THE LESTER VAUGHAN SCHOOL

THIRD FORM PHYSICS MANUAL

INTRODUCTION – Physical Measurement and Units

ENERGY

FORCES

HEAT

ELECTRICITY

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REFERENCE BOOKS

Pople, *New Coordinated Science* – text book
Channon et al, *Mathematics for Caribbean Schools*
Farley & Trotz, *CXC Physics*

INTRODUCTION

Physics is a science of the physical world, it looks at how things work. It encompasses mechanics, light, heat, sound, magnetism, radioactivity, forces and energy. Without Physics the world would not be the same.

The very things we take for granted, electricity to run our appliances, vehicles to get us from place to place, machines to make work easier for us, computers and these things were created by Physicists.

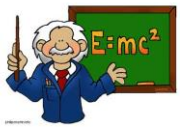
Careers in Physics include Mechanical, Structural and Electrical Engineering, Satellite Engineer, Sound Technician, Forensic Science, Astrophysicist, Pyrotechnician, Solar Energy Physicist, and a Weather Forecaster.

Mathematics is an important part of Physics, your responses to questions in physics will be achieved by the use of mathematical calculations. One of the most important concepts in physics is its practical nature, in that regard accurate readings are extremely essential.

HOW TO EXCEL IN PHYSICS

- **Pay attention in class**, if you are talking or distracted, you will be missing crucial information.
- **Speak up if you do not understand**. Since Physics is Maths based, if you have problems with Mathematics, you may have problems with the calculations in Physics.
- **Know how to use your calculator** properly and well.
- **Keep your equipment** at hand, you will need in addition to pens, a sharp HB pencil, clean erase, ruler, compass and protractor. Accuracy is a must in Physics.
- **Drawing Graphs** is an important skill in Physics, they often are used to display information achieved from an experiment.
- **Reading** – Physics require reading of both the notes you get from your teacher and the text book. It is the first step to learning your work.

- **Always study for tests.** This seems obvious but many students cram for tests the night or even worse, the morning of the day of the test. Studying should take place in stages and doing it right helps you succeed.
- **Use your syllabus to help you study.** The syllabus tells you exactly what you have to be able to do for each topic. Use it to test yourself.
- **Practicals** – take your practical work seriously, write them up properly and you'll never get less than an 'A'.
- **Projects and assignments** – follow the guidelines and you'll get an 'A' grade.
- **Standardized Test** – your standardized test in Physics will be after instruction.



Don't be afraid to try hard enough to find out how good you can really be.

SYLLABUS OBJECTIVES

FROM CCSLC MODULE 5

TOPIC	**DETAILS**
Physical Measurements and Units	SI system, prefixes, scientific notation, standard form, measurement, graphs
Energy	Definition of energy, sources of energy, forms of energy, energy conversions
Forces	Definitions force, weight, resultant forces, calculations of weight, mass and gravity
Electricity	Define electricity, circuits, safety precautions, fuses, electric meters and bills, conservation of energy
Heat	Difference between heat and temperature, thermal expansion, heat transfer – conduction, convection and radiation, insulators and conductors, ventilation

PHYSICAL MEASUREMENT AND UNITS

In science we can make qualitative and quantitative statements. When we make an observation such as" the metal bar expands when heated"; we are making a qualitative statement. When we are taking measurements and we state that "the metal bar expands 2.6 mm"; we are making a quantitative statement. Whenever a quantitative statement is made, the number should always include a unit.

All measurements have units and in order to avoid confusion, we use **S.I. Units** (a universal and standard system of measurement)

International System of Units

Fundamental Quantity		Base SI Unit	
Name	**Symbol**	**Name**	**Symbol**
Mass	m	Kilogram	kg
Length	l	Metres	m
Time	t	Seconds	s
Current	I	amperes	A
Temperature	T	Kelvin/ degrees Celsius	K °C
Amount of substance	n	Mole	mol
Luminous Intensity	I_V	Candela	cd

Sometimes Physicists must use units that are very small or very large. Submultiple units are smaller than the basic unit and multiple units are larger than the basic unit. The base unit is either multiplied by a multiple of 10 (multiple) or divided by a multiple of ten (submultiple)

Common Prefixes

PREFIX	**MULTIPLE**	**DECIMAL EQUIVALENT**	**SYMBOL**
Giga	10^9	1 000 000 000	G
Mega	10^6	1 000 000	M
Kilo	10^3	1 000	K
PREFIX	**SUBMULTIPLE**	**DECIMAL EQUIVALENT**	**SYMBOL**
centi	10^{-2}	0.01	c
milli	10^{-3}	0.001	m
micro	10^{-6}	0.000001	µ
nano	10^{-9}	0.000000001	η
pico	10^{-12}	0.000000000001	p

You must be able to convert units to higher or lower units. If you want to convert a smaller unit to a larger unit, you must divide the number by an appropriate multiple of ten.

Example 1: Convert 6000g =_________kg

First differentiate between the **unit** and the **prefix**. The unit is g (**representing grams**) and the prefix is K (**representing Kilo**). ***HINT PRE means before, hence the PREFIX ALWAYS comes BEFORE the unit.***

If the prefix is located on the right hand side we divide by the prefix to get the final answer. Therefore the answer becomes:

6000 ÷ 1000 = 6 kg

Answer: 6000g = 6 kg

Example 2: Convert 7000mm =_________m

Prefix is m (milli), Unit is m (meters)

If the prefix is located on the <u>left hand side</u> we <u>multiply</u> by the prefix to get the final answer. Therefore the answer becomes:

$7000 \times 0.001 = 7m$

Answer: 7000mm = 7 m

ALTERNATIVE (using Exponents – powers of 10)

$7000 \times (10^{-3}) = 7m$

Answer: 7000mm = 7 m

<u>EXERCISE 1:</u> 1. Convert the following showing all working:

a. 1 g=_______mg
b. 1 kg=_______g
c. 1 kg=_______mg
d. 4 km=_______m
e. 5 km=_______mm
f. 200mm= ______m

2. Write down the values of
   a) 300 cm in m
   b) 500 g in kg
   c) 1500 m in km
   d) 250 ms in s
   e) 0.5 s in ms
   f) 0.75 km in m
   g) 2.5 kg in g
   h) 0.8 m in mm

<u>Standard Form</u>

This is a more convenient way of writing numbers which are very large or very small. To write a number in standard form we try to get it in the following format. ***A × 10^B^*** ***Where A is a number between 1 and 9 and B is either a positive or negative whole number.***

<u>Example 3</u>

On the following page - convert the following into standard form

a) 15700
1.57×10^4

b) 200
2.00×10^2

c) 0.00729
7.29×10^{-3}

d) 0.000059
5.9×10^{-5}

If you have to add two standard numbers you can change them both to ordinary form, add them and convert them back to standard form.

Example 4

$3 \times 10^4 \quad + \quad 5 \times 10^2$
= 30 000 + 500 = 30 500 = 3.05×10^4

HINT

For whole numbers count the number of digits after the first number.
For e.g. 5600 – there are three digits after the 5. The standard for is 5.6×10^3. This is because $10^3 = 10 \times 10 \times 10$

For decimal numbers count the number of zeros after the decimal place as well as the first non zero number. For e.g. 0.0025, this would be two zeroes and first not zero number is 2, hence 3 digits. The answer in standard form is 2.5×10^{-3}. This is because $10^{-3} = 1/10 \times 10 \times 10$

EXERCISE 2

1. Express the following numbers in standard form

1. 9 000 000
2. 600
3. 89 000
4. 55
5. 0.245
6. 0.00098

2. Use your calculator or the method above to work out the following,.

a) $(1.8 \times 10^4) \times (1.2 \times 10^5)$
b) $(9.6 \times 10^2) \div (3 \times 10^{-3})$
c) (5×10^2) x (8 x 105)
d) 4.8 x 107) ÷ (8×10^3)
e) $(7.5 \times 10^3) + (1.4 \times 10^5)$
f) $3.4 \times 10^3 + 6.2 \times 10^3$
g) $9.37 \times 10^4 - 6.51 \times 10^4$

DENSITY, MASS AND VOLUME

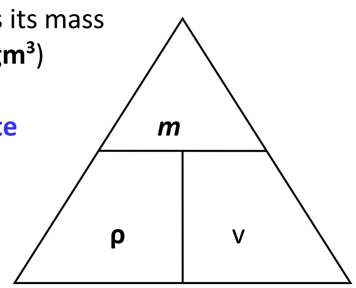
DEFINITIONS:

Mass (m): The mass of an object is the amount of matter it contains. (**Units: kg, g**)

Volume (v): The volume of an object is the amount of space the object takes up. (**Units: m^3, cm^3, Litres**)

Density (ρ- pronounced 'rho'): The density of an object is defined as its mass per unit volume. (**Some units: kg/m^3, kg/cm^3, g/m^3, kgm^{-3}, $kgcm^{-3}$, gm^3**)

Formula: **HINT: You can use a triangle to figure out how to calculate any component of density. If you want to work out the mass, put your finger over the m. Mass = density x volume**



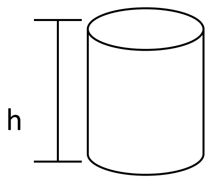
density = $\frac{mass}{volume}$ $\qquad \rho = \frac{m}{v}$ $\qquad$ *Units: kg/m^3 or g/cm^3*

Density is an example of a derived S.I. quantity. Notice the units of density are made up or two basic units.

In order to determine the density of material, we need to find the mass which can be easily determined accurately by using the scale. If the object is a regular shape object we can determine the volume by using the appropriate formula. However, if the object has an irregular shape we can determine its volume by measuring the amount of water displaced in a measuring cylinder.

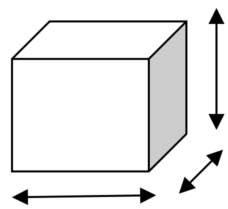
VOLUME OF REGULAR SHAPES

Cylinder



Volume = $\pi r^2 h$

Cube/Cuboid



Volume = length × width x height (L x W x h)

Volume of Liquids

To find the volume of a liquid, we can either use a measuring cylinder, burette or pipette. When reading the volume from these instruments; you should read the bottom of the **curved *meniscus*** and make sure your eye is on the same horizontal as the ***meniscus*.** If you are using a measuring cylinder, it should be on a flat level surface.

Example 5

Calculating Density, volume and mass

a) A piece of metal has a mass of 140g and a volume of 20cm^3. Calculate the density of the metal.

m = 140g **v =20cm^3**

$$\rho = \frac{m}{v}$$

$$\rho = \frac{140}{20}$$

$$\rho = 7g/cm^3$$

The final answer can also be written as: $\rho = 7gcm^{-3}$

b) A body has a density of 0.25g/cm^3. If the mass is 120g, calculate the body's volume.

$$v = \frac{m}{\rho}$$

ρ = 0.25g/cm³ **m = 120g**

$$v = \frac{120}{0.25}$$

$$v = 480cm^3$$

Answer: Volume= 480 cm^3

c) Calculate the mass of a solid gold coin of volume 2.1cm^3, given that the density of the gold coin is 19g/ cm^3.

ρ= 19g/cm³ **v = 2.1cm³**

$$m = \rho \times V$$

$$m = 19g / cm^3 \times 2.1cm^3$$

$$m = 39.9g$$

Answer: mass = 39.9g

d) **Now try this one on your own**. The density of a container is 780 kg/m^3, if the mass of the container is 15600g, calculate the volume of the container.

<u>EXERCISE 3</u>

1. A metal ball has a mass of 2kg and a volume of 6 m^3. What is its density?
2. Water has a density of 1 g/ml. What is the mass of the water if it fills a 10 ml container?
3. A certain gas expands to fill a 3 L container. Its mass is measured to be 0.6 kg. What is its density?
4. A solid is 5 cm tall, 3 cm wide and 2 cm thick. It has a mass of 129 g. What is its density?
5. What is the volume of a marble that has a mass of 3 g and d density of 2.7 g/ml?
6. Water is most dense at 4 degrees Celsius. Since at this temperature 1 ml of water has a mass of 1 g, its density is?
7. A perfect cube has a width of 2 cm. What is the cube's volume? Show your work!
8. A box 5 cm long, 4 cm wide and 6 cm high would have what volume? Show your work!
9. Samples of three unknown liquids have been obtained. Calculate the density of each. Show your work!
   - Sample A has a mass of 24.0 g and a volume of 6.0 ml.
   - Sample B has a mass of 12.0 g and a volume of 6.0 ml.
   - Sample C has a mass of 12.0 g and a volume of 3.0 ml.

GRAPH WORK

Notes on drawing a graph

1. ***Chose the largest convenient scale for your axes*** – make sure that all your readings will fit on the graph paper before you decide on each scale.
2. ***Label your axes*** – each axis should show what is being measured and the units being used.
3. ***Plot the points with small x's or dots with circles***
4. ***Draw the best line you can through the points this is known as a best fit line***

Decide whether the line should go through the origin. Sometimes when we plot our points we realize that they do not "line up" to give us the perfect straight line graph. We need to draw a "**best fit line**".

Steps to drawing a best fit line:
First, we try to balance the ruler so that it passes through as many points as possible, however, we need to make sure that:

(i) the same number of points are above the "best fit" line as below the line.
(ii) the points not on the line are the same distances from the line.
(iii) then draw the straight line or smooth curve which goes closest to most of the points.

[Remember ALWAYS choose new points which lie on the line to calculate the gradient]

5. ***Do not forget to write the title of the graph***.
6. $$Gradient(m) = \frac{y_2 - y_1}{x_2 - x_1}$$

Example 6
A student adds a substance to a measuring cylinder and recorded the mass and the volume as shown in the table below.

Mass / (g)	5	15	25	30	60
Volume / (cm^3)	1	3	5	6	12

(a) Plot a graph of **mass (y - axis) against volume (x - axis)**. **This question can appear written in various forms, which all mean the same thing. For example: it may also appear as: Plot a graph of mass versus volume. Similarly, the First ONE (mass) will <u>ALWAYS</u> be on the Y-axis and the Second (volume) on the X-axis.**

Using a scale of: 2 cm represents 5 g
1cm represents 1 cm^3

Then carefully look at your scale above and determine which represents the y- axis and x- axis

(b) Determine the gradient and state the units of the gradient.
(c) What does the gradient represent?

EXERCISE 4

1. Draw a graph using the information shown in the table below

Mass / (kg)	1	2	5	6	12
Density / (kg/m^3)	10	20	50	60	120

(a) Plot a graph of mass against density

Using a scale of: 2 cm represents 1 kg

1cm represents 10 kg/m^3

(b) Determine the gradient and state the units of the gradient.

(c) What does the gradient represent?

2. Draw a graph using the information shown in the table below

Mass / (g)	5	13	17	21	25	29	40
Volume / (cm^3)	0	10	15	20	25	30	40

(a) Plot a graph of mass against volume

Using a scale of: 1 cm represents 2 g

2cm represents 5cm^3

(b) Determine the gradient and state the units of the gradient.

(c) What does the gradient represent.

3. The force acting on different masses was recorded as shown below.

Force / (N)	0	5	10	16	20	24
mass / (kg)	0	1	2	3	4	5

(a) Plot a graph of Force against mass

Using a scale of: 1 cm represents 1 N;

2cm represents 1 kg

(b) Determine the gradient and state the units of the gradient.

(c) If an object made of the same material used in the experiment has a mass of 3.5 kg, what is the force acting on it?

4. Draw a graph using the information shown in the table below

Mass / (kg)	1	2	5	6	11
Density / (kg/m^3)	10	20	50	60	120

Plot a graph of mass against density

Using a scale of: 2 cm represents 1 kg;
1cm represents 10 kg/m^3

(d) Determine the gradient and state the units of the gradient.
(e) What does the gradient represent?

ENERGY

Energy is defined as: the ability to do work.

SOME COMMON TYPES /FORMS OF ENERGY

- Heat (thermal) energy
- Electrical energy
- Sound energy
- Nuclear energy
- Light energy
- Mechanical energy
- Magnetic energy
- Potential energy - The potential energy of the body is the energy it possesses because of its position or state.
- Kinetic energy - the energy a body possesses because of its motion

Exercise 5
Research and write down definitions for the energies above from Heat to Magnetic energy.

SOURCES OF ENERGY

The sun is our most important source of energy. Without it plants would not be able to photosynthesise and make food that we rely on to live. The energy stored in food is chemical energy. Most of the energy we use to generate electricity comes from

(1) Coal, (2) Oil, (3) Natural gas, (4) water (hydroelectric) and (5) Nuclear fuel.

It is interesting to note that oil and natural gas were all formed from living organisms that died millions of years ago so without the sun they would not be in existence. The use of these traditional fuels can be quite harmful to the environment.

DISCUSSION

Discuss some of the effects of using fossil fuels, water and nuclear fuels on the environment, including the Green House Effect.

Some alternative sources of energy are far more environmentally friendly and include:

(1) Solar, (2) wind, (3) geothermal energy and (4) waves.

Do you know what these sources of energy are referred to? Hint it starts with R……

DANGERS OF COMBUSTION

Combustion produces carbon dioxide, which contributes to the Greenhouse effect. It also produces sulphur dioxide and nitrogen oxides. These gases cause acid rain which corrodes buildings, acidifies waterways and kills wildlife. Leaded petrol releases dangerous lead compounds into the atmosphere.

The following have been done to reduce the harmful effects of burning petrol. Carbon monoxide gas is released during combustion; carbon monoxide is poisonous. It has a greater affinity to hemoglobin than oxygen and thus replaces oxygen in the blood and tissues.

THE LAW OF CONSERVATION OF ENERGY

Energy cannot be created or destroyed but it can be converted from one form to another.

ENERGY CONVERTERS

Many household appliances change energy from one form to another. **They are called energy converters or transducers.** When energy is converted none of it is destroyed even though some can be wasted (converted to a form which is not useful to us).

There are many examples of machines which convert **potential energy into kinetic energy**. The stretched string of a bow possesses potential energy which is converted into kinetic energy of the moving arrow.

Examples of energy Transformations and their uses

- A television changes electrical energy into light and sound energy. During this transformation energy is lost due to heat.

  Electrical energy → light + sound + heat energy
- A toaster changes electrical energy into thermal energy and light.

  Electrical energy → Heat energy + light energy
- A car changes chemical energy from the fuel into thermal and mechanical energy.

  Chemical energy → Heat energy + mechanical energy
- A car battery changes chemical energy into electrical energy and thermal energy.

  Chemical energy → Electrical energy + thermal energy

This electrical energy is then changed into light, sound and again thermal energy.

- A light bulb changes electrical energy into light and heat energy.

  Electrical energy → light energy + heat energy

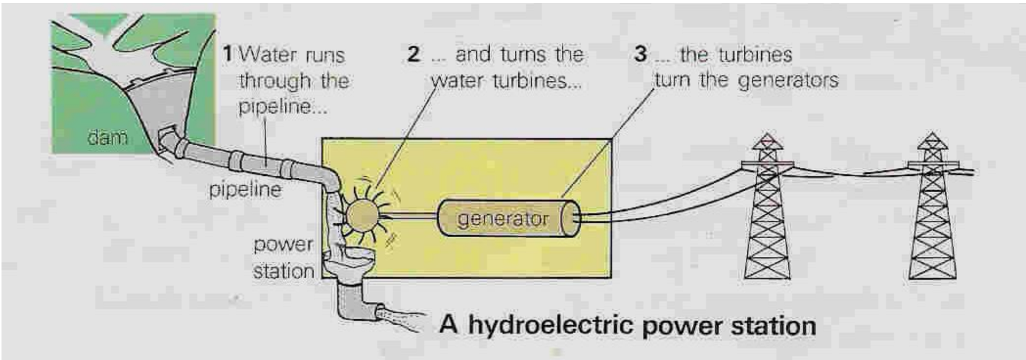
A lot of money is spent on energy sources (fossil fuels). This is why energy conservation is essential in our homes and industries.

DISCUSSION

1. Why do you think humans need to reduce their reliance on fossil fuels?
2. What ways can you save energy at home?

ENERGY CONSERVATION

- Turn off lights when they are not being used.
- Unplug appliances that are not in use.
- Do not leave the fridge door open unnecessarily.
- Use fluorescent lights instead of filament lights.
- If you are going to leave your computer for a short time, do not turn it off. More energy is required to boot up your computer than if you leave it on. Use the stand by or sleep mode instead.
- Energy houses are being built which reduces the amount of fuel needed to be burnt to keep them warm.
- Cars are being fitted with catalytic converters which remove most of the sulphur dioxide and nitrogen oxides from exhaust gases.
- Energy efficient engines burn less fuel.
- Unleaded gasoline eliminates the release of lead compounds into the atmosphere.
- In some Latin American countries cars are being powered by a mixture of gasoline and ethanol.



The water at the top of a waterfall possesses both potential energy and kinetic energy when it reaches the bottom all of this energy is converted to kinetic energy and it can be used to drive turbines to create electricity.

Exercise 6

1. Write down the energy changes occur in the following devices?
   A microphone, an electric kettle, a drilling machine, and atomic bomb, a candle and a flash light.
2. Photosynthesis is a special type of energy converting process. What is the energy of photosynthesis? What type of energy is produced from photosynthesis? Why is photosynthesis one of the most important energy changing processes on earth?

FORCES

Definition: A force is defined as either a push or pull.

Force is measured in a **unit called Newtons (N).**

Some common examples of forces are:

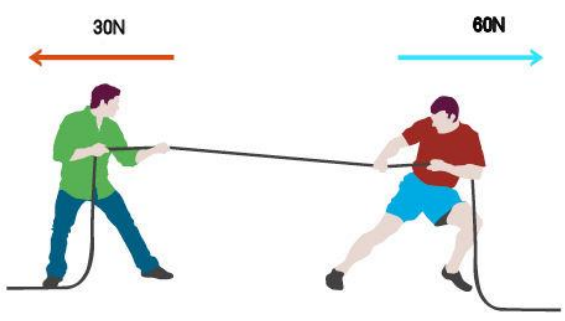
a) Weight- downward pull of gravity on a body.
b) Tension- the force exerted by a stretched rope or string.
c) Friction- a force which acts opposite to the direction of motion and slows/stops an object. Examples are air and water resistance.

Combining Forces (Resultant Forces)

On Earth, very few objects have just one force acting on them. Usually there at least two forces acting though the same point. When this occurs we can combine the forces to form the Resultant Force (the total force or net force).

Example 7

Consider the diagram below where two men are pulling a rope. The man on the left is pulling at 30N to the left and the man on the right is pulling at 60N to the right. What is the resultant force and direction will the rope be pulled?



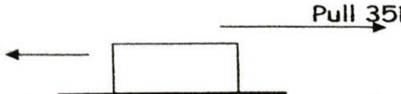
We can calculate the resultant force by using:
Resultant force = 60N-30N = 30N.
Hence the rope will be pulled to the Right.

NOTE: Now we have made one critical assumption always used throughout our physics. The Direction to the RIGHT is POSITIVE, the direction to the LEFT is NEGATIVE. Similarly, when applicable the direction UPWARD is POSITIVE and DOWNWARD is NEGATIVE.

Exercise 7

For each scenario, calculate the resultant force and indicate what direction the object will move.

Resultant Forces

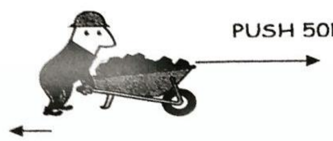


Resultant force = 35N - 10N
25N

Box will move to the right

Work out the following resultant force calculations and state what direction the object will move:

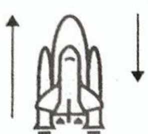
1.



Resultant Force =

Wheelbarrow will move to: ______________

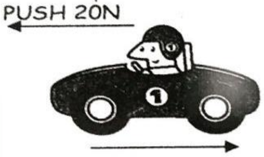
2.



Resultant Force =

Rocket will move: ______________

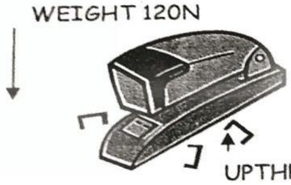
3.



Resultant Force =

Car will: ______________

4.



Resultant Force =

Stapler will move: ______________

5.

Resultant Force =

Canoe will: ______________

MASS, WEIGHT AND GRAVITY

MASS

The mass of an object is the amount of matter it contains. The mass is unchanged no matter where you are in the universe. (As we learnt previously, the SI unit of mass is the kilogram (kg).

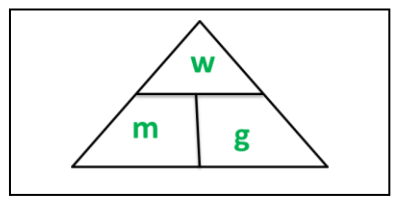
WEIGHT

Weight is the force on a body caused by gravity. The weight of an object depends on where the object is in the universe. Weight of a body is determined by the gravitational pull on that body. We can determine the weight by using the formula: Weight = Mass x Gravity (W= m x g). The unit is the Newton (N).

GRAVITY

Gravity is the pull of a large body on a much smaller body. The earth exerts a gravitational pull on objects which causes an acceleration of g of 10 m/s^2 (10 ms^{-2}). Gravity may also be expressed as 10N/kg which is called the gravitational field strength.

These three quantities can be expressed using the following triangle.



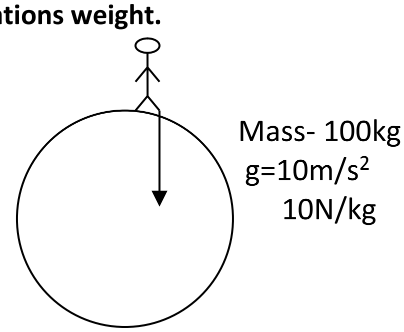
From the triangle we get the formula:

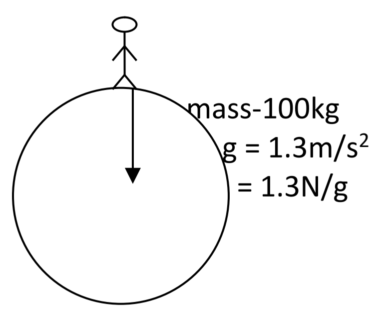
W=mx g

g= W/m

m=W/g

Consider the Example below where one person is on Earth and then on the moon. Look at the calculations weight.





Earth

W = m × g

= 100 × 10

W = 1000N

Weight on earth = 1000N

Moon

W = m × g

= 100 × 1.3

W = 130N

Weight on moon = 130N

So what does this mean?

On Earth a man of mass 100kg weighs 1000N. Since gravity on Earth is 10m/s^2 or 10 N/kg. On the moon the same man of mass 100kg weighs 130 N. Since gravity on the moon is 1.3m/s^2 or 1.3N/kg.

Exercise 8

Calculate the missing values from the table below. Be sure to show all your working.

Planet	Mass (kg)	Gravitational Field strength (N/kg)	Weight on the Planet (N)
Mercury	12	3.7	?
Venus	30	8.9	?
Earth	1000	?	9800
Mars	?	3.7	370
Jupiter	2.5	23.1	?
Saturn	25	?	225
Uranus	10	8.7	?
Neptune	0.05	11.0	?
Pluto	?	0.7	1.33

HEAT AND HEAT TRANSFER

We previously learnt that heat is a form of energy. It can cause the following things to occur:

- An increase in temperature
- An increase in size
- Changes of state from solid to liquid or gas or from liquid to gas.
- It may change the chemical composition of a substance.
- There may be a change in electrical properties of a material.
- There may be a change in colour.

DISCUSSION

What is the difference between heat and temperature?

DEFINITION

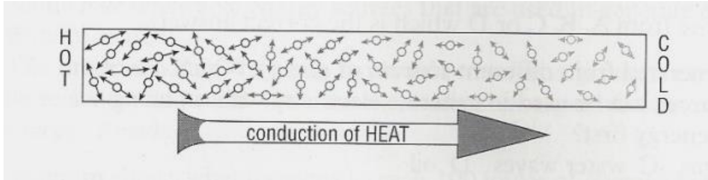
Heat is the form of energy transferred between two substances of different temperatures. This transfer of energy is from the higher temperature object to the lower temperature object.

Temperature is a measurement of the level (amount) of heat or degree of hotness of the body. It is also a measure of the average kinetic energy of the molecules of the body.

Heat may be transferred in any of three ways, **conduction, convection and radiation**.

CONDUCTION

Conduction occurs in solids which are **conductors**. In conduction, the heat is transferred through molecules which begin to vibrate when heated and pass the heat on to their neighbours in this way. See the diagram below, where heat travels from the hot to the cold side as these molecules vibrate. Substances which do not easily conduct heat are called **insulators.**



The knowledge of conduction can be applied in many everyday situations.

1. In the kitchen, appliances which get hot often have insulated handles or bottoms so as not to burn the surface on which they are placed.
2. In home construction, in cold climates the walls and roof are insulated to prevent the house from losing heat from within.
3. Ovens are insulated to help them maintain heat.
4. Clothing which is thickly padded traps air which is an insulator, hence wool and fur clothing keeps the person wearing them warm.
5. Substances which we want to heat up are made up of good conductors e.g. pots and pans used in the kitchen.

GOOD CONDUCTORS	POOR CONDUCTORS (INSULATORS)
Most metals e.g. copper, silver, aluminium, steel	Water, air, glass, wood, vacuum, plastic, cork, polystyrene, fibre glass.

CONVECTION

Convection only occurs in fluids – gases and liquids. Heat is transferred when the heated fluid rises and the cool fluid takes its place causing a **convection current**. The particles must move. The hot fluid rises because it becomes less dense.

> **DISCUSSION**
> Why cannot convection occur in solids?

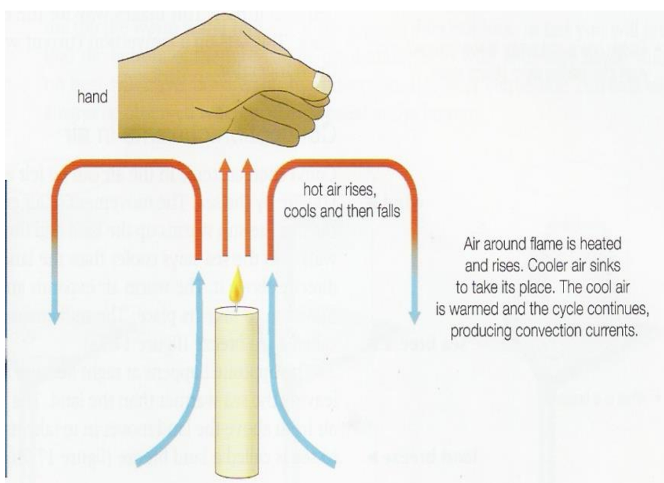


Figure 17.5 Demonstrating convection.

COOKING APPLICATIONS OF CONVECTION

Heat transfer in a cooker

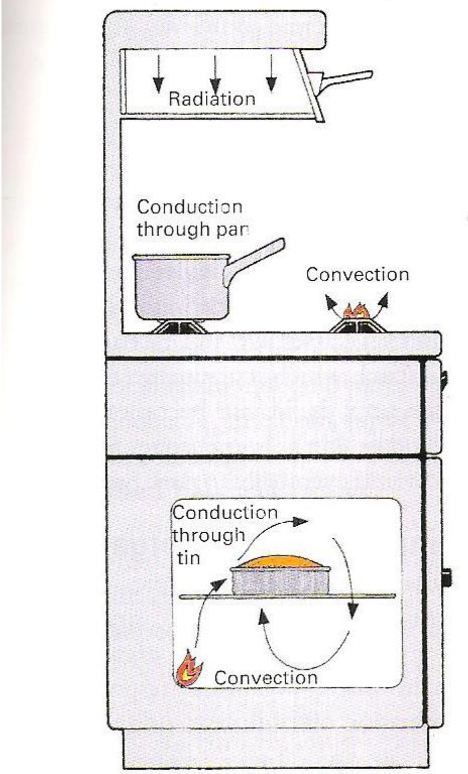
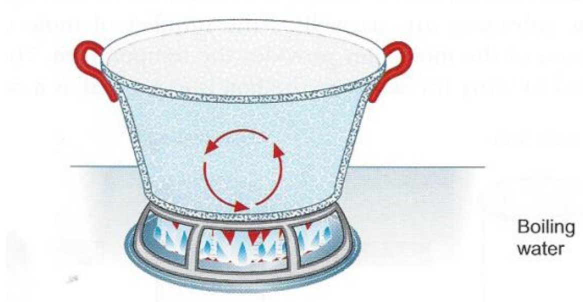
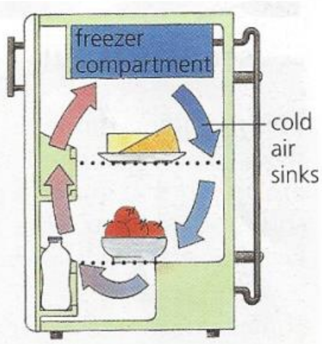


Figure 17.6 Convection currents in an oven.



In a refrigerator, cold air sinks below the freezer compartment. This sets up a circulation which cools all the food in the fridge.



Convection is the reason why a breeze blows from the sea during the day and towards the land during the night. In the day, the land gets warmer than the sea. Warm air rises from the land drawing cool air from over the sea. At night the sea is warmer than the land and warm air rises from it drawing cool air from the land.

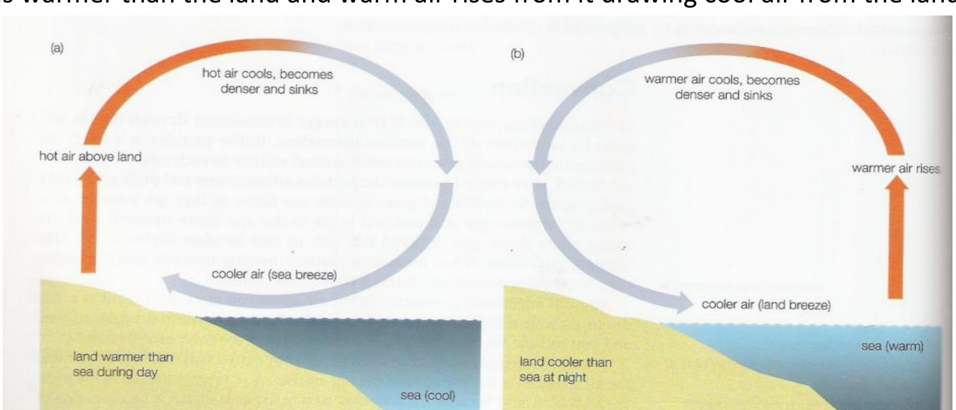
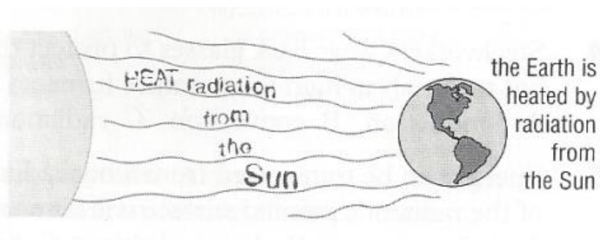


Figure 17.7 Convection currents in the air create land and sea breeze.

RADIATION (Radiant Energy)

Radiation does not need a material medium to travel through or molecules to carry the heat energy. i.e. this type of heat transmission can occur across a vacuum (open space). This is the way we get heat from the sun through the vacuum of space. **Radiation consists of electromagnetic waves**. These waves are partly absorbed and partly reflected by the surface which they hit.

- **Radiation** – when invisible, infra-red electromagnetic waves travel outwards from hot objects. Radiation involves waves and not particles so it can take place through a vacuum.



Radiation and type of Materials

The rate at which a body radiates heat energy depends on its temperature and the nature and area of its surface.

Black dull surfaces radiate more energy than highly polished white surfaces**. **Silvery surfaces are the worst emitters of radiation. This knowledge can be used for everyday use.

ABSORBERS		**EMITTERS**	
BEST	**Dull black**	BEST	**Dull black Surfaces are the BEST absorbers and BEST emitters of Radiation**
	Shiny Black		
	White		
WORST	**Silvery**	WORST	**Silvery surfaces are the WORST Absorbers and the WORSE emitters of Radiation**

Common everyday examples

- A person is cooler if she wears white coloured clothing rather than dark coloured clothing.
- Buildings painted white are cooler than buildings painted in dark colours.
- Brightly polished objects retain their internal energy for a long time. This is why pots and pans are often shiny and a silver teapot hold its heat better than one made from any other material since the ability to emit heat is greatly reduced.

VENTILATION

Proper ventilation helps people and other animals feel more comfortable. The body slows down when it is very hot thus people are not as productive when they are hot. Animals must also be kept cool, over heating of the body may lead to death.

EXERCISE 9

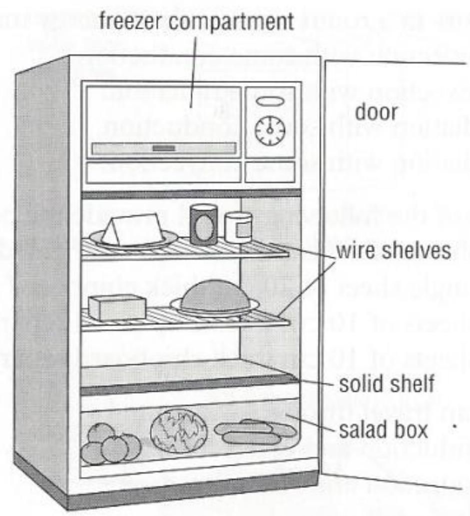
Question 1

Explain why:

a) In hot countries, houses are often painted white.
b) On a hot summer's day, the inside of a white car is cooler than a dark one.
c) If you use a lens to focus the Sun's rays on newspaper the print burns more easily than the white paper.

Question 2

This is the inside of a refrigerator.



a) How do convection currents keep the contents of the refrigerator cool? *4 marks*

b) The shelves in the middle of the refrigerator are made of plastic-coated wire. The shelf over the salad box is a sheet of glass.

(i) Why are wire shelves used in the middle of the refrigerator? *1 mark*

(ii) When food at room temperature is placed in the salad box, heat is conducted through the glass shelf as the food cools. Explain how heat is conducted through the glass shelf using the idea of particles. *4 marks*

QUESTION 3

Three kettles are used in an experiment

When the kettles are left to cool, this is what happens to their temperature:

	Temperatures in		
	Kettle A	**Kettle B**	**Kettle C**
	100	100	100
After 5 min	85	90	80
After 10 min	73	82	65

From the information which kettle:

(a) has the silvery surface?
(b) dull black surface?

ELECTRICITY

Electricity/ Electric current is defined as a flow of Electrons.

HOW IS ELECTRICITY PRODUCED?

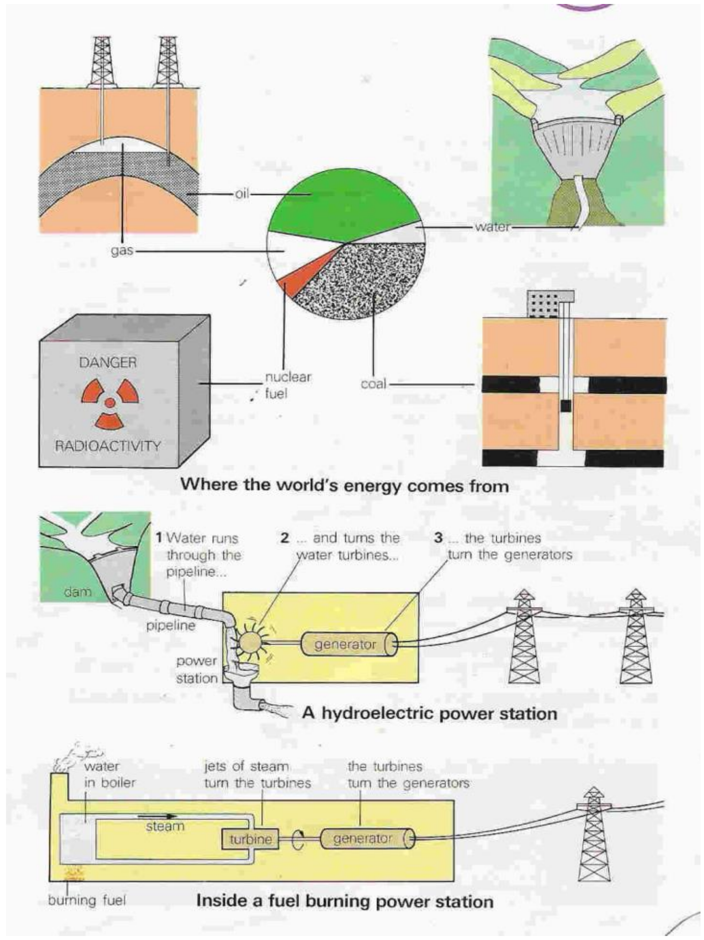
Hydroelectricity – is produced from the stored energy of water held back by a dam. As the water runs downhill from the dam through a pipeline to the power station, it turns water turbines. The turbines turn generators which produce electricity. The energy conversions are as follows:

Stored energy → moving energy (kinetic) → electrical energy

Fuel burning power station-The chemical energy in fuels e.g. coal, oil, gas or uranium (nuclear energy) is converted into heat energy which heats water into steam. The steam turns steam turbines and they turn generators.

Stored energy → heat energy →kinetic energy – electrical energy

See the diagrams below



Conductors and Insulators

Materials which allow electrons to easily pass are called **conductors**. Those which do not allow electrons to easily pass are called **insulators**. The table below highlights a list of good conductors and insulators.

GOOD CONDUCTORS	CONDUCTORS BUT NOT VERY GOOD ONES	INSULATORS
ALL METALS	Human bodies	Dry air
INCLUDING	Frog's legs	Plastic
Copper	Dirty water	Balloons
Silver	Salty water	Nylon socks
Gold	Damp air	Wood
Mercury	Sweaty hands	Rubber
Carbon	Cows on electric fences	Distilled water
	silicon	

THEORIES OF ELECTRIC CURRENT

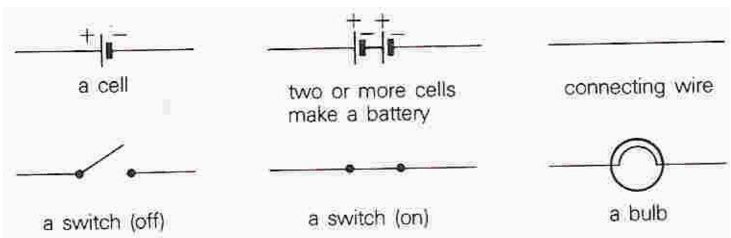
Conventional current flow

This is a flow of charge from the positive terminal to the negative terminal. This was the first means in which electricity/current was defined.

Electron Flow

This is a flow of electrons which move from the negative terminal to positive terminal. This was the later means in which electricity was defined.

Common Electronic Symbols



Circuit

A circuit is a closed loop where electrons flow. Electrons are pushed through a circuit by a battery (two or more cells). Electrons must have an unbroken pathway and prefer the easiest route. Thus electrons will travel along a thick wire in preference to a thin wire. This is illustrated in the diagram to the below.

Electric currents - are measured in amperes (A). The device which measures the current is called an ammeter. An ammeter has two connections: a positive (+) which is red and a negative (-) which is black. The ammeter must be connected the right way or the needle will move backwards instead of forwards.

See diagram on the next page.

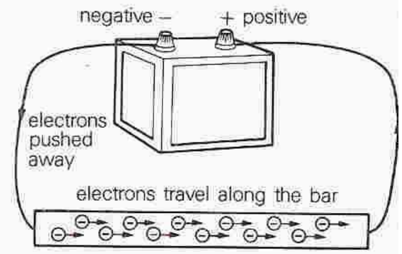


Figure 6 Electrons can be pushed through a metal bar by a battery.

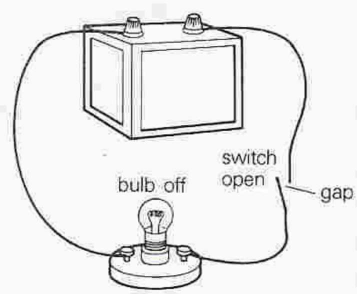


Figure 7 If a circuit is broken, electrons cannot flow.

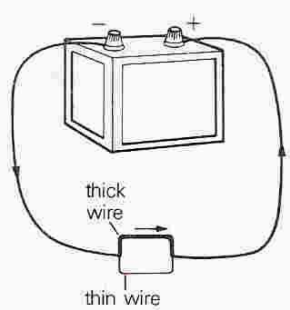


Figure 8 Electrons will travel along a thick wire in preference to a thin wire.

Voltage is the driving force or electrical push in a circuit. It is measured in volts (V) with a voltmeter. Voltmeters are connected across the component being measured.

Resistance- this is the ability of a material to resist the flow of current. A bulb in a circuit will add resistance to that circuit. Current can be increased in a circuit by lowering the resistance or increasing the voltage.
The reason why electricity flows through thick wires easier than thin wires is because they offer less resistance. Every material has an electrical resistance. The greater the material's resistance, the smaller the current which flows through it. **Resistance is measured in ohms (Ω).**

When a current flows through a wire, electrical energy is changed to heat energy. When a current is pushed through a high resistance wire by a large voltage, large amounts of heat is produced.

Electrical Quantity	**Instrument Used**	**Connection Made**	**Units**	**Symbol**
Voltage	Voltmeter	In parallel or across the Component	Volts	V
Current	Ammeter	In series or along with the component	Amperes	A
Resistance	Ohmmeter	In Parallel or across the component	Ohms	Ω

SERIES AND PARALLEL CIRCUITS

In a series circuit, the current is the same throughout the circuit. In a parallel circuit, the current splits up when it comes to a junction.

In a parallel circuit the current through the branches add up to the total current in the main part of the circuit.

EXERCISE 10

1. Define an insulator? Define a conductor?
2. Why are electric wires made of copper but coated with plastic?
3. (a) Why do firemen not wear metal hats?
   (b) Fishing near electricity wires is always dangerous, but using a carbon fibre rod makes it even more unsafe. Explain why.
4. Copper has a smaller resistance than nichrome. What does this mean?
5. What can you say about the resistance of (a) a conductor and (b) an insulator?
6. The resistance of a car headlight bulb changes after it has been switched on. The resistance increases as the bulb heats up. How will this affect the current flowing through the bulb? Explain.

RESEARCH

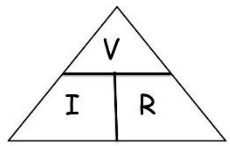
Draw an example of a SERIES CIRCUIT and a PARALLEL CIRUIT using lamps.

RELATIONSHIP BETWEEN CURRENT, VOLTAGE AND RESISTANCE

The relationship between current, voltage and resistance is defined by the triangle:

The Three (3) equations can be obtained:
V = I x R, I = V/R and R = V/I

Let us try to find the unknown quantity using the correct equation:



1. A 12 V car battery is connected to a circuit whose total resistance is 6Ω. What current will flow?

2. A 12 V battery is connected to a circuit. If the current is 2 mA, what must the resistance of the circuit be? **Hint you must first convert mA into A.**

3. What voltage battery would be needed to send a current of 3 A round a circuit whose total resistance is 4Ω?

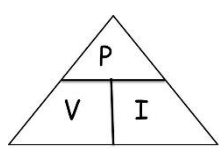
FUSES

The purpose of a fuse is to protect household equipment. If a current flowing through a wire is bigger than they are designed to take, the fuse will melt and stop all electricity going to a particular device. This also prevents the wiring from overheating, melting its insulation and starting fires. A fuse consists of a short length of thin wire with a low melting point, rather like solder.

POWER

The relationship between Power, Voltage and Current can be recalled using the triangle:

Power = voltage x current (P=V x I)
where power is measured in watts.
Similarly we can get **I=P/V or V=P/I**



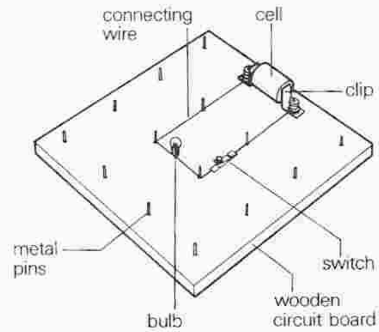


Figure 1 A simple electric circuit can be built on a circuit board.

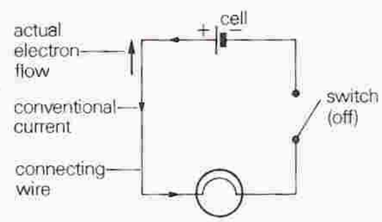


Figure 2 This circuit diagram is a map of the circuit in Figure 1.

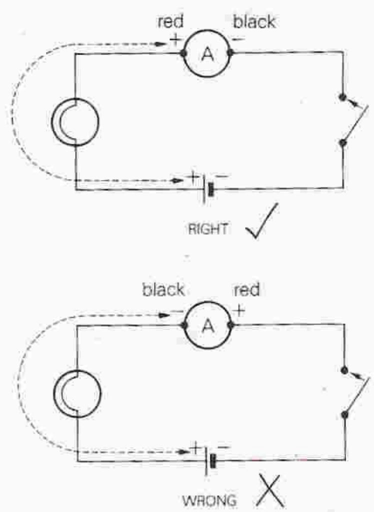


Figure 3 The red connection on an ammeter must be joined to the positive connection of the cell.

Example

An electric hand dryer rated at 1.1 kW is designed to run off the 110V mains. Suggest a suitable fuse for it.

NB. Recall your conversion first change the 1.1KW to W

1.1 kW = 1.1 x 1000= 1100 W,

Using our equation: **I = P / V = 1100 / 110 ∴ current I = 10 A**

The wiring to the appliance will have a current of 10 A. The fuse should be rated as close as possible to the rating current value, so early failure would protect all equipment. A fuse which would blow at 13 A or 15 A would be appropriate.

EXERCISE 11

List five safety precautions that should be observed when interacting with electricity.

CIRCUIT BREAKERS

Circuit breakers are more used instead of fuses. A circuit breaker contains little electromagnets connected in series with the rest of the circuit. If the current gets too high, the electromagnet becomes strong enough to operate a switch to turn it off.

Try this question

An extension cord, rated at 5 A, is bought to run a television set. Your mother unplugs the TV set and plugs in the electric iron (110 V, 1.1 kW) instead.

(a) Why is this a bad thing to do?
(b) What is likely to happen?
(c) What are the dangers?

A PLUG SOCKET

The third pin in a mains socket is the earth connection. The earth connection is connected by very low resistance wires to a metal plate or rod buried in the soil just outside the house. If an appliance has a metal case and something goes wrong with the wiring, the metal could become live (giving you an electric shock/ being electrocuted if you touch it).

IMPORTANCE OF THE EARTH WIRE

The earth wire serves as a protection mechanism that allows the current to pass to the earth instead of through you the consumer, hence a protection mechanism from electric shock/electrocution.

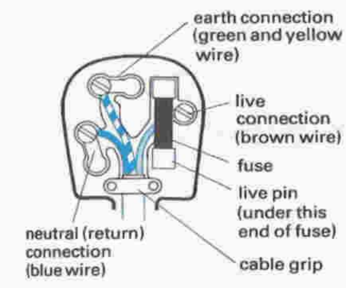


Fig. 50.7 How to wire a plug

50.5 How to wire plugs

The insulation round the wires in the cord of an appliance will be colour-coded to indicate which is which. These should be the colours:

BROWN: the live wire;
BLUE: the neutral (return) wire;
GREEN AND YELLOW: the earth wire, connected to the metal casing.

A two-pin plug connects just to the live and neutral wires; the extra pin in a three-pin plug is for the earth wire.

Warning! There may be local variations in the colours of the wires in some parts of the Caribbean. If in doubt, ask a qualified electrician.

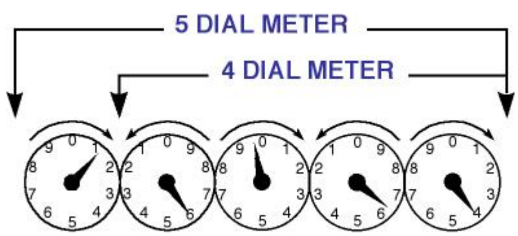
If you have to wire up a plug for yourself (Fig. 50.7), there are some important things which for safety's sake you must get right. The main ones are these:

1 Firmly connect the right wire to the right pin.

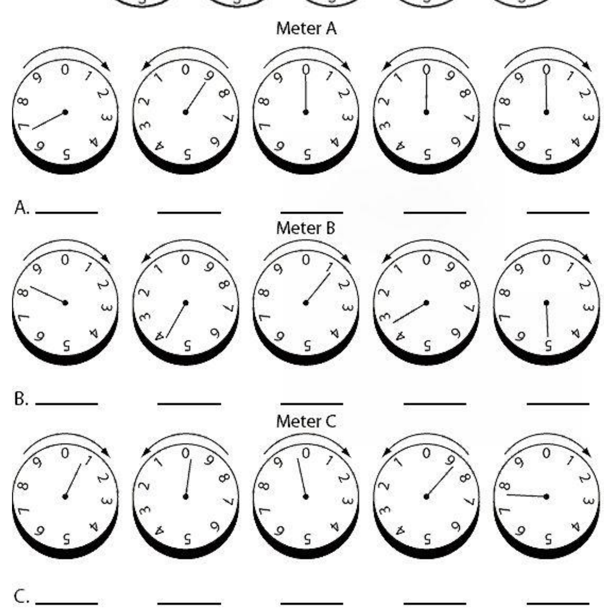
READING THE ELECTRIC METER

The total amount of electricity used is measured by an electric meter. Meters range from ANALOGUE (a dial type meter) and DIGITAL (a meter that gives a numeric value). The values achieved from each meter gives what is called the Kilowatts-hours (KWh), the amount of energy consumed.

The diagram below shows a reading obtained from an ANALOGUE electric meter. Notice how the final value of KWh is achieved.
KWh used = 15,964KWh



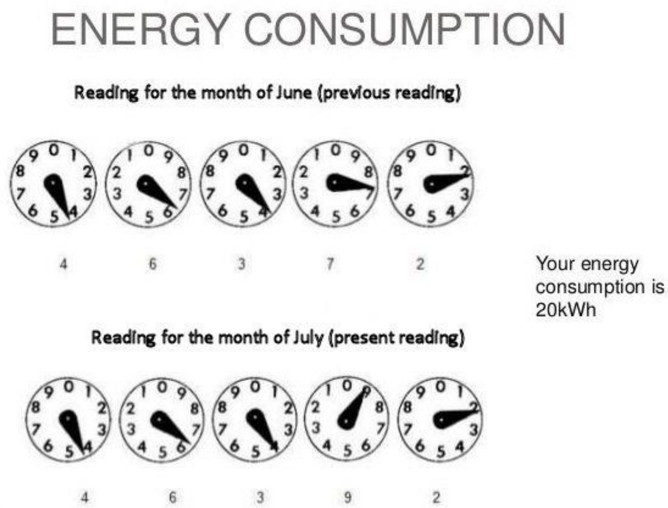
Determine the reading on the following meters A, B and C:



ELECTRICITY BILLS

To determine the amount of electricity used within a given period, for example a month, the meter is read before and at the end of the month. The two values obtained (current reading and previous reading) are then subtracted to obtain the KWh used. See the example below:

The KWh used is:
Present reading – previous reading
46, 392 – 46, 372 = 20KWh



<u>CALCULATING ELECTRICITY BILLS</u>

If electricity is charged according to the following rates:

Customer Charge (Fixed charge)- $10.00
Energy 1st Blk 150 KWh @ 0.15 per KWh
Energy 2nd Blk 68KWh @ 0.176 per KWh
Fuel KWh @ 0.336581
Vat 17.5%

If the present reading is: 24,126 KWh and the previous reading was: 23,908 KWh. **The cost of the Electricity used is calculated as follows.**

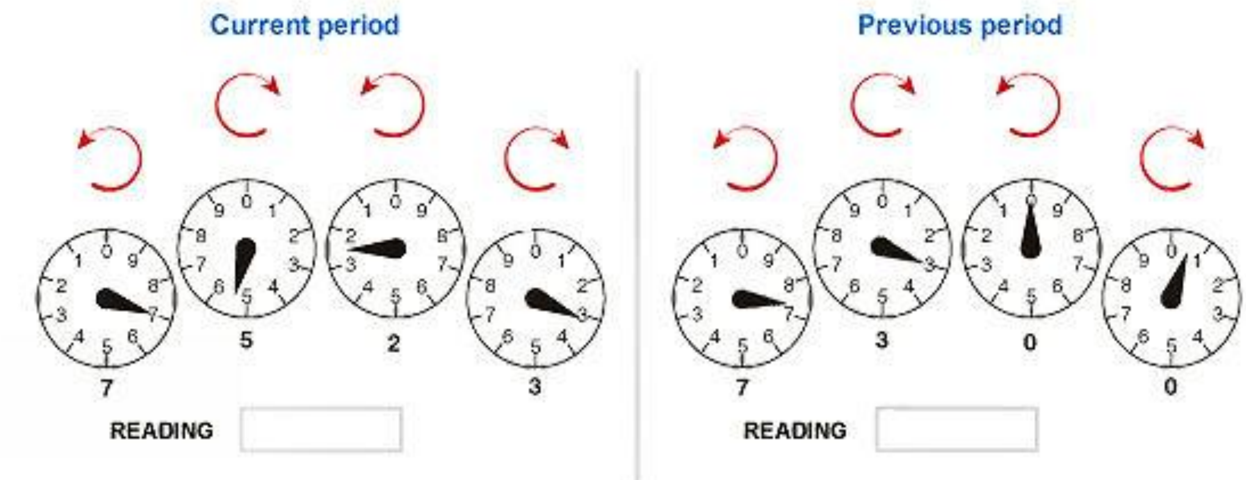
KWh used = 24,126 - 23,908 = 218 Kwh

Customer Charge (Fixed charge)	$10.00
Energy 1st Blk 150 KWh @ $0.15 per KWh	0.15 x 150 = $22.50
Energy 2nd Blk @ $0.176 per KWh	(218-150 = 68KWh) 0.176 x 68 = $11.97
Fuel KWh @ $0.336581	218 x 0.336581 = $73.37
TOTAL	**$117.84**
Vat 17.5%	(17.5/100) x 117.84 $20.62
FINAL TOTAL	**$138.46**

EXERCISE 13

Using the diagrams below determine the KWh used and hence calculate the total cost of the electricity bill using the scheme above.

A.



B.