 142 is 10^2. Since 142 in scientific notation you count going to the left it becomes 1.42 x 10^2.

3) 1 0 0 0 0 = 1.0 x 10^4 order of magnitude would be given as 10^4

4) The average distance between two atoms is 1.6 x 10^{-10}m. The order of magnitude for is 10^{-10}m.

Now check what you have just learnt by trying out the learning activity below!

Learning Activity 4 **20 minutes**

Answer the following questions on the spaces provided. Show all your working out.

1. What is the order of magnitude for each of the following numbers?

   (i) 195 000 ____________________

   (ii) 0.00282 ____________________

   (iii) 650 ____________________

   (iv) 170 million ____________________

---

2. Estimate the order of magnitude of the answer for each of the following calculations.

   (i) 60 x (32 x 10^6) ______________ (ii) $\frac{800000}{400}$ ______________

Thank you for completing learning activity 4. Now check your work. Answers are at the end of the module.

Measurement of Mass

Mass is the amount of matter in an object. It is measured in units called grams (g), kilograms (kg) and tonnes (t). There are 1000 grams in a kilogram and 1000 kilograms in a tonne. Objects with a very small mass are measured in milligrams (mg) or grams (g). Heavier objects are weighed using kilograms or tonnes. See table below.

Mass	Equivalent	Conversion to smaller	Conversion to bigger
1 gram (g)	=1000 milligrams (mg)	X 1000 to get mg	
1 kilograms (kg)	=1000 grams (g)		÷ 1000 to get kg
1 tonnes	=1000 kilograms (kg)	X 1000 kg to get t	

Table 6 Mass of equivalent

Example

(a) Change 220g to kg

Solution

You will be converting a smaller unit to a bigger unit so you divide.
So in 1kg there are 1000g.

Therefore, $220\text{g} = \frac{1\text{kg}}{1000\text{g}}$

$= \frac{220\cancel{\text{g}}}{1} \times \frac{1\text{kg}}{1000\cancel{\text{g}}}$ cancel the unit **g** what is left is **kg**

$= \frac{220}{1} \times \frac{1\text{kg}}{1000}$

$= \frac{220\text{kg}}{1000}$

$= 0.22\text{kg}$

(b) Change 52kg into g

Solution

You will be converting a bigger to smaller unit so you multiply.
In every 1kg there are 1000g

Therefore, $52\text{kg} = \frac{1\text{kg}}{1000\text{g}}$

$= \frac{52\cancel{\text{kg}}}{1} \times \frac{1000\text{g}}{1\cancel{\text{kg}}}$ cancel **kg** what is left is the unit **g**

$= \frac{52}{1} \times \frac{1000\text{g}}{1}$ what is left is the unit **g**

$= 52\ 000\text{g}$

Instruments used to measure mass are called balances or scales.

Figure 4 Balance Scale

Figure 5 Analogue scale

Weight (W) is a property of mass. It is a force of gravity which pulls a mass to the center of the earth**.** In a region of gravitational field, this is proportional to the mass. Weight is calculated using the formula:

Weight = mass x force of gravity
= mg
(On earth g = 9.8N/kg or 10N/kg)

Example
What is the weight of a boy whose mass is 65kg? (Use g= 10N/kg)

Solution:

Given m = 65kg and g = 10N/kg

Therefore, W = mg

$$= \frac{65\cancel{kg}}{1} \times \frac{10N}{1\cancel{kg}}$$ cancel the unit **kg**

W = 650N

Weight varies with location, but mass is always the same.

The gravitational field strength of Earth is 9.8m/s^2 or 9.8N/kg or 10N/kg. Hence, the weight of 20kg rice bag is

$$= \frac{20\cancel{kg}}{1} \times \frac{10N}{1\cancel{kg}}$$

= 200N

The gravitational field strength on moon is 1.6N/kg. Hence the weight of 20kg rice bag will be

$$= \frac{20\cancel{kg}}{1} \times \frac{1.6N}{1\cancel{kg}}$$

$$= 32N$$

A 20kg bag of rice here on Earth, whose gravitational pull is greater than the moon will be difficult to carry, but if you are going to carry that same amount of 20kg bag of rice on the moon, it would be lighter. The mass will not change but the weight will change due to the moon's gravity being less than that of the Earth.

Mass	weight
-is a measure of the amount of matter in an object	-is related to the gravitational force on an object
-can be measured by comparing with standard masses	- can be measured by measuring forces
-is the same in all places	-varies from place to place
-is measured in kilograms in the SI system	-is measured in newton
-is a scalar quantity	-is a vector quantity

Table 7 Comparison of mass and weight

Density (in symbol ρ)
The density of a material tells us how much of the material (that is its mass) is packed into a unit volume.

The approximate densities of some common substances are given in Table below.

Solids	Density (g/cm^3)	Liquids	Density (g/cm^3)	Gases	kg/m^3
aluminium	2.7	paraffin	0.80	air	1.3
copper	8.9	petrol	0.80	hydrogen	0.09
Iron	7.9	pure water	1.0	carbon dioxide	2.0
gold	19.3	mercury	13.6		
glass	2.5				
wood	0.80				
ice	0.92				
polythene	0.90				

Table 8 Densities of some common substances

Density is defined as the ratio of mass (m) over volume (v). The unit is measured in kg per cubic metre and is calculated from the formula:

$$\text{Density} = \frac{\text{mass}}{\text{volume}} \quad \text{that is } \rho = \frac{m}{V}$$

where **ρ** is density in kg/m^3, **m** is mass in kg and **V** is volume in m^3

Example 1

An aluminium cube has a mass of 22kg and a volume of 8.1m^3. Calculate its density.

$$\begin{aligned}\text{Density (aluminium)} &= \frac{\text{mass}}{\text{volume}}\\ &= \frac{22\text{kg}}{8.1\text{m}^3}\\ &= 2.71\text{kg/m}^3\end{aligned}$$

Example 2

A lead cube has a mass of 90g and a volume of 8.0cm^3. Calculate its density in kg/m^3.

$$\begin{aligned}\text{Density (lead) } \rho &= \frac{\text{mass}}{\text{volume}}\\ &= \frac{90\text{g}}{8\text{cm}^3}\\ &= 11.25\text{g/cm}^3 \quad \text{(convert to kg/m}^3\text{) x 1000}\\ &= \frac{11.25\cancel{\text{g}}}{1\cancel{\text{cm}^3}} \times \frac{1\text{kg}}{1\cancel{000}\cancel{\text{g}}} \times \frac{1\,000\,\cancel{000}\cancel{\text{cm}^3}}{1\text{m}^3} \quad \text{(Cancel g, cm}^3\text{ and 000)}\\ &= \frac{11.25}{1} \times \frac{1\text{kg}}{1} \times \frac{1000}{1\text{m}^3}\\ &= 11\,250\text{kg/m}^3\end{aligned}$$

If volume and density are given and the mass is unknown, rearranging the formula gives

$$\mathbf{m = V \times \rho}$$

Example 3

The density of copper is 9g/cm^3, find the mass if it has a volume of 5cm^3.

Data: Given ρ = 9 g/cm^3,
V = 5cm^3

Solution

$$\begin{aligned}m &= V \times \rho\\ &= \frac{5\cancel{\text{cm}^3}}{1} \times \frac{9\text{g}}{1\cancel{\text{cm}^3}} \quad \text{(cancel the unit cm}^3\text{ what is left is grams}\\ &= 5 \times 9\text{g}\\ &= 45\text{g}\end{aligned}$$

If volume and density are given and the mass is unknown, rearranging the formula gives:

$$\mathbf{V = \frac{m}{\rho}}$$

Example 4
The density of copper is 9g/cm^3, find the volume if the mass is 63g.

Data: ρ= 9 g/cm^3, m= 63g

Solution:
$$V = \frac{m}{\rho}$$
$$= \frac{63\cancel{g}}{9\cancel{g}} \times \frac{cm^3}{1}$$ (cancel unit g and what is left is cm^3, which is the unit for volume)
$$= 7cm^3$$

The SI unit of density (ρ) is the kilogram per cubic metre (kg m^{-3} or g cm^{-3}). Thus converting 1g/m^3 to kg/m^3.

Change 1gcm^{-3} to kgm^{-3}	**Change 1kgm^{-3} to gcm^{-3}**
$\frac{1\cancel{g}}{1c\cancel{m^3}} \times \frac{1kg}{1\cancel{000g}} \times \frac{1\,000\,\cancel{000cm^3}}{1m^3}$	$\frac{1\cancel{kg}}{1\cancel{m^3}} \times \frac{1\cancel{000g}}{1\cancel{kg}} \times \frac{1\cancel{m^3}}{1\,000\,\cancel{000}cm^3}$
$= \frac{1}{1} \times \frac{1kg}{1} \times \frac{1000}{1m^3}$	$= \frac{1}{1} \times \frac{1g}{1} \times \frac{1}{1000cm^3}$
$= \frac{1000kg}{1m^3}$	$= \frac{1g}{1000cm^3}$
$= 1000kg/m^3$ or $1000kgm^{-3}$	$= 0.001g/cm^3$ or $0.001gcm^{-3}$
$= 1 \times 10^3 kg/m^3$ or $1 \times 10^3 kgm^{-3}$	$= 1 \times 10^{-3} g/cm^3$ or $1 \times 10^{-3} gcm^{-3}$

Density of regularly shaped solid
To get the density of a regularly shaped object, first get the mass of a regular object by using a balance. And to get the volume, measure its dimensions (length, width, thickness) with a ruler.

Density of irregularly shaped solid
The density of irregularly shaped solid is calculated in the same way. The mass of a solid is found on a balance. Its volume is measured by a method known as water displacement method. The diagrams below illustrate the water displacement method.

Figure 6 Mass of irregular solid on a balance

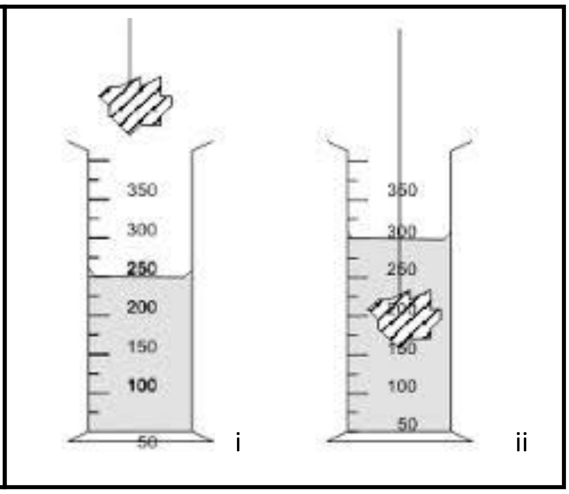
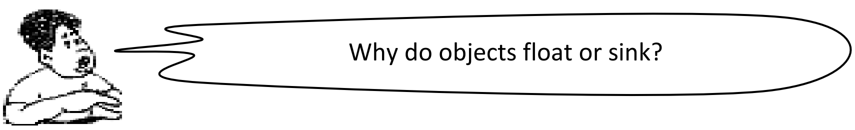


Figure 7 Water displacement is read and compared, the difference is the volume

Density of irregular shaped liquid
The mass of an empty beaker has to be measured first using a balance. A known volume of the liquid is transferred from a burette or a measuring cylinder into the beaker. The mass of the beaker plus liquid is found and the mass of liquid is obtained by subtraction.

Density of air
The density of air can be found by measuring the mass and the volume of the air. Using a balance the mass reading is taken. The air is then removed from the flask using a vacuum pump, and a second mass reading is taken. Subtract the two masses and the difference gives the mass of the air which was on the flask. The volume of the air is found by filling the flask with water and pouring it into the measuring cylinder. Having the mass and the volume you can now calculate the density of air.



Density explains why some things are lighter and some are heavy. Whether an object will float or sink in a fluid depends on its density. Substances that float in water have lower densities than water. Similarly, substances that sink in water have higher densities than water.

Why does a steel ship float whereas an iron ball sinks?

When an object like a cruise liner is made up of more than one material, we will have to consider its average density. Average density of an object is calculated by dividing its total mass by its total density.

For example

A cruise liner has a mass of 76 800 tonnes. It also occupies a large volume 268m long, 32m wide and 25m high. This high volume is not entirely made up of steel, it contains a considerable amount of air in the various rooms and cabins.

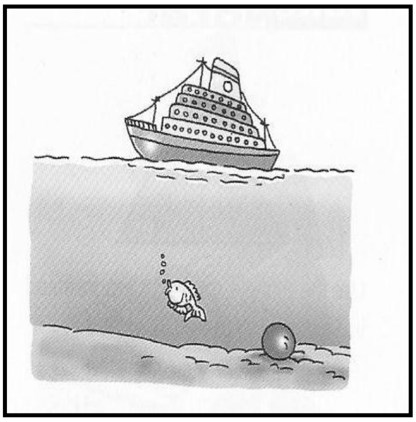


Figure 8 Ship float due to lesser density than saltwater

Its volume is 268 x 32 x 25= 214 400m^3. Its mass is 76 800 tonnes = 768 000 x 1000kg. (Convert tonnes to kg 1 tonne = 1000kg)

Average density = mass/ volume
= 76 800 x 1000 ÷ 214 400
= 358kgm^{-3}

The average density of the ship is actually less than the average density of saltwater which is 1025kg m^{-3}.

Volume of regular solids

The quantity of space an object takes up is called its volume. It is defined as the amount of space occupied by something that may be a solid or liquid. The standard unit of volume measurement is in cubic metres (m^3). The cubic meter is rather a large unit of volume for everyday laboratory work, and it is often more convenient to measure volumes using the cubic centimetre (cm^3). 1cm^3 is the volume of a cube with sides 1cm long.

$$1\text{cm}^3 = \frac{1}{100}\text{m X} \frac{1}{100}\text{m X} \frac{1}{100}\text{m}$$
$$= \frac{1}{1\ 000\ 000}\text{m}^3$$
$$= 0.0000010\text{m}$$

For a regularly shaped object such as a square or a rectangular block,

Volume = length x width x height or

Volume = area x height

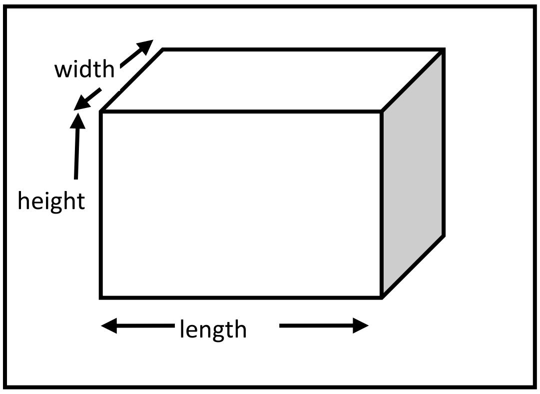


Figure 9 Rectangular block

Volume of irregular solids

For small object that sinks in water, the volume of the object is given by $V = V_2 - V_1$

Where

V_1 = volume of water before immersing the object, and

V_2 = volume reading after immersing the object.

As shown in figure below.

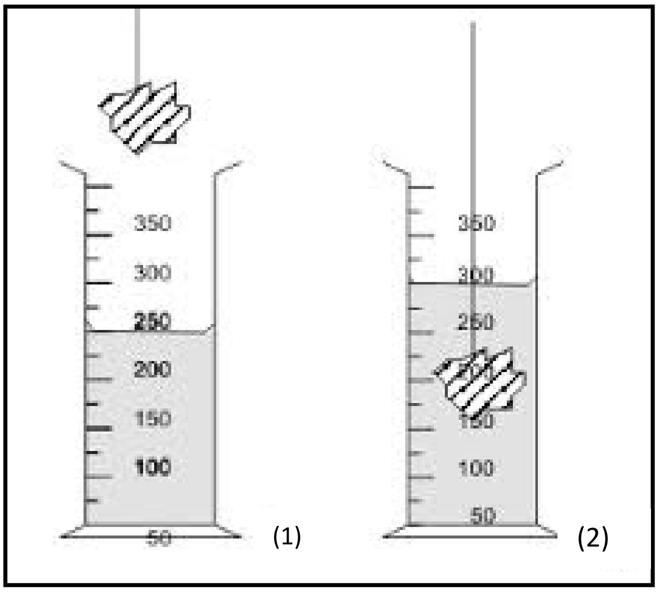


Figure 10 Finding volume of irregular solids

Note: Ensure that your eyes are level with the bottom of the curved liquid surface meniscus before reading V_1 or V_2 in cm^3.

In the diagram on the left the reading of the water before immersing the object is 250, after immersing the object the reading became 300.

From the formula in the previous page,

$$V = V_2 - V_1$$
$$= 300 - 250$$
$$= 50$$

so the volume of the irregular solid is $50cm^3$.

Volume of liquids

The volume of liquid may be obtained by pouring it into a measuring cylinder. A known volume can be read accurately. When making a reading, be upright and your eye must be level with the bottom of the curved liquid surface, that is, the meniscus.

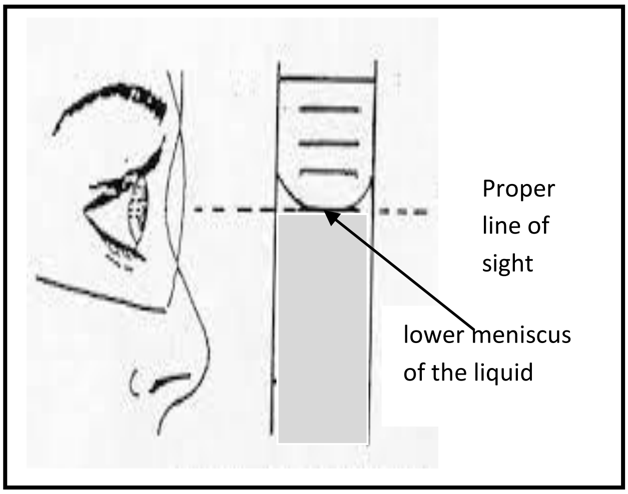


Figure 11 Reading curved liquid surface

Liquid volumes are expressed in litres (l). A litre is defined as $1000cm^3$ or $1 \times 10^{-3}m$.
Thus, 1ml = $1cm^3$.

1 litre (L) = 100 centilitres (cL)
= 1000 millilitres (mL)

Example

How many litres are there in 50 000 millimetres?

There is 1000ml in a 1L. To converting smaller to a bigger unit, you divide. So 50 000 millilitres = 50 000 ÷ 1000 litres = 50 litres

Measurement of Time

Time is the measure of duration of events and the intervals between them.
The unit for time is the second (s). All clocks and watches make use of some devices that 'beat' at a steady rate. "Grandfather" clocks used the swings of a pendulum.

Modern digital watches count the vibrations made by a tiny quartz crystal. They are easier to read and capable of measuring to one hundredth of a second. In using a stopwatch, there is

a time lapse between seeing an event and the starting of the watch. This time lag is the reaction time. Clocks used by people every-day show hours, minutes and seconds.
Smaller units of time based on the second are the millisecond, the microsecond and the nanosecond.

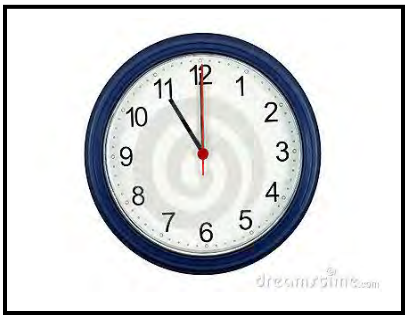


Figure 12 Clock

1 hour (hr) = 60 minutes (min)

1 minute (min) = 60 second (sec)

1 millisecond (ms) = $\frac{1}{1000}s = 10^{-3}s$ = 1 x 10^{-3}s in scientific notation.

1 microsecond (μs) = $\frac{1}{1\ 000\ 000}s = 10^{-6}s$ = 1 x 10^{-6}s in scientific notation.

1 nanosecond (ns) = $\frac{1}{1\ 000\ 000\ 000}s = 10^{-9}s$ = 1 x 10^{-9}s in scientific notation.

It is very important to note that if you are converting hour to second, all you have to do is to first convert hour to minute and then to seconds. You are not to convert directly to seconds which is always a common mistake of most students.

Example 1
Convert 1 hour to seconds by multiplying

$$\frac{1\cancel{hr}}{1} \times \frac{60min}{1\cancel{hr}}$$ (hour cancels out and what remains is in minutes)

$$= 60\ minutes$$

But 1 minute = 60 seconds then convert minutes to sec.

$$\frac{60\cancel{mins}}{1} \times \frac{60sec}{1\cancel{min}}$$ (the unit minutes cancel out and seconds remains as the unit)

$$= 3600\ seconds$$

Example 2
How many milliseconds are there in an hour?

$$1\,\text{hour} = 60\,\text{minutes}$$
$$= \frac{60\cancel{\text{mins}}}{1} \times \frac{60\,\text{sec}}{1\cancel{\text{min}}}$$
$$= \frac{3\,600\cancel{\text{sec}}}{1} \times \frac{1000\text{ms}}{1\cancel{\text{sec}}}$$
$$= 3\,600\,000\text{ms}$$

Now check what you have just learnt by trying out the learning activity below!

Learning Activity 5

20 minutes

Answer the following questions on the spaces provided.

1. Converting 75.3 grams to kilograms gives ___________ kg.

---

2. Convert the following:

(a) 35cm into m ___________m

(b) 562g into kg ___________kg

(c) 1ml into cm^3 ___________cm^3

(d) 1.5 hours into seconds ___________seconds

---

3. If the density of wood is $0.5g/cm^3$, what is the mass of:

(i) $1cm^3$? ___________

(ii) $2cm^3$? ___________

(iii) $10cm^3$? ___________

4. What is the density of a substance of:

   (i) mass 100g and volume $10cm^3$?

   (ii) 98g of gold and volume $2.5cm^3$?

---

5. What is the mass of $5m^3$ of cement of density $3000kg/m^3$?

---

6. When a golf ball is put in a measuring cylinder of water, the water level rises by $30cm^3$ when the ball is completely submerged. If the ball weighs 33g in the air, find its density.

Thank you for completing learning activity 5. Now check your work. Answers are at the end of the module.

Vector and Scalar Quantities

Physical quantities such as length, volume, mass, density, temperature and time can be expressed in terms of magnitude or size alone (together with a unit). For example, consider a person with a mass of 60kg. The '60kg' tell you everything there is to say about the person's mass. Quantities like these require a magnitude or size as its specification is called **scalar quantities**.

A scalar is a quantity that has only magnitude (size)

Quantities such as force, velocity, acceleration, momentum and pressure are vector quantities and are expressed in terms of both magnitude and direction.

A vector is a quantity that has both magnitude and direction

Vector notation

There are many ways of writing the symbol of a vector. Vectors are denoted by symbols with an arrow pointing the direction above it.

For example $\vec{a}$ $\vec{V}$ $\vec{F}$ $\overline{AB}$

Let us take force as an example; force is applied to a stationary motor car to make it move some distance in a certain direction. Force is mass times acceleration. Therefore, if the velocity of car is 25 m/s to the north, then force is a vector quantity. Quantities that require both magnitude and direction as its specification is termed **vector quantities.**

Scalar- require magnitude only	Vector - magnitude and direction
Length	Displacement
Speed	Velocity
Time	Acceleration
Volume	Force
Mass	Magnetic flux density
Energy	Weight
Frequency	Momentum
Pressure	Torque
Power	Moment
Temperature	Electric current
Charge	Electric field

Table 9 Scalar and vector quantities

Representation of vectors

- vectors are represented by drawing arrows. The length represents magnitude and arrowhead indicates direction.
- vectors are added geometrically by placing the tail of one vector on the head of another. The resultant is the vector that begins at the tail of the first vector and ends at the arrow head of the final vector.
- vectors can be subtracted by adding the negative vector.

A vector is represented by an arrow that has both magnitude and direction, represented by a segment of a line as shown in A. A vector has a tail and head as shown in B. The length of the arrow represents the magnitude of the vector, and the direction of the arrowhead shows the direction of the vector as shown in C. Thus the line AB, in the following figure 13 B, can be interpreted as 3m North East.

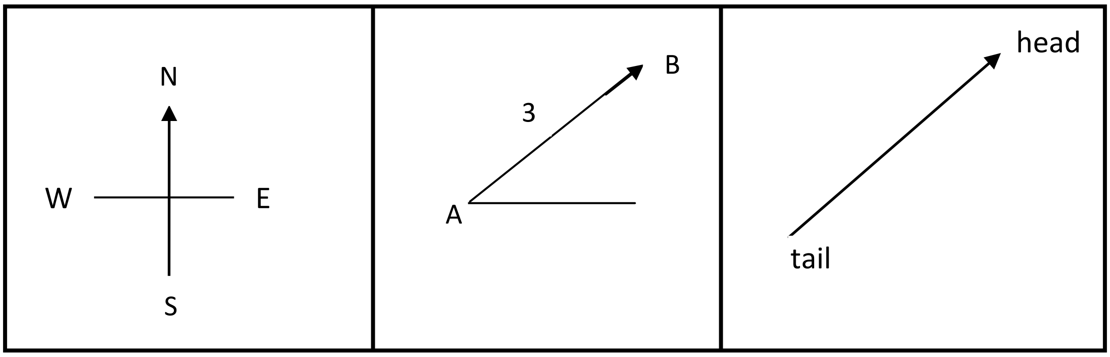


Figure 13 A B C

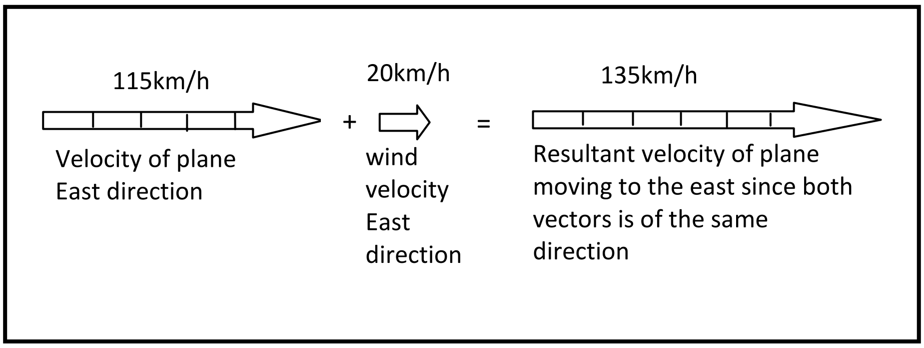
Combining vectors

Vectors are added graphically. Arrows representing two or more vectors can be combined to produce a single resultant or outcome vector.

Example 1

An Air Niugini aeroplane is travelling east at a velocity of 115km/h. The wind also blows east at 20km/h. The resultant can be found by drawing two vectors to the same scale and adding head to tail.

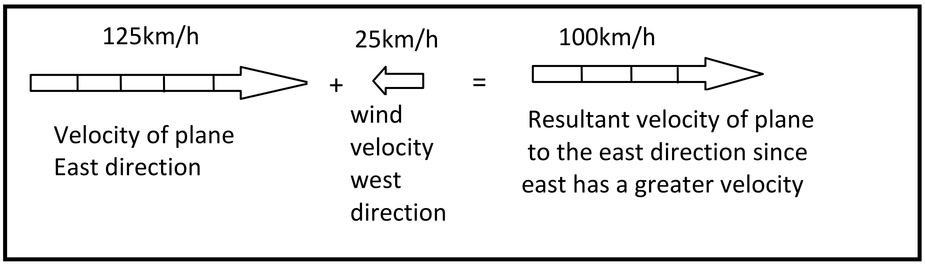
The resultant of 135km/h has the same direction as the component velocities.



Vectors of the same direction – added

Example 2

The velocity of an aeroplane is 125km/h and its course is eastward. The wind blows towards the west at 25km/h. The headwind will slow the plane down. The resultant velocity of the aeroplane is found by adding the vectors head to tail again. The resultant velocity of the aeroplane will be 100km/h east. (The resultant, has the same direction as the greater velocity)

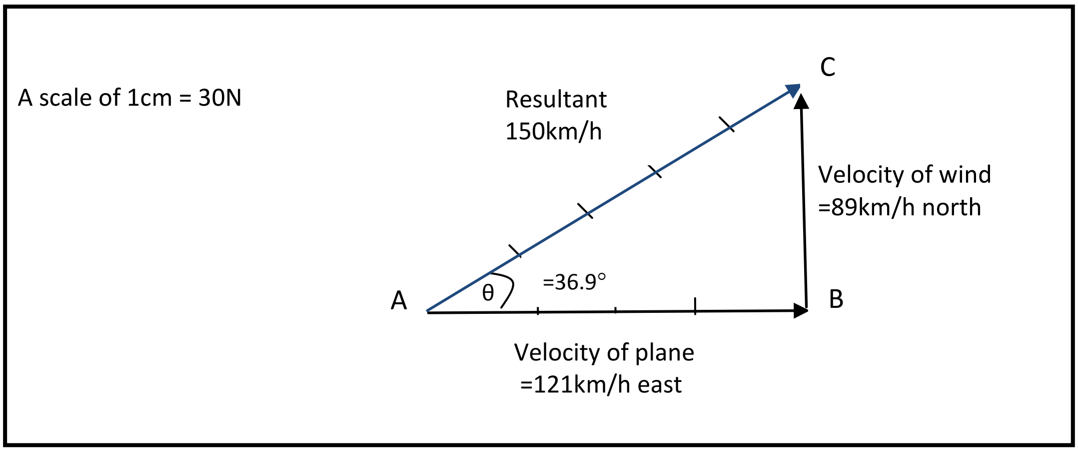


Vectors of different direction- subtracted

Example 3

A pilot in Air Niugini aeroplane flying eastward at 121km/h encounters a strong wind of 89km/h blowing to the north. To find the resultant velocity, we draw a scale diagram and use a trigonometry principle – Pythagoras Theorem.

In this case, the vectors are added head to tail as shown in the diagram above. The diagram is found by joining the starting point to the finishing point. The resultant is the diagonal of the triangle constructed by using the component velocity vectors x and y as sides. The resultant is 150km/h (since the scale is 1cm = 30N there are 5cm in the resultant 5 x 30 = 150N from the sphere 3-4-5) in a direction E36.9°N can be calculated by Pythagoras's theorem or measured from the scale diagram that is tan θ = 90/120 = 0.75, then θ = 36.9°



Pythagorean Theorem

Using the Pythagorean Theorem

$\overline{AC}^2 = \overline{AB}^2 + \overline{BC}^2$

$AC = \sqrt{AB^2 + BC^2} = \sqrt{121^2 + 89^2}$

$AC = \sqrt{14641 + 7921}$

$AC = \sqrt{22562}$

$= 150$

On the calculator

90 $\boxed{\div}$ 120 $\boxed{=}$ $\boxed{\text{INV or SHIFT}}$ $\boxed{\tan}$ $= 36.9^0$

Why did we use tangent? We will review a little bit of trigonometry.

In a right triangle (the triangle that forms 90° angle), the longest side is called the hypotenuse. Y axis is the side that is opposite the right angle. We say that YZ is the side opposite angle X while XY is the side adjacent to angle at X.

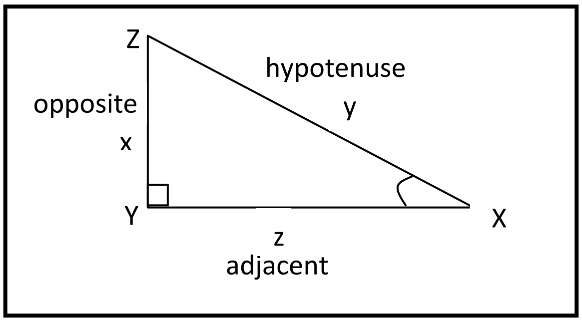


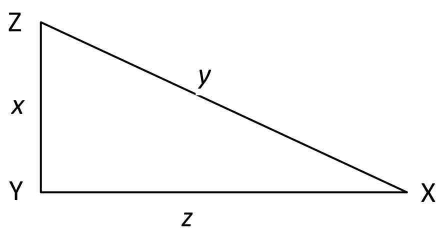
Figure 14 Trigonometric function

The trigonometric ratios of right –angled triangles

sine X = $\dfrac{\text{opposite}}{\text{hypotenuse}}$ = x/y = sin X

cosine X = $\dfrac{\text{adjacent side}}{\text{hypotenuse}}$ = x/y = cos X

tangent X = $\dfrac{\text{opposite side}}{\text{adjacent side}}$ = y/x = tan X



The ratios can be remembered using this mnemonic:

SOH CAH TOA *sock-ah-towa*	(Sin = O/H Cos = A/H Tan= O/A)

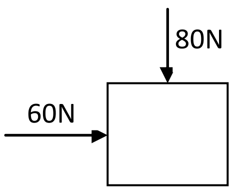
Now check what you have just learnt by trying out the learning activity below!

Learning Activity 6

30 minutes

Answer the following questions on the spaces provided. Show all your working out.

1. Two forces act on a block as shown below. Calculate the resultant force.



2. A yacht is sailing south at 4m/s and meets a current of 3m/s east.

   What is the resultant velocity of the yacht?

3. Two water skiers are being pulled along by a speedboat such that their two ropes are at 90° to one another.

   Calculate the resultant pull of the skiers on the boat if each pulls with a force of 500N.

4. Find the sum of a:

   (a) mass of 6kg and 8kg.

   (b) force of 6N acting in opposition to a force of 8N.

Thank you for completing learning activity 6. Now check your work. Answers are at the end of the module.

11.1.2 Dimensional Analysis

Dimensional Analysis

Every physical quantity can be expressed in terms of its basic dimensions of mass, weight, volume, length and time.

The dimensions of quantity can be used to check an equation or formula for correctness or to suggest the form an equation may take.

Dimensions of a quantity are placed in square brackets [ ] for example [M] for mass, [L] for length, [T] for time and [I] for electric current.

The formula of velocity = distance/time, a distance is measured using its length so the dimension for length is [L] and time is [T]. The dimension of velocity is [L/T] or $[LT^{-1}]$

Dimensions of work is [M] for mass x acceleration (a) where a is =velocity / time^2 so [L] for velocity $[T^{-2}]$, so acceleration x distance would be $[LT^{-2}]$ x [L] for distance

$W = [M \times LT^{-2} \times L]$ put the L together

$W = [ML^2T^{-2}]$

In the SI system, the unit of speed is the metre per second. Other units used are mile per hour, kilometer per hour and centrimetre per minute. But all these units have one thing in common and that is, each is a unit of length per unit of time. The quantity, length per unit time is called the dimension which is the physical nature of a quantity. Thus, we say the dimension (physical nature) of speed is length per unit time.

Every physical quantity can be expressed in terms of its basic dimensions. Dimensions of a quantity is placed in square brackets [ ] where the square brackets is read as **dimensions of**.

[ ] means dimensions of

For instance, the dimension of speed placed in a square bracket is $[LT^1]$.

Other examples of dimensions for some physical quantities are given in the table below.

Physical Quantity	SI Unit	Dimension & Symbol
Mass **(m)**	kilogram **(kg)**	mass **[M]**
Distance **(d)**	metres **(m)**	length**[L]**
Time **(t)**	seconds **(s)**	time **[T]**
Area **(A)**	metre squared **(m^2)**	length squared **[L^2]**
Volume **(V)**	metre cube **(m^3)**	length cubed **[L^3]**
Density **(D)**	kilogram per metre cube **(kgm^{-3})**	mass per length cubed **[ML^{-3}]**
Speed **(s)**	metres per second **(ms^{-1})**	length per unit time **[LT^{-1}]**
Velocity **(v)**	metres per second **(ms^{-1})**	length per unit time **[LT^{-1}]**
Acceleration **(a)**	metres per second squared **(ms^{-2})**	length per time squared **[LT^{-2}]**

Table 10 Other examples of dimensions for some physical quantities

When writing the dimensions of a physical quantity, we use the symbols [M] for mass, [L] for length, and [T] for time as the basis because these three dimensions are the fundamental dimensions.

Example 1
Express the quantities area, volume, density, velocity and acceleration in terms of their dimensions.

Solution
(i) [area] = length x width

= [length] [width]

= [length] x [length]

= [L x L]

= [L^2]

(ii) [volume] = length x width x height

= [length] x [width]x [height]

= [length] x [length] x [length]

= [L x L x L]

= [L^3]

(iii) velocity

$$= \frac{\text{distance}}{\text{time}}$$

$$= \frac{[\text{distance}]}{[\text{time}]}$$

$$= \frac{[\text{length}]}{[\text{time}]}$$

$$= \left[\frac{L}{T}\right]$$

$$= [LT^{-1}]$$

(iv) [density]

$$= \frac{[\text{mass}]}{[\text{volume}]}$$

$$= \frac{[M]}{[L]^3}$$

$$= [ML^{-3}]$$

(v) acceleration

$$= \frac{\text{velocity}}{\text{time}}$$

$$= \frac{[\text{velocity}]}{[\text{time}]}$$

$$= \frac{[LT^{-1}]}{[T]}$$

Note: Velocity = $[LT^{-1}]$

$$= [LT^{-1}][T^{-1}]$$

$$= [LT^{-2}]$$

Example 2

Find the dimensions of Work, given that Work= Force x distance

Solution Work = force x distance (Force = mass x acceleration)

Force = mass x acceleration x distance

= [mass] x [acceleration] x [distance]

= $[M] \times [LT^{-2}] \times [L]$

= $[ML^2T^{-2}]$

Example 3

Show that the equation $v^2=u^2 + 2as$ is dimensionally correct, where v = final velocity, u= initial velocity, a = acceleration and s= distance.

Solution

(i) $v^2 = u^2 + 2as$ (replace the symbols with unit symbols

$(ms^{-1})^2 = (ms^{-1})^2 + 2 \times ms^{-2} \times m$ (**guideline 1**)

$m^2s^{-2} = m^2s^{-2} + 2m^2s^{-2}$ (add the terms on the left)

$m^2s^{-2} = 3m^2s^{-2}$ (remove the number 3 – **guideline 2**)

$m^2s^{-2} = m^2s^{-2}$ (replace the units symbols with dimensions)

$[L^2T^{-2}] = [L^2T^{-2}]$ (**guideline 3**)

Therefore, $v^2 = u^2 + 2as$ is dimensionally correct

OR

(ii) $v^2 = u^2 + 2as$ (replace the symbols with dimensions)

$[LT^{-1}]^2 = [LT^{-1}]^2 + 2 \times LT^{-2} \times L$

$[L^2T^{-2}] = [L^2T^{-2}] + 2[L^2T^{-2}]$ (add the terms on the left)

$[L^2T^{-2}] = 3L^2T^{-2}$ (remove the number 3-**guideline 2**)

$[L^2T^{-2}] = L^2T^{-2}]$ **(guideline 3)**

Therefore, $v^2 = u^2 + 2as$ is dimensionally correct.

Now check what you have just learnt by trying out the learning activity on the next page!

Learning Activity 7

20 minutes

Using dimensional symbols prove that the following equations are correct.

1. $s = ut + \frac{1}{2}at^2$ if s = distance, u = initial velocity, t = time, a = acceleration

2. v = u + at where v = velocity, a = acceleration and t = time

3. $\frac{1}{2}mv^2 = Fs$ where m = mass, v^2 = velocity, F = force and s = distance

Thank you for completing learning activity 7. Now check your work. Answers are at the end of the module.

11.1.3 Error Analysis

In physics, error does not mean mistake. It means uncertainty in physical measurements. Thus, error analysis is the study of uncertainty in physical measurements. If you were to count the number of desks in your classroom, you would obtain an exact value. But if you were to measure the length of your room using a tape measure, your measurement would be an approximation.

Measurements can never be exact because they are subject to some amount of error. Experimental error, itself, is measured by its accuracy and precision. Error is a measure of the accuracy of a measurement to the accepted or true value. Accuracy is how close a measurement is to the accepted or true value while precision measures how close two or more measurements agree with the accepted or true value.

Types of errors in measurement

Systematic errors are errors caused due to the error in the instrument, and usually can be corrected by simple calculation of improved experiment technique.

These effects result from:

- an incorrectly adjusted measuring instrument (such as stopwatch that runs too fast and so give greater time)
- use of an instrument that has a zero error.
  That is, it does not read zero for zero measurements (such as an ammeter used to measure current) the needle may point to 0.1, even when not connected in a circuit.

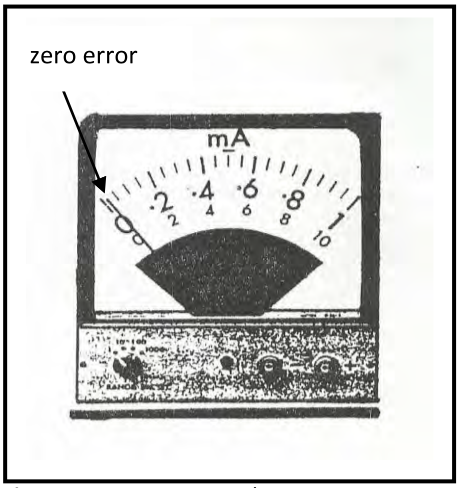


Figure 15 Ammeter with zero error

Other examples of systematic error are the following:

(1) a metre ruler with worn ends,
(2) a dial instrument with a needle that is not properly zeroed, and
(3) human reaction time that is always either too late or too early.

Random (irregular or accidental error) are errors of observation which measurement is just as likely to be larger or smaller than the true or accepted value. Random error occurs when the same quantity is measured several times and is estimated to the nearest division on a measuring instrument and or measuring instrument not being particularly sensitive.

Imagine a student using a stopwatch to measure the time for a pendulum for ten complete swings. Assuming that the students have a good reaction time, the measurements may be slightly high on some trials and slightly low in others. In other words there will be a variation in results about an average value.

A common source of error in reading scales is **parallax error** (human error) as shown in the diagram below. The apparent shift of the object's position when the observer's position changes. It occurs when the line through the pointer to the scale does not make a right angle with the scale. To overcome parallax error when reading instruments, you should view the dial and needle perpendicularly.

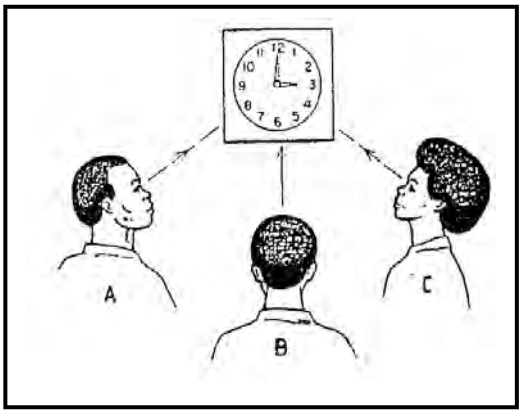


Figure 16 Parallax error

How would you minimize errors?

Errors cannot be eliminated, but can only be minimize. This can be done by:
- estimating error
- choosing an appropriate measuring instrument for that particular tasks
- carrying out the procedure carefully step by step and checking result regularly

Relative error is when you measure the length or the mass of an object. You are in fact taking two readings from your instrument. You measure a start position and a finish position in each measurement; you have an absolute error equal to the limit of reading of the instrument or the smallest graduation on the instrument's scale. You may state your uncertainties or error as a relative or fractional error (Percentage error)

$$\text{Relative Error} = \frac{\text{Absolute error}}{\text{Accepted value}}$$

Absolute error

Absolute error is an error in quantity**.** Consider an object's length measured by using a ruler to be 2.83 ±0.5mm. This measurement has an absolute error of ±0.5. If you are going to calculate for percentage error for this you will have 0.5/2.83 x 100 = 17.7. So the measurement 2.83 ±0.5 can also be written as 2.83 ±17.7%.

To calculate for absolute error use the following formula:

$$\text{Absolute error} = \text{measured value} - \text{accepted value}$$
$$E_a = (O - A)$$

If the value is measured several times, then the mean can be calculated and an estimate of the accuracy can be given. For example, a result of 83.2 ± 0.4 mm would indicate that your estimated value is 83.2mm but it could be between 82.8mm and 83.6mm. The absolute error is estimated at 0.4mm.

A digital ammeter with a display of 456mA seems to be saying that the current is exactly 456mA. The accuracy or absolute uncertainty of the meter is ±1mA. Thus, the reading should be expressed as (456 ± 1) mA.

For this reading,
1mA is the absolute error 456 is the estimated value. Note that the absolute error has units but the fractional and percentage uncertainties are ratios.

Or as a percentage error:

$$\text{Percentage error} = \frac{\text{error}}{\text{actual value}} \times 100$$

Example 1
Measure the length of two rods using a metre ruler and find:

Length 1 = 2.000m ± 1 x 10^{-3} m

Length 2 = 0.100m ± 1 x 10^{-3}m

Solution

$$RE_1 = \frac{1 \times 10^{-3}}{2.000} = 5 \times 10^{-4}$$

$$RE_2 = \frac{1 \times 10^{-3}}{0.1} = 1 \times 10^{-2}$$

Example 2
Results of a luxury car road test.

Speed	Speedometer correction (km/h)			
Indicated	60	80	100	111
Actual	59	78	96	104

(a) Find the relative (or fractional) error at an actual speed of 96km/h.

(b) What is the percentage error at 96km/h?

Solution
(a) Error = measured value – actual value = 100-96 = 4km/h

$$\text{Relative error} = \frac{4}{96} = 0.0416$$

(b) Percentage error = 0.0416 x 100 = 4.16 %

Working with errors

(i) Adding and subtracting numbers with errors

When you add or subtract two measurements with errors, you just add the errors. You add the errors regardless of whether the numbers are being added or subtracted. Your final answer should have as many decimal places as the data with least number of decimal places. Answer should have as many significant figures.

Example

(20.4 ± 0.5mm) + (32.3 ± 0.5mm)

(0.5mm + 0.5mm) **Add the errors together**

= ± 1.0mm **We get ± 1.0mm as our final error**

= 52.7 ± 1.0mm **We just need to put this (± 1.0mm) on the end of our added measurement**

(ii) For multiplication and division;

When multiplying or dividing, the answer should have as many significant figures as the least significant measurement supplied in the data. The absolute errors should convert to percentage errors. The result is combined. The final step involves converting the percentage error back to an absolute error. Rounding off the absolute error should be done so that the least significant digit in the error would affect the least significant digit.

Example

A piece of paper is measured and found to be 5.63 ± 0.15mm wide and 64.2 ± 0.7mm long. What is the area of this piece of paper?

Solution

Data: length = 64.2 ± 0.77mm and width = 5.63 ± 0.15mm

Area = length x width

= (64.2 ± 0.7mm) x (5.63 ± 0.15mm)

First work out the answer by just using the numbers, forgetting about errors

= 64.2 x 5.63

= 361.446

Then, work out the relative errors in each number

$$= \frac{0.15}{5.63} = 0.0266$$

$$= \frac{0.7}{64.2} = 0.0109$$

Add them together

$$0.0266 + 0.0109 = 0.0375$$

This value (0.0375) is the relative error in the value you get multiplying the two numbers together 64.2 by 5.63 gives 361.446. We could write this as a percentage error. To convert to a percentage error, multiply by 100.

$$0.0375 \times 100 = 3.75\%$$
$$= 361.446 \pm 3.75\%$$

To write the answer with an absolute error, we need to multiply the 361.446 by the relative error:

Value x relative error of value = Absolute error
361.446 x 0.0375 = Absolute error
Absolute error = 13.55

This means our final answer is:

$= 361.446 \pm 13.55\text{mm}^2$

$= 361 \pm 14\text{mm}^2$

(round 361.446 and 13.55 to the nearest whole number and that is 361 and 14)

Now check what you have just learnt by trying out the learning activity below!

Learning Activity 8

30 minutes

Work out the answer to each question below and show all your working out in the space provided after each number.

1. Calculate the percentage error for the following speeds as indicated in the table in example 2.

   a) 59km/h

b) 78km/h

c) 104km/h

d) Is the speedometer consistent throughout the 59-104km/h range?
____
____

2. Calculate the percentage error when a race of 10.4s is timed at 10.5s

3. If a = (1.87 ± 0.02)mm and b= (1.62 ± 0.01)mm, find (a-b) and its percentage uncertainty?

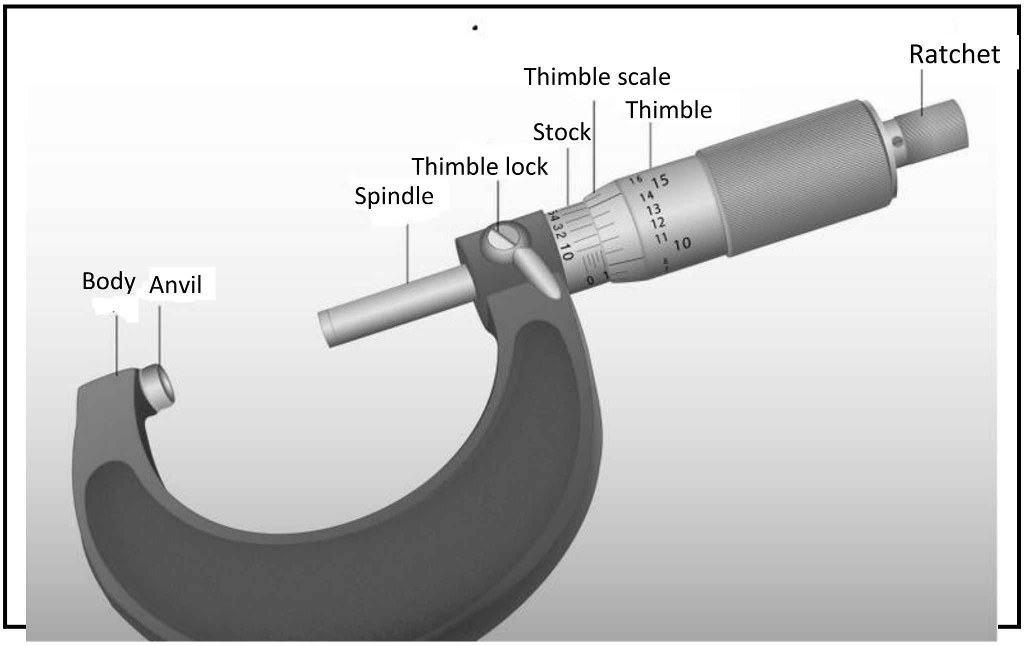
Thank you for completing learning activity 8. Now check your work. Answers are at the end of the module.

Measuring instruments

A micrometer is used to measure accurately small lengths. Micrometers are useful for determining the diameter of rods, ball bearing, thickness of paper, and marbles. The following are ways on how to use a micrometer.

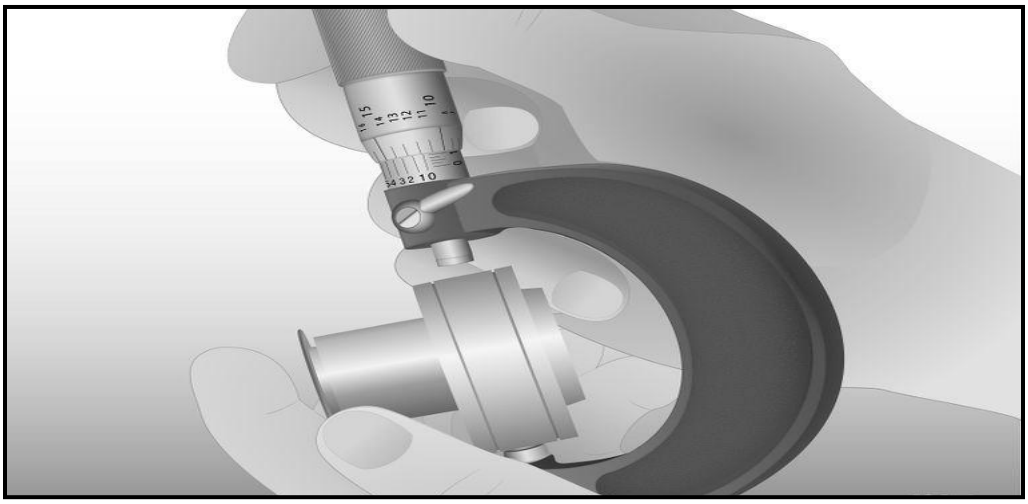
Method One: Measuring using a micrometer

Step 1. Become familiar with the parts of a micrometer.



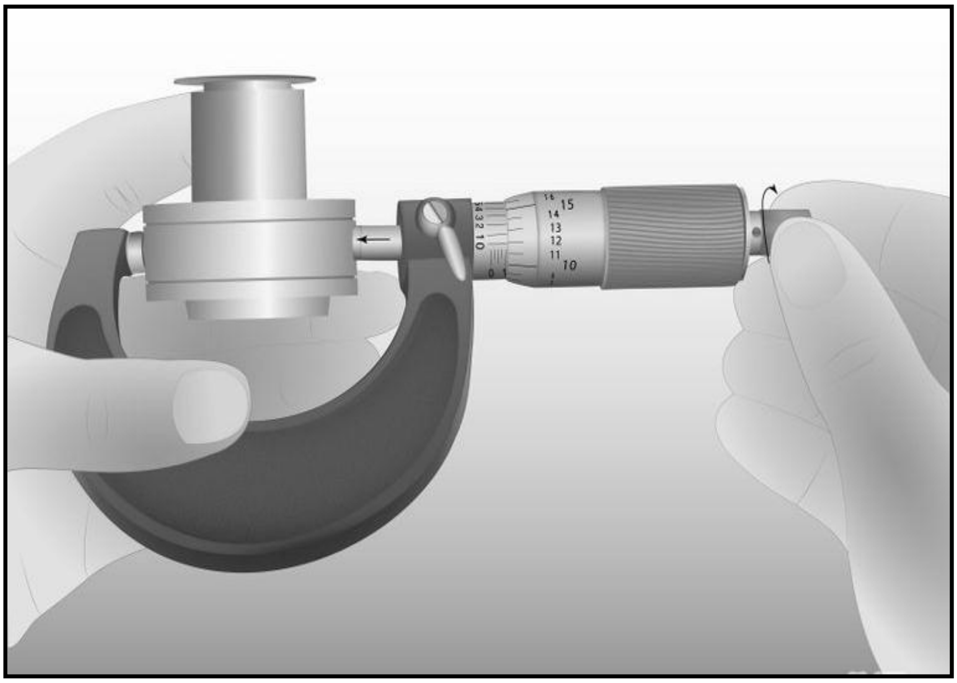
Parts of a micrometer

Step 2. Place the object between the anvil and spindle.



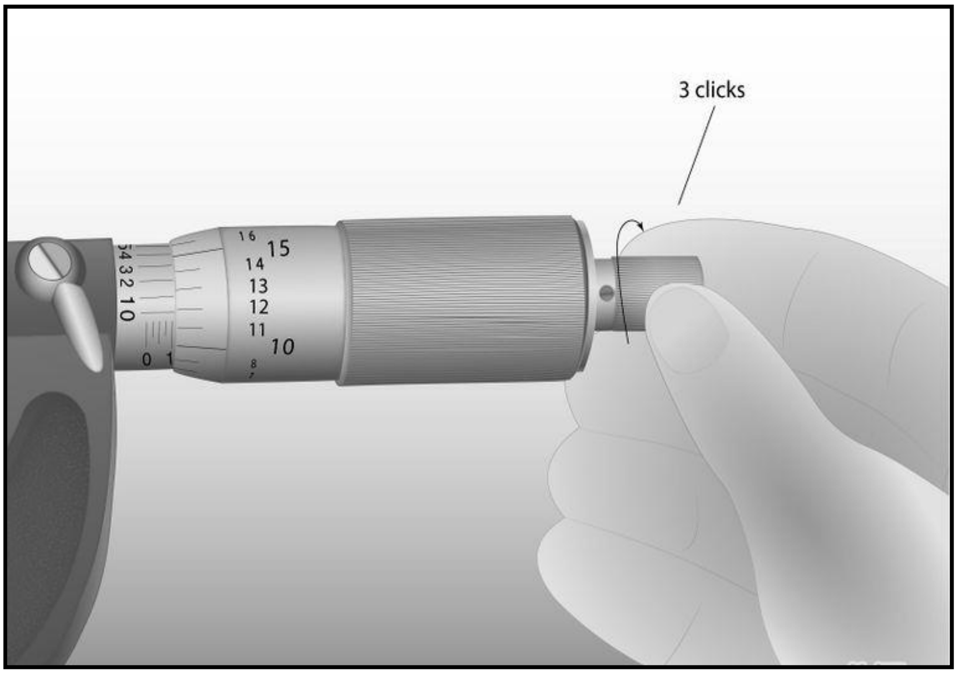
Object between the anvil and spindle

Step 3. Turn the ratchet until the spindle meets the object.



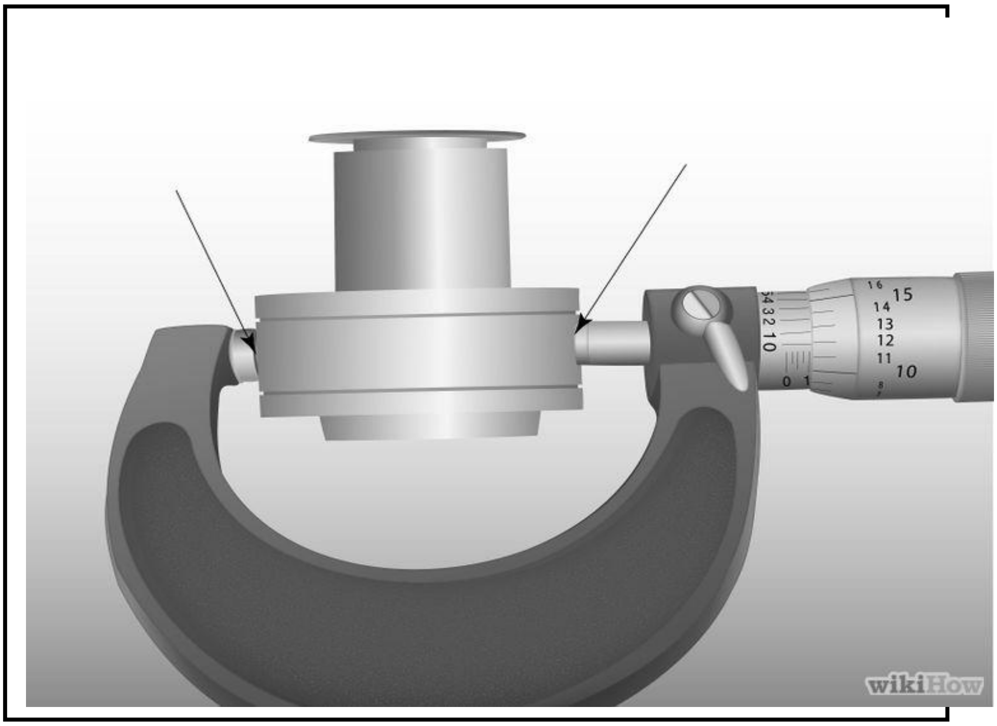
Meeting with the object

Step 4. Spin ratchet until you hear three (3) clicks.



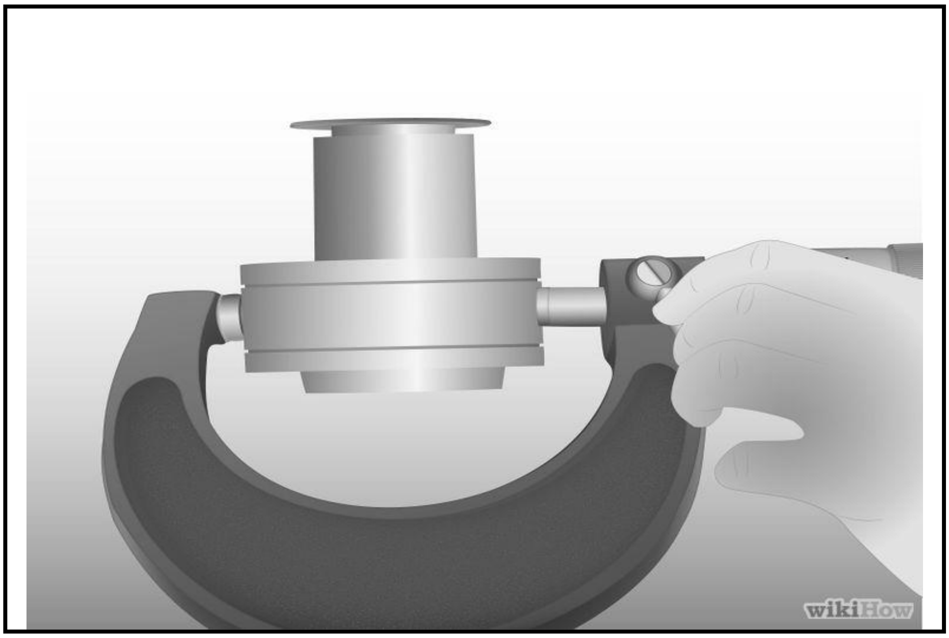
Ratchet stop

Step 5. Verify if both the anvil and spindle are touching the object evenly.



Anvil and spindle holding the object

Step 6. Set the thimble lock while the micrometer is still on the object



Thimble lock

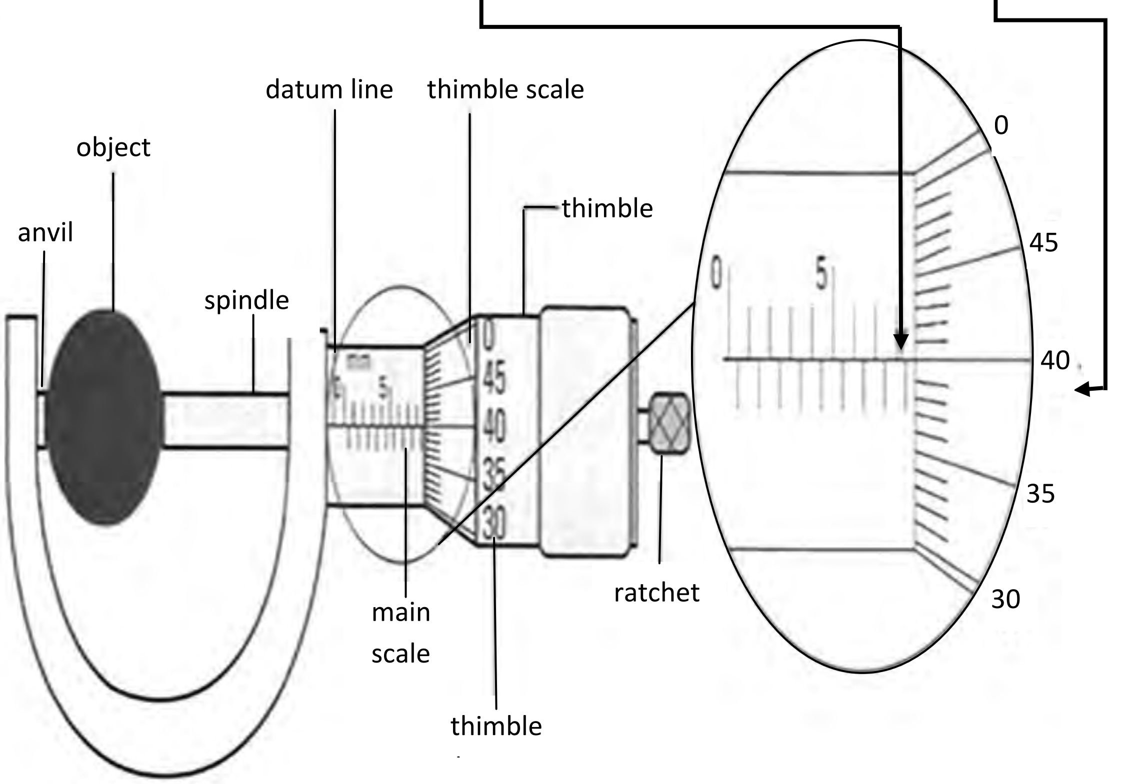
Step 7. Reading the micrometer

Step1

Read the main scale by reading at the edge of the thimble. In this case, it is 8.5

Step 2

The thimble scale has 50 divisions, each of which is 0.01mm.Take the thimble reading opposite the datum line of the main scale. In this case, it is 40 divisions, which give a value of 40 x 0.01mm = 0.40mm

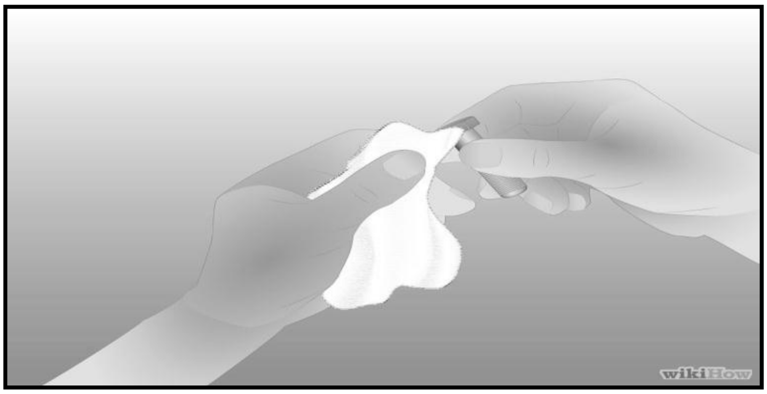


Step 3

The diameter is found by adding the main scale reading to the thimble reading: 8.5mm + 0.40mm = 8.90mm

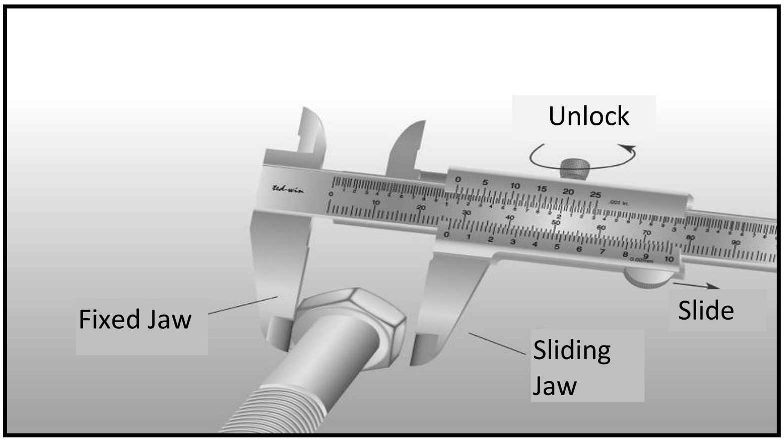
The **vernier calipers** are used to measure length to an accuracy of 0.01cm.
The figure below shows the vernier calipers being used to measure the diameter of a sphere.

Step 1. Make sure that whatever you are measuring is clean and smooth on the edges.



Cleaning the object

Step 2. Open the jaws of the caliper and position them on both sides of the screw.



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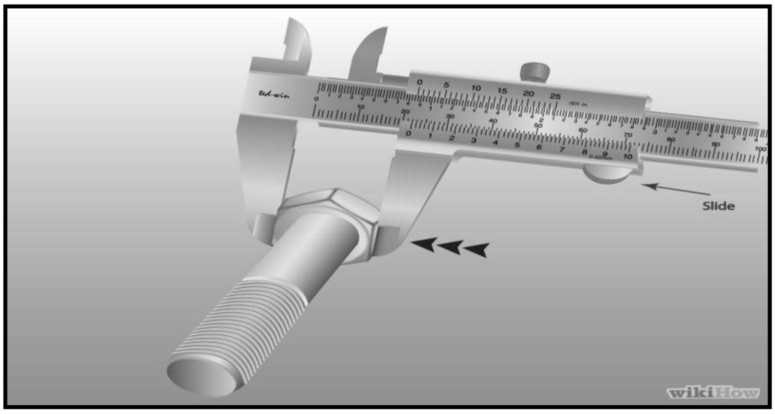
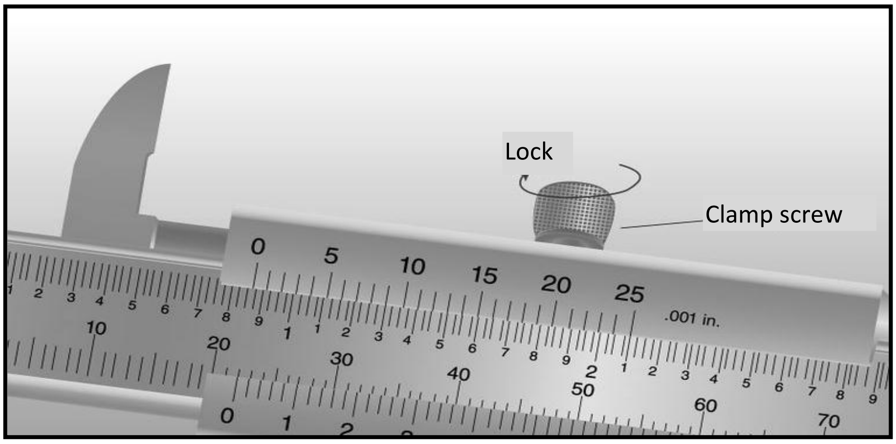
Initial position

Step 3. Push the jaws firmly against the screw.



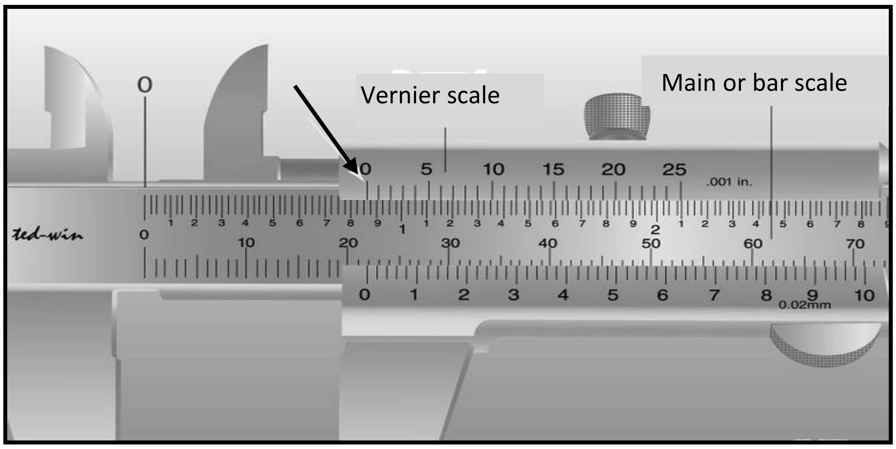
Fixing the position

Step 4. Lock the clamp screw so that the jaws do not move.



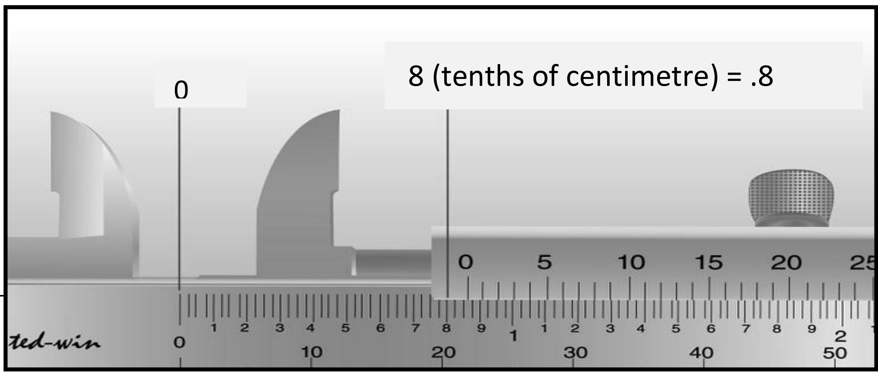
Locking the caliper for reading

Step 5. On the vernier scale is a small number 0. Look at how many divisions it is past on the bar scale.



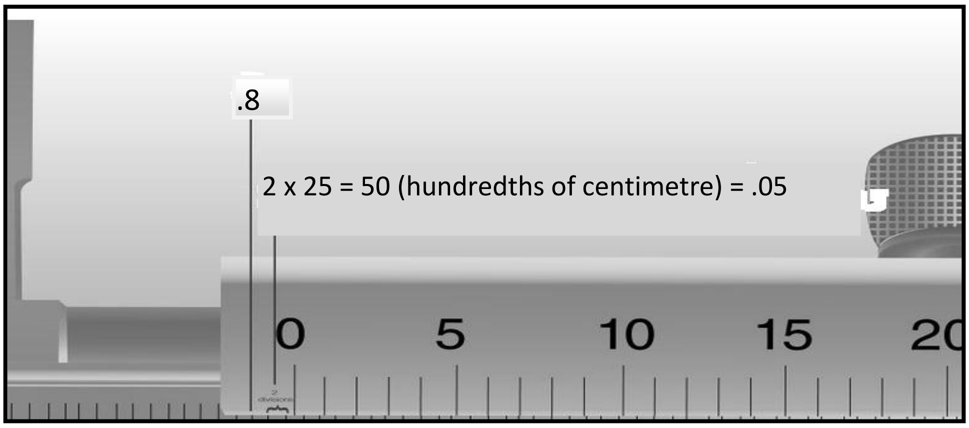
At zero reference

Step 6. See how many smaller (numbered) divisions the small zero has gone past. They represent how many tenths of centimetre the work piece is measuring in addition to the number of whole centimetres.



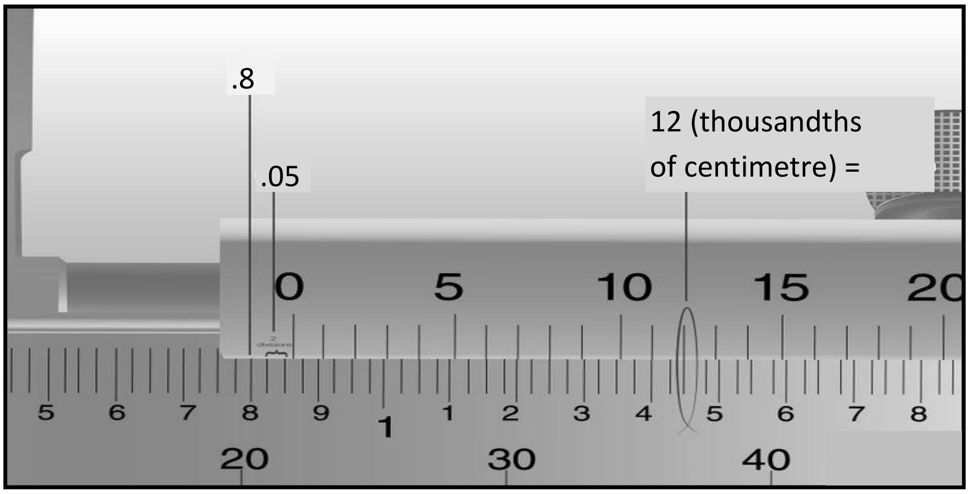
Reading by the tenths

Step 7. See how many smaller divisions the small 0 has gone past in the last numbered division. This number multiplied by 25 is how many hundredths of centimetre.



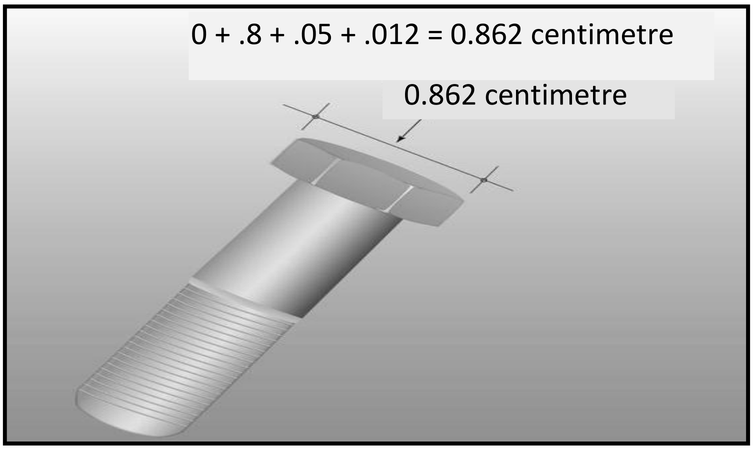
Reading by the hundreds

Step 8. Determine which division line on the vernier scale best lines up with a division on the bar scale. The figure below is thousandths of a centimetre.



Reading by the thousandths

Step 9. By adding the inch measurement, the tenths of a centimetre, the hundredths, and the thousandths, you will have a measurement to 3 decimal place accuracy.



Final reading

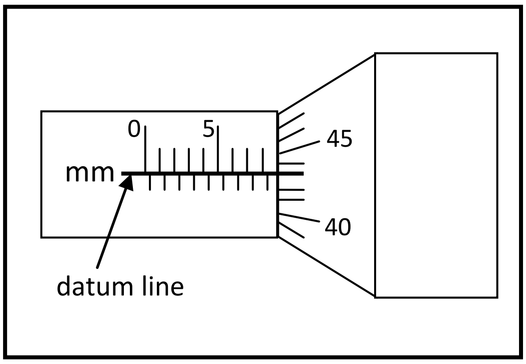
Now check what you have just learnt by trying out the learning activity below!

Learning Activity 9

20 minutes

Answer the following questions on the spaces provided with each number.

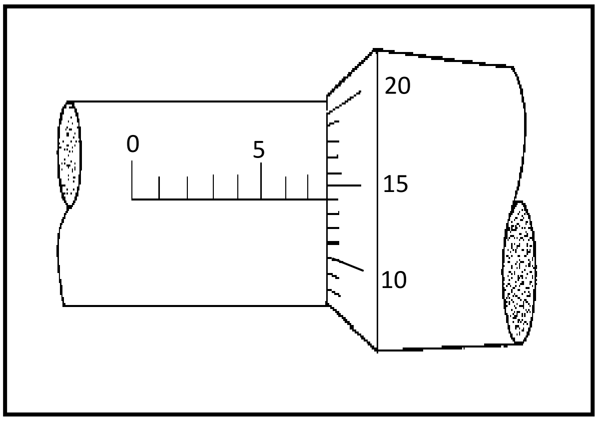
1. State the reading showed in the diagram below.



Thimble scale and stock

Reading ______________________

2. State the micrometer reading below.



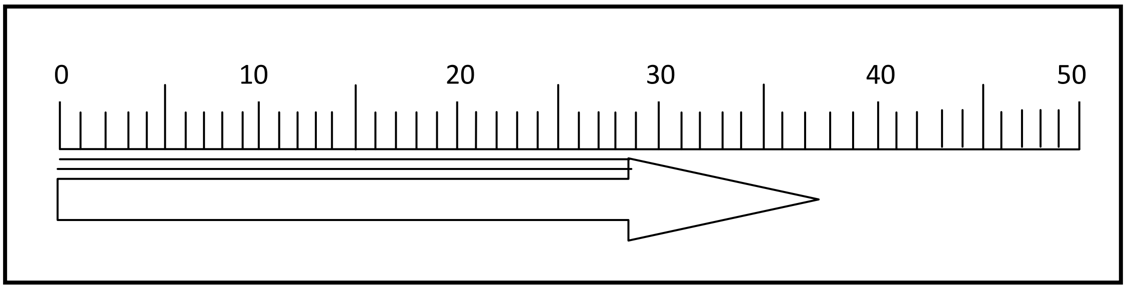
Reading ___________________

Micrometer thimble scale

3. A metal satellite antenna of length 7.6039cm is heated and expands to 7.6052cm.

What is its change in length in metres?

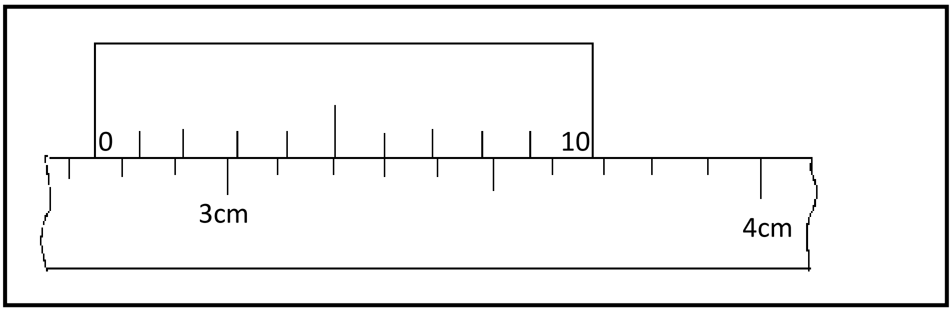
4. What is the length of the pencil measured in millimeter with a rule, as shown in the diagram below? Convert your answer to a centimeter.



Ruler measurements

Length _______________________

5. What reading is shown on the Vernier scale?



Vernier caliper scale

Reading___________________

Thank you for completing learning activity 9. Now check your work. Answers are at the end of the module.

11.1.4 Graphs

Graphs are visual representation of data. In many experiments, the aim is to find a relationship between two or more variables that are measured. The relationship is done by drawing a graph of the values of one variable from the values of another variable and then comparing the shape of the graph against known graphs to determine the form of the relationship.

In a general sense, a graph is a plot of a dependent variable versus the independent variable. The horizontal or x-axis is the independent variable or cause. The effect of that cause is plotted on the vertical or the y-axis. Because the effect is dependent on the cause, the y-axis is called the dependent variable.

The most common graph is one in the form of a straight line or linear relation which has the equation:

$$\boxed{y = mx + c}$$

where x and y are the variables, m is the gradient or slope of the line, and c is the intercept on the vertical (y) axis, or the value of y, where x = 0.

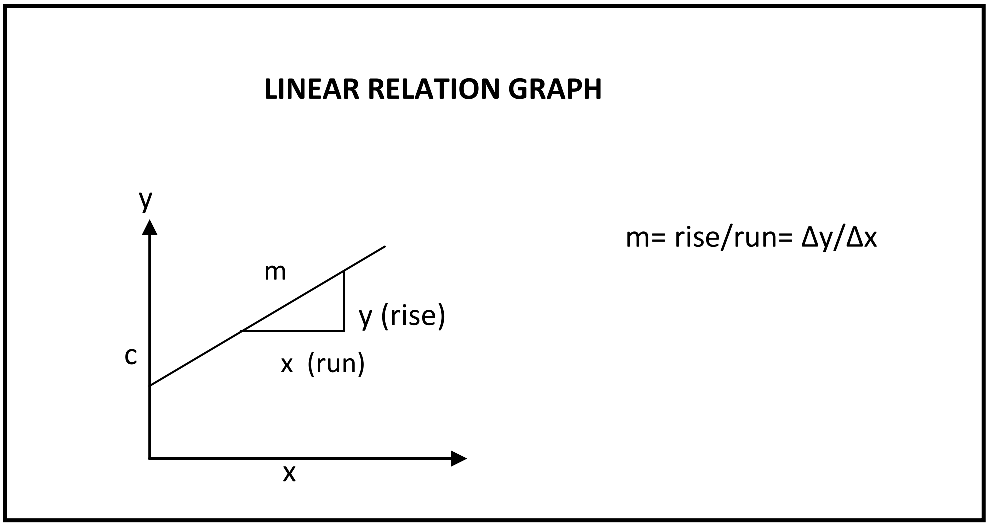


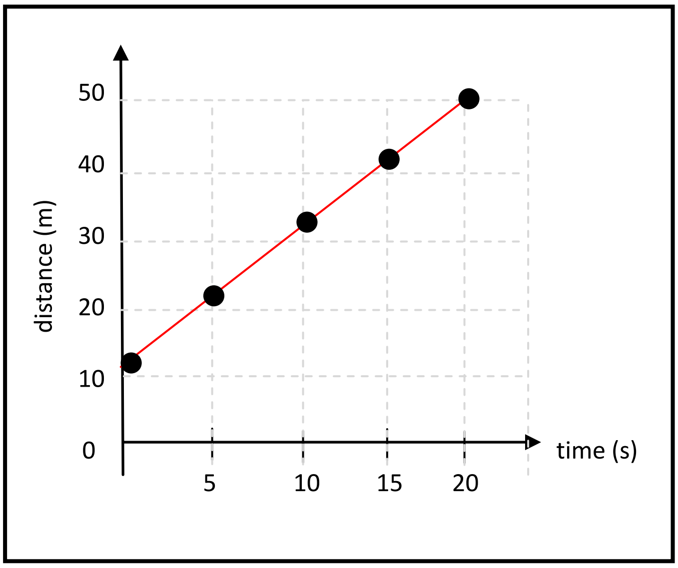
Figure 16 Linear relation graph

Example 1

The table below shows sample linear relation readings of distance and time.

x	0	5	10	15	20
y	16	24	33	41	50

When the reading in the table above are used to plot a graph of y and x, a continuous line joining the points is a straight line passing through the origin.



Graphical representation of table above

Formula for finding gradient

1.) $m = \frac{y^2 - y^1}{x^2 - x^1} = \frac{50 - 16}{20 - 0}$

$= \frac{34}{20} = 1.7$

2.) $m = \frac{33 - 16}{10 - 0} = \frac{17}{10} = 1.7$

In this graph the y is the dependent variable (distance ,m) , x is the independent variable (time, s) , m is the gradient of the line which can be found by choosing two points on the line and finding the change in the y-axis, Δy, and the change in the x-axis, Δx, between the two points. The name of the notation Δ is called 'Delta' meaning a change between two quantities. The slope or gradient is m= Δy/Δx (Δdistance/Δtime) c is the intercept on the y-axis.

Any variable can be plotted on the x-axis and y-axis but it is usual to plot the independent variable (the one that is controlled) on the x-axis and the dependent variable (the one that is not controlled) on the y-axis. The variables in a straight line graph are described as being directly proportional to each other. In this kind of relationship, doubling the value of x has the effect of doubling the value of y, tripling the value of x triples the y, and so on.

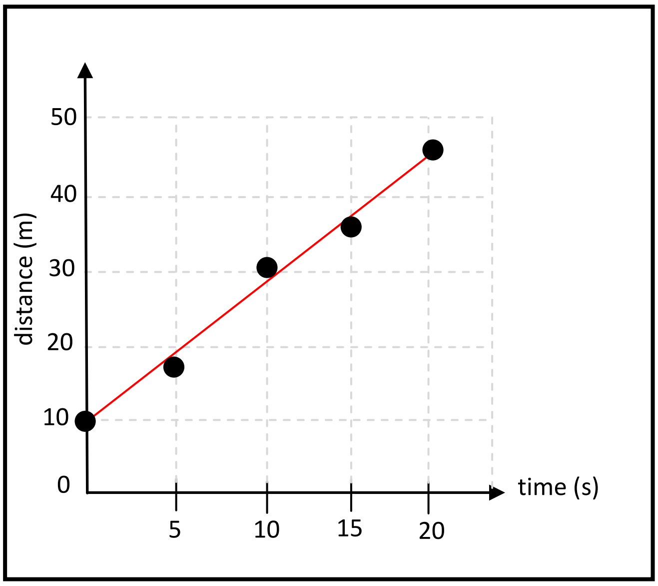
If the graph is a straight line, then it is possible to find the gradient and intercept from the graph. In the graph above the y- intercept is + 16, while the gradient (= rise/ run) is 1.7 (that is 34/20). The equation for the straight line is therefore,

$$d = 1.7t + 16$$

Example 2

Supposed an experiment is conducted whereby the distance of a motorist is noted at a regular time interval. When the data are plotted on a set of axes, a 'line of best fit' can be drawn through the points plotted. It is possible for the 'line of best fit' to miss all the given points.

Line of best fit is a straight line that best represents the data on a scatter plot. This line may pass through some of the points, none of the points, or all of the points.

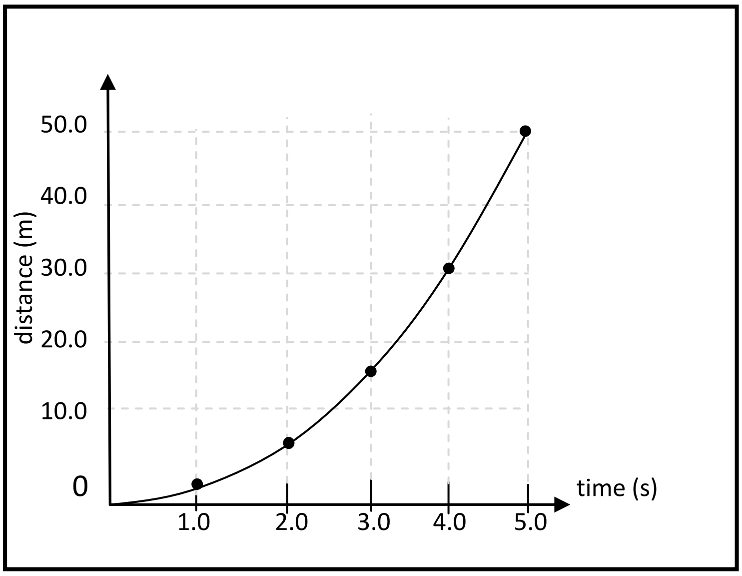


Line of best fit

In the graph above the y-intercept is 10, while the gradient (30/20). The equation for this straight line is therefore d = 1.5t + 10.

Example 3
Sample curved path reading of distance and time

Distance (m)	0.0	2.0	8.0	18.0	32.0	50.0
Time (s)	0.0	1.0	2.0	3.0	4.0	5.0

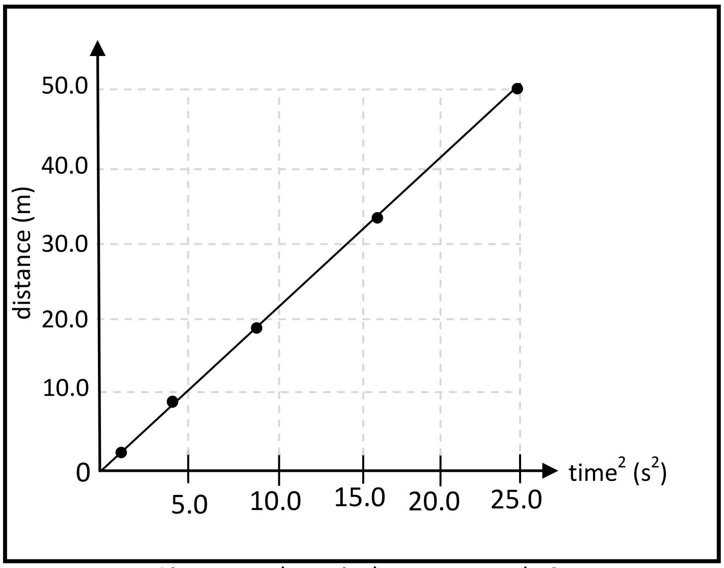


Curved graph

When the relationship between two variables is not linear, a curved graph will result. It is difficult to see the relationship between variables on a curved graph. Usually, the variables are changed (by squaring or taking square roots) until a graph becomes linear. When a linear is obtained, the relationship is more clearly seen, since the change variables are then **proportional** to one another.

Example 4
Changing curved graph to linear graph

Distance (m)	0.0	2.0	8.0	18.0	32.0	50.0
Time (s)	0.0	1.0	2.0	3.0	4.0	5.0
Time^2 (s^2)	0.0	1.0	4.0	9.0	16.0	25.0

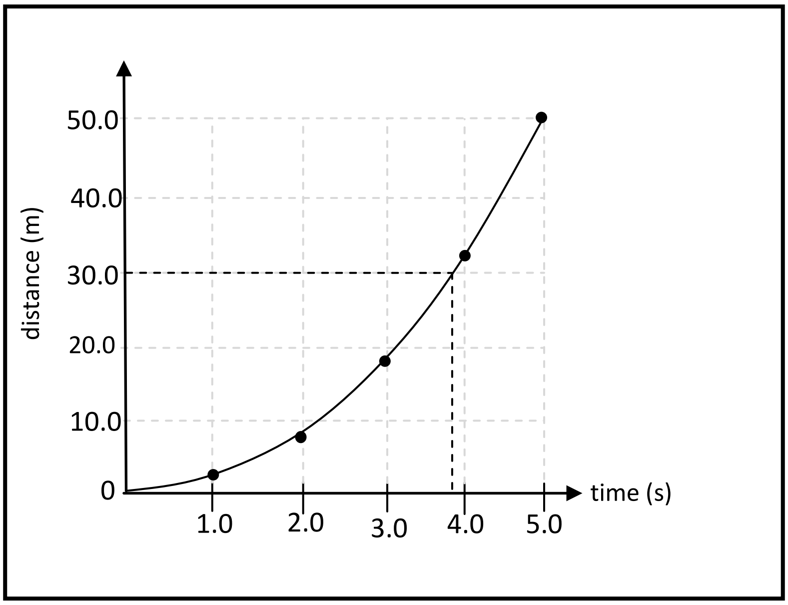


Linear graph equivalent to example 3

Taking the origin (0, 0) and the coordinates (25.0, 50.0m) as the two points to calculate the slope: m= Δy/Δx = 50.0 -0 / 25.0-0 = 2.0ms^{-2}

The relationship between distance and time is distance = 2.0 x time^2 or d= 2.0t^2.

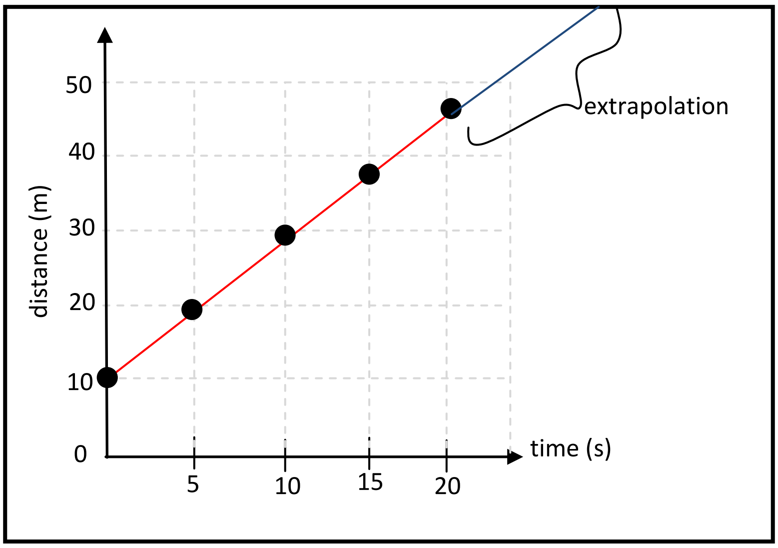
To find the time at which the distance is 30m on the graph in example 2, you can draw a horizontal dotted line across the 30m mark on the distance axis to where it intersect the curve. Then draw another vertical line down to where it intersects the time axis. Then you will find out that the time is estimated to be 3.8s. This process is called **interpolation** where you estimate values *within* the range of plotted measurements.



Interpolated graph

Estimation of values *outside* the range of measurement is called **extrapolation** as shown on the extrapolated graph below. This type of estimation is less certain than interpolation because it is not known whether or not the relationship is still valid for larger or smaller values.

For example if you are given a graph and asked to extrapolate, then you can go beyond or outside the range as shown below.



Extrapolated graph

Clues to relationship

The shapes of graphs often give a clue to the relationship between variables, below are four graphs and the relationship they suggest.

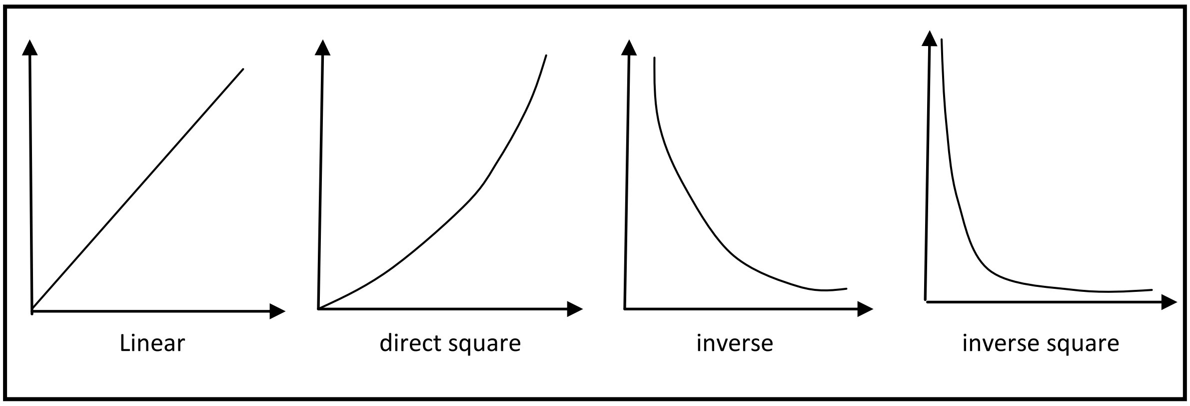


Figure 18 Graphs and its relationship

Now check what you have just learnt by trying out the learning activity below!

Learning Activity 10

20 minutes

Answer the following questions on the spaces provided.

1. A spiral spring is suspended from one end and its length is measured when different masses are attached to the other end.

Mass (m) in g	10	15	30	50	75
Length (l) in cm	22	25	30	37	48

(a) Graph the results and obtain a formula relating L and M

(b) What is the length of the upstretched spring?

(c) If the corresponding graph for another spiral spring is a steeper straight line, what does this mean?

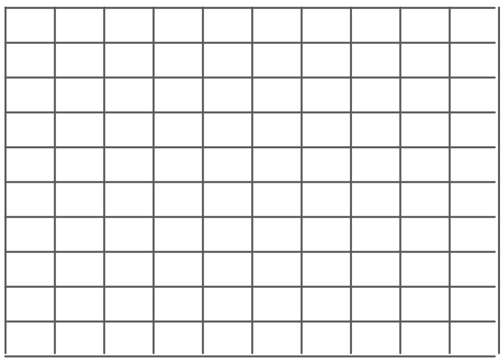
(d) Use the formula to evaluate the length of the spring when the load is 65g. Check the answer from your graph.

---

2. Pairs of readings for the quantities m and v are given below.

m	0.25	1.5	2.5	3.5
v	20	40	56	72

(a) Plot a graph of m (vertical axis) and v (horizontal axis)



(b) Is m directly proportional to v? Explain your answer.

____

____

____

(c) Use the graph to find v when m =1

Thank you for completing learning activity 10. Now check your work. Answers are at the end of the module.

NOW REVISE WELL USING THE MAIN POINTS ON THE NEXT PAGE.

Summary

You will now revise this module before doing **ASSESSMENT 1**.
Here are the main points to help you revise. Refer to the module topics if you need more information.

- Measurement is defined as the act of finding the size of a physical quantity. An example of measurement means the use of a ruler to determine the length of a piece of paper.
- There is an international system of units called the SI system (*Systeme International d'unites*) which is most commonly used around the world and by scientists.
  Measurable features or properties of objects are often called physical quantities. All physical quantities should be quoted with their numerical value and their unit.
- Fundamental quantities (or base quantities) are those which are used to define all other quantities (derived quantities). In this system seven units are defined for the fundamental or basic quantities. These are:
  - Length is measured in a unit called metre. Instruments used to measure length include the ruler, the micrometer and the vernier caliper.
  - Mass is a measure of the amount of material in a body. Mass measures in grams or kilograms. It can be measured using a beam balance.
  - Time is usually measured in seconds using a stopwatch.
  - Current is measured using an ammeter. The unit used is ampere.
  - Temperature is measured using a thermometer and the unit used is Kelvin
  - Luminous intensity which has a unit of candela.
  - Amount of matter is measured using the unit mole
- Derived units can be divided into two groups
  1. Those that have a special name and symbol such as Watt (W) , Hertz (Hz) Joule (J) Newton (N).
  2. Those that do not have special symbol and name such as volume , density, velocity and force.
- A multiple of a unit in the international system is formed by adding a prefix to the name of that unit. The prefixes change the magnitude of the unit by orders of ten like, for example, the prefix Milli is added to a standard unit meter. We call it millimeter.
- Every physical quantity can be expressed in terms of its basic dimensions of mass, length, time, etc. Dimensions of a quantity are placed in square brackets [ ], i.e. [M] for mass, [L] length, and [T] for time.
- All measurements include errors or uncertainties, either systematic or random.
- Powers of 10 are called 'scientific notation' which has a general formula of $M \times 10^n$, where M is a number between 1 and 10 and n is the positive or negative exponent.
- The order of magnitude is the power of 10 closest to the number.
- Significant figures are those digits in a number that are known with certainty plus the first digit that is uncertain
- Scalar quantities have magnitude only. They can be added, subtracted, multiplied and divided by normal arithmetic.
- Vector quantities have direction as well as magnitude. They must be added by parallelogram rule (head to tail)

- Graphs have two axes. The horizontal or x –axis is the independent variable or cause. The effect of that cause is plotted on the vertical or y-axis. Because the effect is dependent on the cause, the y-axis is the dependent variable.
- The equation for the straight line graph always takes the general form of $y= mx + c$, where x and y are the variables, m the gradient of the line, and c is the intercept on the vertical axis.
- The graph of data is a straight line through the origin, then the variables are in direct proportion to each other.

We hope you have enjoyed studying this module. We encourage you to revise well and complete Assessment 1.

NOW YOU MUST COMPLETE ASSESSMENT TASK 1 AND RETURN IT TO THE PROVINCIAL CENTRE CO-ORDINATOR.

✓ Answers to Learning Activities 1 -10

Learning Activity 1

1. (a) 3 (b) 1 (c) 2 (d) 4 (e) 1 (f) 4 (g) 2
2. 34.7 + 19.65 = 54.35 so there are 4 sig figs in the sum of these set of data
3. Area = length x width
   Units of (area) = units of (length x width)
   = metre x metre
   = metre^2 or m^2

Learning Activity 2

1. (a) 2.7×10^7 (b) 7.12×10^{-6} (c) 8.21×10^2
   (d) 1.01×10^{-4} (e) 8.125×10^{10} (f) 2.05×10^{-9}

2. (a) 5 800 000 (b) 0.00000632 (c) 85600
   (d) 0.00252 (e) 23 000 000 000
   (f) 0.000 000 000 0610

3. 2.8×10^3

4. a) 2.98×10^8km/s b) 1.0×10^{13}km

Learning Activity 3

1. a) magnitude, unit
   b) derived
   c) prefixes
2.

Base quantity	Name of base unit	Symbol quantities
Length	**meter**	**m**
Mass	**kilogram**	**kg**
Time	**second**	**s**
Electric current	**ampere**	**A**
Temperature	**kelvin**	**K**
Luminous intensity	**candela**	**Cd**
Amount of substance	**mole**	**mol**

3. (a) 330mA = A

1A = 1000mA

330/1000 = 0.33A

(b) 6.3km= m

1km= 1000m

6.3 x 1000 = 6300m

(c) 1MJ= 100 000 000J

2MJ x 1 000 000 000 = 200 000 000J

(d) 1g = 1000mg

18 / 1000 = 0.018g

(e) 1kg =1000g

2000/1000 = 2kg

(f) 1km= 1000

= 18 x 1000 = 18000m

4. 1 kilo-ampere = 1000000 milliamperes

Smaller to bigger unit operation used is division

2/1000000= 0.000002 milliamperes

5. 1MW = 1 000 000 000mW

0.0345mW/ 1 000 000 000= 3.45 x 10^{-11}MW

Learning Activity 4

1. (i) 10^5 (ii) 10^{-3} (iii) 10^2 (iv) 10^8

2. (i) 3.2 x (32 x10^6) = 192 000 000 = 1.92 x 10^8 = 10^8
Therefore order of magnitude is 10^8

(ii) 800 000÷ 400 = 2000 = 2.0 x 10^3 = 10^3
Therefore order of magnitude is 10^3

Learning Activity 5

1. 0.0753

2. (a) 1m = 100cm

$35 \div 100 = 0.35m$

(b) 1kg = 1000g

$562 \div 1000 = 0.562kg$

(c) $1ml = 1cm^3$

$2ml= 2cm^3$

(d) 1.5 hr convert to minutes 1.5 x60= 90 minutes convert to seconds 90 x 60 = 5400 sec.

3. (i) D= m/v m = D x v (derived from the equation of density)

$D= 0.5 \times g/cm^3 \times 1cm^3 = 0.5g$

(ii) m= D x v

0.5 x 2 = 1g

(iii) m= D x v

0.5 x 10 = 5g

4. (i) D = m/v

$D = 100g \times 10cm^3$

= 1000g/cm

(ii) D = m/v

$= 98g \times 2.5 = 245g/cm^3$

5. D= m/v m = D x v

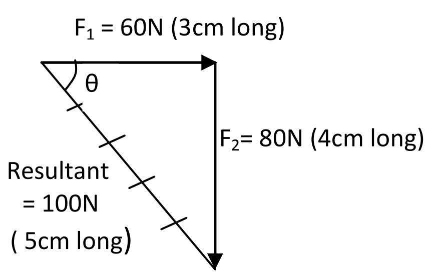
$= 3000kg/\cancel{m}^3 \times 5\cancel{m}^3 = 15,000kg$

6. D= m/v

$D= 33g \ X \ 30cm^3 = 990g/cm^3$

Learning Activity 6

1. Use a scale of 1cm=20N

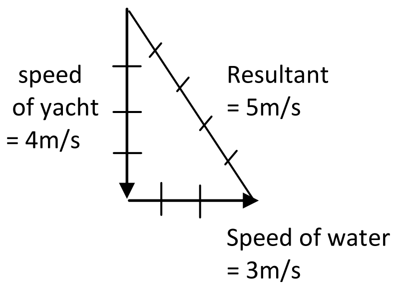


Resultant = 100N at an angle of 53° to the 60N force

Alternatively, we could have used the Pythagoras's Theorem and trigonometry to find the resultant and angle

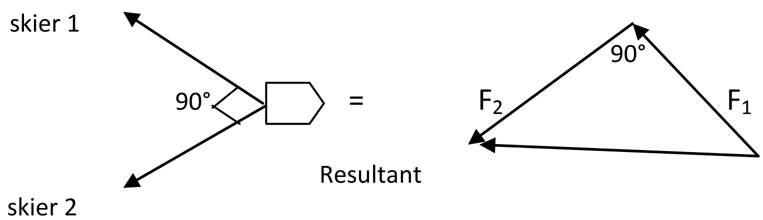
$R = \sqrt{60^2 + 80^2}$ = 100, tan θ = 80/20, so θ = 53°

2. Draw a scale diagram.



Resultant = 5km/h in a direction S36.9° E

3.



Resultant = $\sqrt{500^2 + 500^2}$ = 707.1 N at 45° to each rope

4. (a) 14kg (b) 2N

Learning Activity 7

a. Data: s = [L] u = $[LT^{-1}]$ t = [T] a = $[LT^{-2}]$

Solution:

$[L] = [LT^{-1}][T^1] + \frac{1}{2}[LT^{-2}][T^2]$

$[L] = [LT^0] + [LT^0]$

[L] = [L] + [L] The constants are removed.

[L] = 2[L]

[L] = [L]

Therefore the equation is dimensionally correct.

b. Data: $v = [LT^{-1}]$ $a = [LT^{-2}]$ $t = [T]$ $u = [LT^{-1}]$

Solution:

$[LT^{-1}] = [LT^{-1}] + [LT^{-2}][T^{1}]$

$[LT^{-1}] = [LT^{-1}] + [LT^{-1}]$

$[LT^{-1}] = 2[LT^{-1}]$

$[LT^{-1}] = [LT^{-1}]$

Therefore, the equation is dimensionally correct.

c. $\frac{1}{2}mv^2 = Fs$ where m = mass,v^2 = velocity, F = force = mass x acceleration and s = distance

Data: $m = [M]$ $v = [LT^{-1}]$ $F = ma = [MLT^{-2}]$ $s = [L]$

Solution:

$= [M][LT^{-1}]^2 = [M] \times [LT^{-2}] \times [L]$

$= [M]\ [L^2\ T^{-2}] = [M]\ [L]^2\ [T]^{-2}$

$= [ML^2T^{-2}] \quad = [ML^2T^{-2}]$

Therefore the equation is dimensionally correct.

Learning Activity 8

1. (a) 1.7 % (b) 2.6% (c) 6.7%

   (d) No the speedometer is not consistent

2. 0.96%

3. (a-b) = (0.25± 0.03)mm

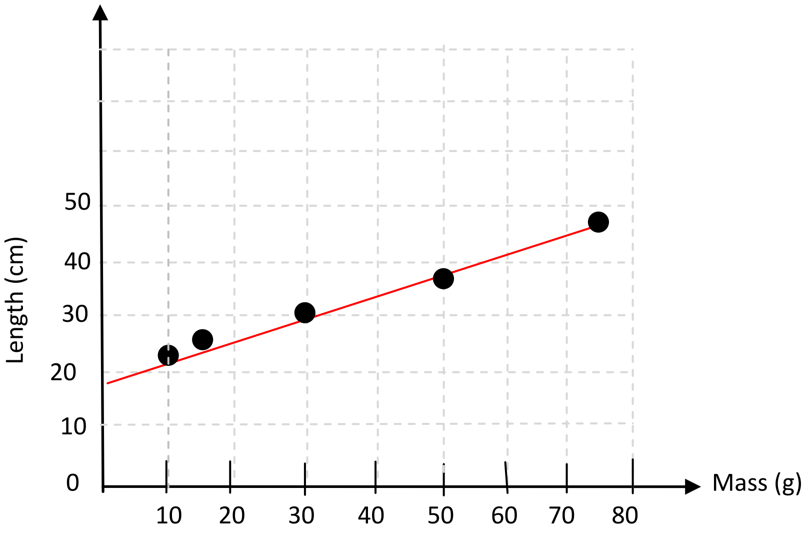
   0.03/ 0.25 x 100 = 12%

Learning Activity 9

1. 8.93mm
2. 7.64
3. 7.6052-7.6039 =0.0013cm convert to m
   1m = 100cm = 0.0013/100 = 0.000013m
4. 37.5 or 37±.5
5. 2.76cm

Learning Activity 10

1.



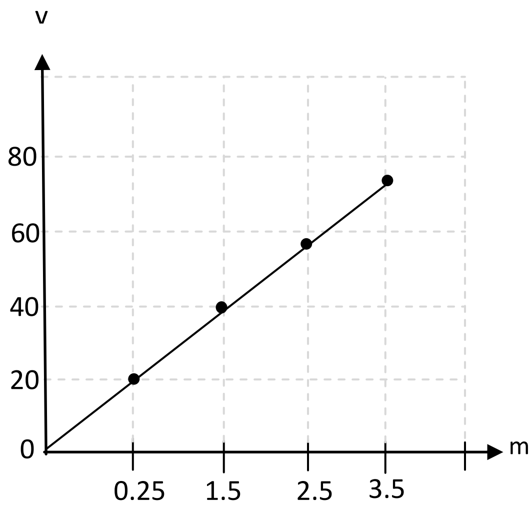
(a) L-intercept = + 18, gradient = 0.4 (approximately)
Formula: L = 0.4M + 18

(b) 18cm

(c) Greater extension is provided in this spring for the same load

(d) 44cm

2. (a)



(b) no

(c) 32

If you have queries regarding the answers, then please visit your nearest FODE provincial centre and ask a distance tutor to assist you.

References

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PC NO.	FODE PROVINCIAL CENTRE	ADDRESS	PHONE/FAX	CUG PHONES	CONTACT PERSON		CUG PHONE
1	DARU	P. O. Box 68, Daru	6459033	72228146	The Coordinator	Senior Clerk	72229047
2	KEREMA	P. O. Box 86, Kerema	6481303	72228124	The Coordinator	Senior Clerk	72229049
3	CENTRAL	C/- FODE HQ	3419228	72228110	The Coordinator	Senior Clerk	72229050
4	ALOTAU	P. O. Box 822, Alotau	6411343 / 6419195	72228130	The Coordinator	Senior Clerk	72229051
5	POPONDETTA	P. O. Box 71, Popondetta	6297160 / 6297678	72228138	The Coordinator	Senior Clerk	72229052
6	MENDI	P. O. Box 237, Mendi	5491264 / 72895095	72228142	The Coordinator	Senior Clerk	72229053
7	GOROKA	P. O. Box 990, Goroka	5322085 / 5322321	72228116	The Coordinator	Senior Clerk	72229054
8	KUNDIAWA	P. O. Box 95, Kundiawa	5351612	72228144	The Coordinator	Senior Clerk	72229056
9	MT HAGEN	P. O. Box 418, Mt. Hagen	5421194 / 5423332	72228148	The Coordinator	Senior Clerk	72229057
10	VANIMO	P. O. Box 38, Vanimo	4571175 / 4571438	72228140	The Coordinator	Senior Clerk	72229060
11	WEWAK	P. O. Box 583, Wewak	4562231/ 4561114	72228122	The Coordinator	Senior Clerk	72229062
12	MADANG	P. O. Box 2071, Madang	4222418	72228126	The Coordinator	Senior Clerk	72229063
13	LAE	P. O. Box 4969, Lae	4725508 / 4721162	72228132	The Coordinator	Senior Clerk	72229064
14	KIMBE	P. O. Box 328, Kimbe	9835110	72228150	The Coordinator	Senior Clerk	72229065
15	RABAUL	P. O. Box 83, Kokopo	9400314	72228118	The Coordinator	Senior Clerk	72229067
16	KAVIENG	P. O. Box 284, Kavieng	9842183	72228136	The Coordinator	Senior Clerk	72229069
17	BUKA	P. O. Box 154, Buka	9739838	72228108	The Coordinator	Senior Clerk	72229073
18	MANUS	P. O. Box 41, Lorengau	9709251	72228128	The Coordinator	Senior Clerk	72229080
19	NCD	C/- FODE HQ	3230299 Ext 26	72228134	The Coordinator	Senior Clerk	72229081
20	WABAG	P. O. Box 259, Wabag	5471114	72228120	The Coordinator	Senior Clerk	72229082
21	HELA	P. O. Box 63, Tari	73197115	72228141	The Coordinator	Senior Clerk	72229083
22	JIWAKA	c/- FODE Hagen		72228143	The Coordinator	Senior Clerk	72229085

FODE SUBJECTS AND COURSE PROGRAMMES

GRADE LEVELS	SUBJECTS/COURSES
Grades 7 and 8	1. English
	2. Mathematics
	3. Personal Development
	4. Social Science
	5. Science
	6. Making a Living
Grades 9 and 10	1. English
	2. Mathematics
	3. Personal Development
	4. Science
	5. Social Science
	6. Business Studies
	7. Design and Technology- Computing
Grades 11 and 12	1. English – Applied English/Language& Literature
	2. Mathematics - Mathematics A / Mathematics B
	3. Science – Biology/Chemistry/Physics
	4. Social Science – History/Geography/Economics
	5. Personal Development
	6. Business Studies
	7. Information & Communication Technology

REMEMBER:

- For Grades 7 and 8, you are required to do all six (6) subjects.
- For Grades 9 and 10, you must complete five (5) subjects and one (1) optional to be certified. Business Studies and Design & Technology – Computing are optional.
- For Grades 11 and 12, you are required to complete seven (7) out of thirteen (13) subjects to be certified.

Your Provincial Coordinator or Supervisor will give you more information regarding each subject and course.

GRADES 11 & 12 COURSE PROGRAMMES

No	Science	Humanities	Business
1	Applied English	Language & Literature	Language & Literature/Applied English
2	Mathematics A/B	Mathematics A/B	Mathematics A/B
3	Personal Development	Personal Development	Personal Development
4	Biology	Biology/Physics/Chemistry	Biology/Physics/Chemistry
5	Chemistry/ Physics	Geography	Economics/Geography/History
6	Geography/History/Economics	History / Economics	Business Studies
7	ICT	ICT	ICT

Notes: You must seek advice from your Provincial Coordinator regarding the recommended courses in each stream. Options should be discussed carefully before choosing the stream when enrolling into Grade 11. FODE will certify for the successful completion of seven subjects in Grade 12.

CERTIFICATE IN MATRICULATION STUDIES		
No	**Compulsory Courses**	**Optional Courses**
1	English 1	**Science Stream:** Biology, Chemistry, Physics
2	English 2	**Social Science Stream:** Geography, Intro to Economics and Asia and the Modern World
3	Mathematics 1	
4	Mathematics 2	
5	History of Science & Technology	

REMEMBER:
You must successfully complete 8 courses: 5 compulsory and 3 optional.