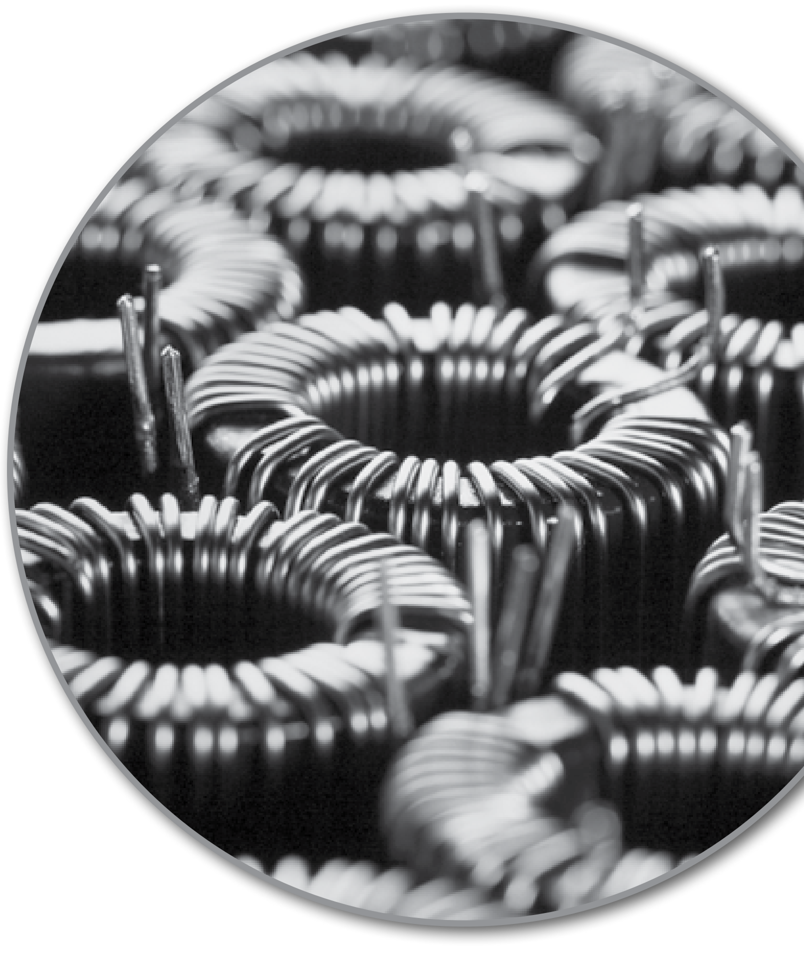
Fundamental
Physics
for O Level
Teaching Guide

Ian Collins



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Introduction to Fundamental Physics for O Level Teaching Guide

This Teaching Guide has been written for teachers preparing students for the O Level Physics exam and complements the material presented in the student's book, *Fundamental Physics for Cambridge O Level*.

This Guide contains a number of resources which will enable the teacher to deliver the course more easily and effectively:

Suggested demonstrations The demonstrations suggested in this Guide can be carried out by teachers before introducing a topic. These 20 demonstrations involve presenting material and conducting classroom activities to stimulate students' interest in a new topic. Clear instructions have been provided to guide teachers in conducting the demonstrations effectively.

Suggested investigations The investigations suggested in this Guide can be assigned to students after a certain topic has been discussed in class. These 25 investigations would help students to conduct research and design investigations independently outside the classroom to explore the topic covered in class. The instructions in the Guide offer sufficient flexibility to enable students to devise their own strategy without prescribing a particular method.

Suggested practical exercises This series of exercises provides guidance for practical work which might be used to support the content in the student's book. Each of the 25 exercises includes a list of materials and apparatus to be used, and step-by-step instructions on the collection of valid data. Materials and apparatus are chosen to be simple and readily available in most centres delivering this subject. Exercises are quantitative wherever possible, and each of them includes appropriate assessment opportunities.

Alternative-to-practical exercises Alternative-to-practical exercises have been included in this Guide to provide practice to students appearing for ATP exam. Effort has been taken to develop a questioning strategy and style that would enable students to prepare themselves for the final examinations. These 10 exercises cover most of the important topics from the curriculum and can be administered to students at the end of the relevant topics from the student's book rather than towards the end of the course.

Worksheets The worksheets included in this Guide have been developed to facilitate the teacher in providing reinforcement material to students after a topic has been covered in class. All of the 25 worksheets may be assigned either to be completed in class or as homework.

Assessment sheets The 25 assessment sheets provided in this Guide can be used to test students' comprehension after a topic has been completed in class. The assessment questions have been designed to enable students to grasp the questioning style they are likely to come across in their examinations.

Friction

This demonstration might be conducted in the classroom to support discussion on the effects of friction on the motion of an object.

Aim
To demonstrate friction

Equipment
- two textbooks

Method
1 Interleave two thick textbooks.
2 Have two students try and pull the books apart.

Explanation
As the pages are interleaved, the total friction between the two books is greater than the friction between two pages multiplied by the number of pages in each book.

The friction between pages depends on the weight of the other pages, and the force with which the books are pulled apart.

Circular motion

This demonstration might be conducted in the classroom to support discussion on circular motion.

Aim
To demonstrate that the centripetal force (and acceleration) of an object performing circular motion is perpendicular to the direction of velocity of the object

Equipment
- 1 m length of string
- cork

Method
1 Attach the cork to the string securely.
2 Swing the cork above your head and show that if you wish to launch the cork to the back of the classroom, e.g. from south to north, you have to let go of the string at the point where the string is perpendicular to that direction, e.g. west to east.

Explanation
Explain that a centripetal force is necessary for keeping an object moving in a circular path as opposed to a straight line.

Circular motion: centripetal acceleration

This demonstration might be conducted in the classroom to support discussion on circular motion.

Warning

It is worth practising this demonstration beforehand.

Aim

To demonstrate the existence of centripetal acceleration

Equipment

- bucket
- coin

Method

1 Place the coin at the bottom of the bucket.

2 Choose a location, either in the laboratory/classroom or playing field, where there is enough space to swing the bucket at arm's length.

3 Swing the bucket in a vertical plane.

Explanation

Explain that if the rotation speed is fast enough then the centripetal acceleration (force) acting on the coin at the top of the circular path is greater than the gravitational acceleration (force) at that point, and therefore the coin does not fall out of the bucket.

Inertia

This demonstration might be conducted in the classroom to support discussion on Newton's first law.

Aim

To demonstrate Newton's first law

Equipment

- coin
- card
- glass

Method

1 Place the card over the mouth of the empty glass.

2 Place the coin on the card.

3 Flick the card horizontally from under the coin.

Explanation

The coin is not rigidly fixed to the card and the friction between the two is negligible. This means that the inertia (reluctance to move) of the coin causes it to drop vertically under the influence of gravity into the glass.

This is similar to the waiter's tablecloth trick where he is able to remove the tablecloth from the table by pulling it horizontally leaving the plates, cutlery, and glasses in place. Do not try this! There are numerous videos on the Internet.

Atmospheric pressure

This demonstration might be conducted in the classroom to support discussion on atmospheric pressure.

Aim

To demonstrate that atmospheric pressure is applied in all directions

Equipment

- glass
- water
- grease-proof paper or a thin, light sheet of plastic

Method

1. Fill the glass with water so that it neither overflows nor leaves air pockets when the grease-proof paper is placed on top.
2. Place the grease-proof paper on top of the water to cover the glass.
3. Turn the glass upside-down.
4. The water should stay in the glass.

Explanation

When upside-down, the glass supports the atmospheric pressure from the sides and above. The atmospheric pressure pushes upwards onto the grease-proof paper ensuring that the water stays in the glass. If air is allowed into the glass the water will fall out.

Conclusion

Atmospheric pressure is unopposed in this demonstration.

Heat transfer: conduction

This demonstration might be conducted in the classroom to support discussion on good and bad conductors of heat.

Aim

To demonstrate the transfer of heat in solids

Equipment

- 1 aluminium plate, 30 cm × 30 cm
- 1 wooden plate, 30 cm × 30 cm
- 1 plastic plate, 30 cm × 30 cm
- tripod, gauze, and Bunsen burner
- aluminium, iron, copper, and stainless steel rods, coated with temperature-sensitive paint or wax, connected to a manifold

Demonstration 1

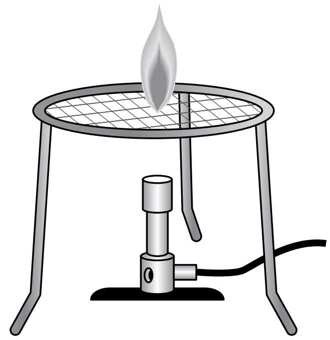
1 Hand around the plates made from different materials to the students.

2 The metal one should 'feel' colder than the other two even though they are at the same room temperature.

Explanation

Aluminium is a better thermal conductor and therefore removes more heat from the hand, making it feel colder.

Demonstration 2: the principle of the Davy safety lamp



1 Place the Bunsen burner beneath the gauze.

2 Open the gas tap.

3 Light the gas above the gauze.

4 The gas can pass through the gauze but the flame cannot pass below it.

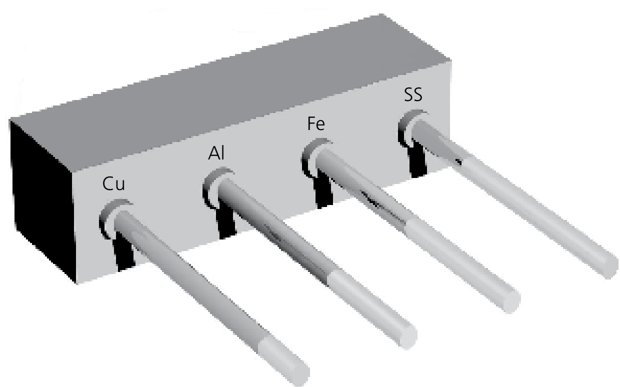
Explanation

The gauze conducts the heat away from the flame so that the temperature below the gauze remains lower than the ignition temperature of the gas.

Application

The Davy safety lamp avoided igniting pockets of flammable gases igniting in mines, which was a common occurrence when candles were used as sources of light in the mines.

Demonstration 3



1 Fill the reservoir with boiling water.

2 The length of rod over which the colour of the temperature-sensitive paint has changed should be visible.

Explanation

Each material has a different ability to transfer heat through conduction, known as its coefficient of thermal conductivity.

Heat transfer: convection

This demonstration might be conducted in the classroom to support discussion on convection in fluids.

Aim

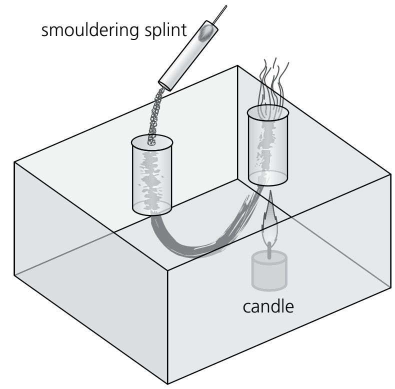
To demonstrate convection in liquids and gases

Equipment

- potassium permanganate crystals
- Bunsen burner, tripod, and stand
- large glass beaker
- pair of tweezers
- small candle
- smouldering splint
- model of a room with an open fire: a closed Perspex box with two openings on the top face and at either end of the box

Demonstration 1: convection in air

1. Light the candle and place it below one of the openings (chimney).
2. Hold the smouldering splint into the plastic box through the second opening.
3. Observe that the smoke is drawn down the opening, travels across the box, and then passes up the chimney above the candle.

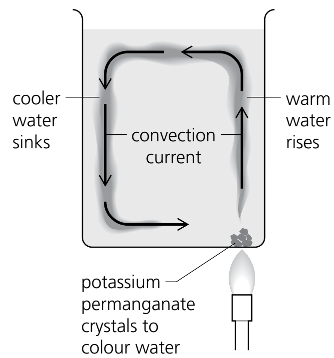


Explanation

As the hot air rises above the flame of the candle due to the reduced density of hot air, it draws in colder air towards the candle from the second opening. This demonstrates the natural convection currents created by a flame.

Demonstration 2: convection in water

1. Fill the beaker with water and place on a stand above the Bunsen burner.
2. Place two potassium permanganate crystals on the bottom of the beaker, towards the edge of the beaker.
3. Heat the bottom of the beaker at the location of the crystals.
4. Note the creation of convection currents.



Explanation

Hot water rises above where the Bunsen burner is heating the water due to the reduced density of hot water, and it draws in colder water towards this hottest point. This demonstrates the natural convection currents in liquids created by a source of heat.

Absorption of heat

This demonstration might be conducted in the classroom to support discussion on good and bad absorbers of heat.

Aim

To demonstrate that dark surfaces are better absorbers of heat than light surfaces

Equipment

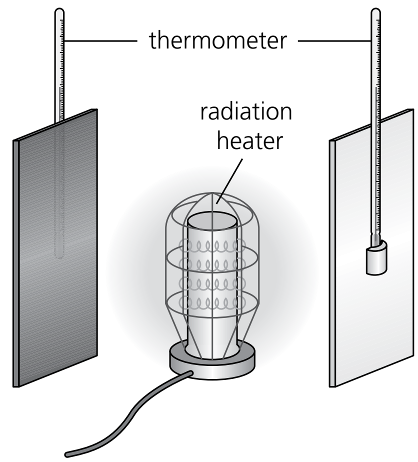
- 2 thermometers
- small radiant heater
- 2 plates, 4 cm × 4 cm, one painted black, one painted white

Method

1 Attach a thermometer to each of the plates.

2 Secure the two plates vertically with the thermometers pointing away from each other. Place the radiant heater between the plates, making sure that it is equidistant from each of them.

3 Note the temperature rise on both the plates.



Explanation

The black surface absorbs light more efficiently than the white surface. This is why the black plate heats up more quickly than the white one.

Application

To keep objects cooler in radiative heat, paint them white or silver to reflect the heat, e.g. white houses in hot countries, fire-fighters' suits, satellite electronics, etc.

To heat objects up in radiative heat, paint them black to absorb the heat, e.g. solar panels are always dark in colour.

Phase changes

This demonstration might be conducted in the classroom to support discussion on phase change.

Aim

To demonstrate that temperature remains constant during a phase change

Equipment

- temperature probe connected to a data logger with an output to a projector
- ice at a temperature below 0°C
- beaker
- tripod
- heater
- stirrer

Method

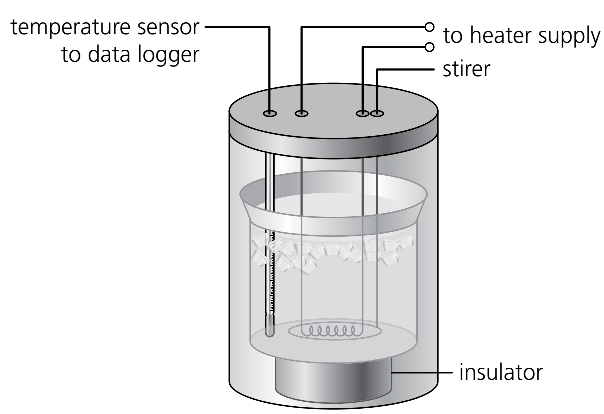
1 Fill the beaker with ice.

2 Position the temperature probe close to the bottom of the beaker but not touching it.

3 Switch on the heater.

4 Start recording the temperature as a function of time, e.g. at a rate of five measurements per second.

5 Stir regularly.



Observation

Note that the temperature does not change when it reaches 0°C, even if heat is being added, until all the ice has melted.

Plot the temperature-time curve and note its slope (gradient) before the phase transition and after the phase transition.

Explanation

As a substance changes phase, the energy input is used to modify the bonds between the molecules (potential energy) and not to increase their average kinetic energy (temperature).

The slope of the temperature-time curve is inversely proportional to the specific heat capacity of the substance. The slope in the liquid phase of water is approximately half the slope in the solid phase of water (ice).

The effect of pressure on the boiling point of water

This demonstration might be conducted in the classroom to support discussion on factors affecting evaporation and the boiling point of a liquid.

Aim

To demonstrate that boiling point is affected by pressure

Equipment

- glass bell jar that can be evacuated by a vacuum pump
- heater
- beaker of water
- thermometer

Method

1 Half-fill a beaker with cold tap water.
2 Place the beaker in the bell jar and evacuate the bell jar using the pump.
3 Observe the water boiling when the pressure is sufficiently low.
4 Vent the bell jar to atmospheric pressure.
5 Remove the beaker and pass around the class to test its temperature.

Explanation

Pressure affects the boiling point of a liquid. The lower the pressure, the lower the boiling point. This principle is true for all substances. The opposite effect is used in a pressure cooker where foods can be boiled at a higher temperature, taking less time to cook.

Thermal expansion

This demonstration might be conducted in the classroom to support discussion on the effects and applications of thermal expansion.

Warning

Use eye protection and a Perspex screen.

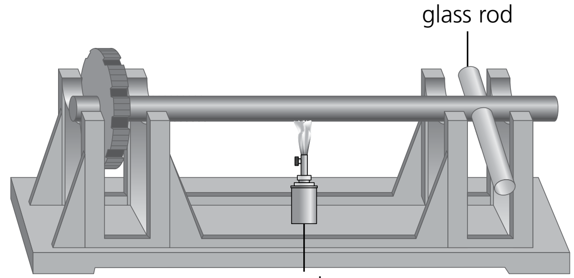
Aim

To demonstrate expansion and contraction with temperature in solids

Equipment

- anvil
- glass rod
- bimetallic strip
- butane torch
- metal sphere on chain and metal aperture small enough to just let the sphere pass through when cold

Demonstration 1



1. Place glass rod in the anvil and tighten until secure.
2. Heat the arm of the anvil until the glass rod breaks.

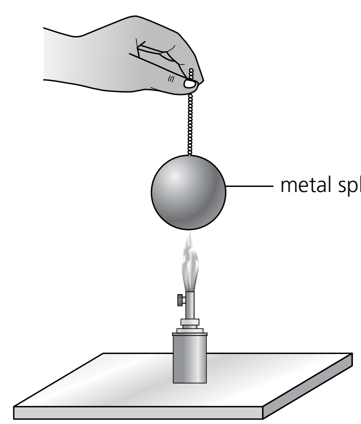
Explanation

Heat absorbed by molecules increases their kinetic energy and they become capable of maintaining large intermolecular distances. This results in expansion.

Application

Thermal expansion joints on buildings, bridges, railway tracks, electrical power lines, etc.

Demonstration 2



1. Show that the metal sphere can pass through the aperture when cold.
2. Heat up the sphere.
3. Show that the metal sphere can no longer pass through the aperture when hot.

Application: thermal bonding

Cooling down an object such as the sphere, to just fit into an aperture.

Separating two glasses stuck inside each other. To separate them, cool the inner one with cold water and heat the outer one with hot water. The contraction and expansion, respectively, should provide enough space to part the glasses.

Demonstration 3

1. Heat up the bimetallic strip to show that it bends as a result of the different coefficients of expansion of the two metals.
2. Cool it down to show that it bends in the opposite direction.

Application

Used as a temperature controller in electric irons, fire alarms, etc.

Molecular structure of solids, liquids, and gases

This demonstration might be conducted in the classroom to support discussion on the kinetic model of matter.

Aim

To demonstrate that intermolecular forces of attraction are strongest among molecules in solids, becoming weaker in liquids and weakest in gases

Equipment

- marbles
- tray
- book

Method

1 Place 8–10 marbles in a tray and shake them around. The marbles move around relatively freely across the tray.

2 Place a thick book as a barrier to divide the tray into half so that all the marbles are present in one half. Shake the marbles around. The marbles move less freely and knock about frequently.

3 Reduce the space available to the marbles by pushing the book further inwards and shake the marbles. The marbles hardly move away from their positions as the space is reduced.

Explanation

The marbles in the first step represent molecules in gases by large distances between them and their free movement. As the space in the tray is reduced, the molecules come closer together and move around less freely to represent molecules in liquids and solids.

Brownian motion

This demonstration might be conducted in the classroom to support discussion on factors affecting the motion of molecules.

Aim

To demonstrate the existence of molecules in air

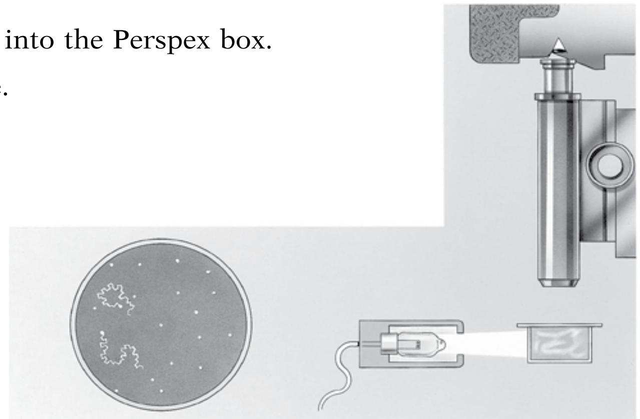
Equipment

- microscope (the images from a digital microscope, if available, can be projected for the whole class to see)
- Perspex box
- smoke from a smouldering splint

Method

1 Blow some smoke from the smouldering splint into the Perspex box.

2 View the smoke particles under the microscope.



Explanation

The molecules are invisible under an optical microscope, but their presence can be inferred from the motion of the much larger smoke particles. This interpretation of Brownian motion, together with his interpretation of the photoelectric effect, earned Einstein the Nobel Prize in Physics in 1921.

Sound propagation in a vacuum

This demonstration might be conducted in the classroom to support discussion on sound propagation.

Aim

To demonstrate that sound is a mechanical wave and cannot propagate in a vacuum

Equipment

- glass bell jar that can be evacuated by a vacuum pump
- battery-powered alarm clock
- foam pad to sit the alarm clock on, or a system to hang the alarm clock from the bell jar to minimize the propagation of sound through mechanical parts

Method

1 Set the alarm clock to ring indefinitely.

2 Place the alarm clock in the bell jar and evacuate the bell jar using the vacuum pump.

3 As the vacuum is created, the sound of the alarm decreases until it cannot be heard over the vacuum pump.

4 Switch off the vacuum pump and vent the system to atmospheric pressure.

5 The alarm can be heard again.

Explanation

Sound consists of mechanical waves and requires a medium to travel through. By removing the air from within the bell jar, the sound waves from the alarm clock can no longer propagate away from it.

Reflection, refraction, and total internal reflection

This demonstration might be conducted in the classroom to support discussion on reflection, refraction, and total internal reflection.

Warning

Wear eye protection. Never look directly into the beam of a laser. Stand out of the plane of the laser beam and behind the laser to avoid direct line of sight with it. Make sure that students do the same.

Aim

To demonstrate the principle of reflection, refraction, and total internal reflection at the water-air interface

Equipment

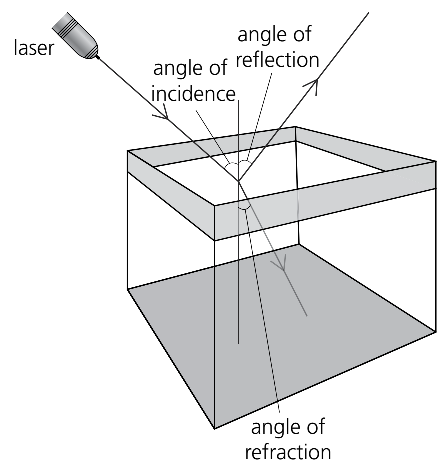
- small, rectangular fish aquarium
- one flat mirror, 5 cm × 4 cm, with a string glued to one end
- smoke machine or chalk dust
- laser
- colouring

Demonstration 1: reflection

1 Fill the tank with coloured water.

2 Arrange the laser such that the laser beam is incident at 45° to the air-water interface.

3 You should see the reflected beam of light at the air-water interface when smoke or chalk dust is present in the air above the water.



Explanation

On a smooth surface, such as a mirror, and at the interface between transparent media such as air and water, light can be reflected. The angle of reflection, as measured with respect to the surface normal, is equal to the angle of incidence.

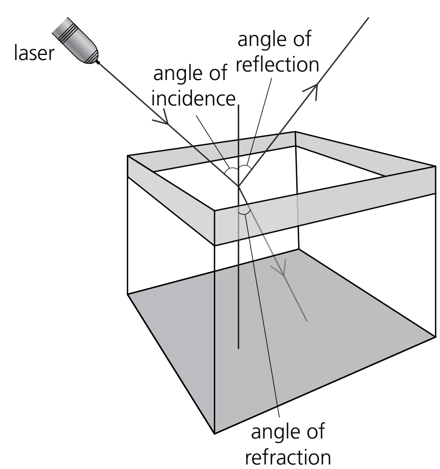
Demonstration 2: refraction

1 Fill the tank with coloured water.

2 Arrange the laser such that the laser beam is incident at 45° to the air-water interface.

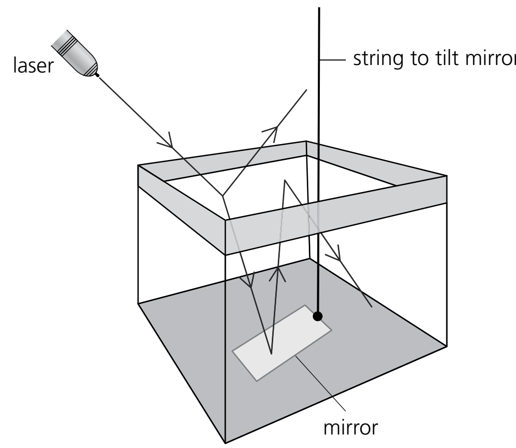
3 Illuminate the path of the laser beam using a smoke machine or chalk dust.

4 Note the change of direction of the incident beam of light from the laser in air and the beam in the water—the refracted beam.



Explanation
The speed of light in a transparent medium depends on the optical density through which it travels. If the beam of light is not at perpendicular incidence when it enters a new medium, then the change in medium results in a change of angle of the beam of light.

Demonstration 3: total internal reflection
1 Fill the tank with water.
2 Place the second mirror at the bottom of the tank.
3 Place the supported mirror at 45° above the tank.
4 Arrange the laser such that it enters the water hitting the mirror at the bottom of the water.
5 Using the string attached to the mirror, slowly raise one end of the mirror to change the angle of incidence between the laser beam and the mirror.
6 Increase the angle until the reflected beam hits the surface of the water and no refraction is seen. Beyond this angle the water-air interface becomes mirror-like and totally reflects the incident beam.



Explanation
On going from a more optically dense medium, such as water, to a less optically dense medium, such as air, the beam of light cannot be refracted into the less optically dense medium if the incident angle is greater than a certain value—the critical angle. Therefore, the beam can only be reflected, hence total internal reflection is observed.

Induced magnetism

This demonstration might be conducted in the classroom to support discussion on induced magnetism and magnetic and magnetized materials.

Aim
To demonstrate magnetic induction

Equipment
- bar magnet
- two iron nails, about 4 cm long

Method
1 Demonstrate that the two iron nails are not magnetized by bringing them together without them being attracted to each other.
2 Bring a nail close to one end of the bar magnet. Make sure it is clearly not touching the magnet.
3 Bring the second nail towards the first nail so that it touches it.
4 Observe that the nails are attracted to each other.
5 Remove the bar magnet. The nails lose their magnetization and are no longer attracted to each other.

Explanation
When a magnetic material is brought into a magnetic field the magnetic domains of that material align themselves to the magnetic field. This results in that material also becoming magnetic. A soft ferromagnetic material, such as iron, completely loses its magnetization once the external magnetic field is removed.

Water is a polar molecule

This demonstration might be conducted in the classroom to support discussion on electric charges.

Aim
To demonstrate that water is a polar molecule

Equipment
- slow stream of water from a running tap
- woollen cloth to charge the balloon
- balloon

Method
1 Blow up a balloon and tie a knot in it.
2 Run a tap to produce a slow but continuous stream.
3 Charge up the balloon by rubbing it against the woollen cloth.
4 Bring the charged balloon slowly towards the running tap.
5 Observe that the stream of water is attracted to the balloon.

Explanation
Water is composed of one oxygen and two hydrogen atoms. In forming the water molecule, the electrons from the hydrogen atoms spend more time around the oxygen than around the hydrogen atom. This means that the ‘centres’ of the positive and negative charges are not at the same point. By putting the water molecule in a radial electric field, provided by the charged balloon, the molecules align themselves to that field and are attracted to the source of the field.

Van de Graaff generator

This demonstration might be conducted in the classroom to support discussion on electric fields.

Warning
People with a heart condition, such as those wearing a pacemaker, must not come into close contact with a Van de Graaff generator in operation.

Aim
To demonstrate the effect of ionization of air, the effect of a lightning conductor on discharging a charged cloud, and to map the electric field around your head when charged

Equipment

- Van de Graaff generator
- earthed metal sphere
- sharp point
- electrostatic windmill: an ∫-shaped metal rod with tapered ends that can be balanced in the middle from a sharp vertical point from the top of the Van de Graaff generator so that it rotates freely
- plastic step or box that can support the weight of a person
- comb

Demonstration 1

1. Place the earthed metal sphere about 20 cm from the Van de Graaff generator. The best method to do this is to attach the earthing cable to the supply. If the earth used is the same as that of the Van de Graaff generator then the mains power might trip due to the current surge in the mains circuit during a discharge.
2. Switch on the Van de Graaff generator and observe the discharges that jump between the generator and the earthed sphere.
3. Switch off the generator and discharge it using the earthed sphere.

Explanation

Due to the electric field set up between the generator and the earthed sphere, ionization of the air occurs, providing a conduction path between the generator and the sphere. As the discharge occurs light similar to a lightning strike is generated and can be seen.

Demonstration 2

1. Repeat the above demonstration, but when the discharges between the generator and earthed sphere are occurring point a sharp point at the generator from a distance of about 1.5 m to 2 m.
2. Observe that the frequency of discharge reduces significantly or even ceases.
3. Stop pointing the sharp point at the generator and the discharges resume.

Explanation

Ionization of the air occurs at the tip of the sharp point causing an ion beam to slightly reduce the charge on the generator. This means that the generator takes longer to charge up for the electric field to be sufficiently high to cause ionization and a discharge between generator and earthed sphere. Lightning conductors not only provide a charged cloud and a safe current path to Earth, but also reduce the probability of a lightning strike by slowly discharging the cloud.

Demonstration 3

1. Attach the sharp point to the top of the generator onto which the electrostatic windmill can rest and rotate freely.
2. Switch on the Van de Graaff generator and observe the electrostatic windmill rotate.
3. Switch off the generator and discharge it using the earthed sphere.

Explanation

Ionization of the air occurs at the tips of the electrostatic windmill due to the accumulated charge at the points. This ionization causes a stream of ions to be emitted away from the tips of the windmill. The tips of the windmill recoil, due to the conservation of momentum, resulting in a rotation of the windmill.

Demonstration 4

1 Ask a volunteer with medium length hair to stand on the insulating step or box whilst touching the generator with one hand and holding the comb in the other. To avoid an electric shock it is important that the volunteer not let go of the generator or come into close contact with an object at Earth potential.

2 Switch on the Van de Graaff generator and observe the volunteer's hair stand up on end. The volunteer can make a most impressive effect if the hair is combed in an upward direction.

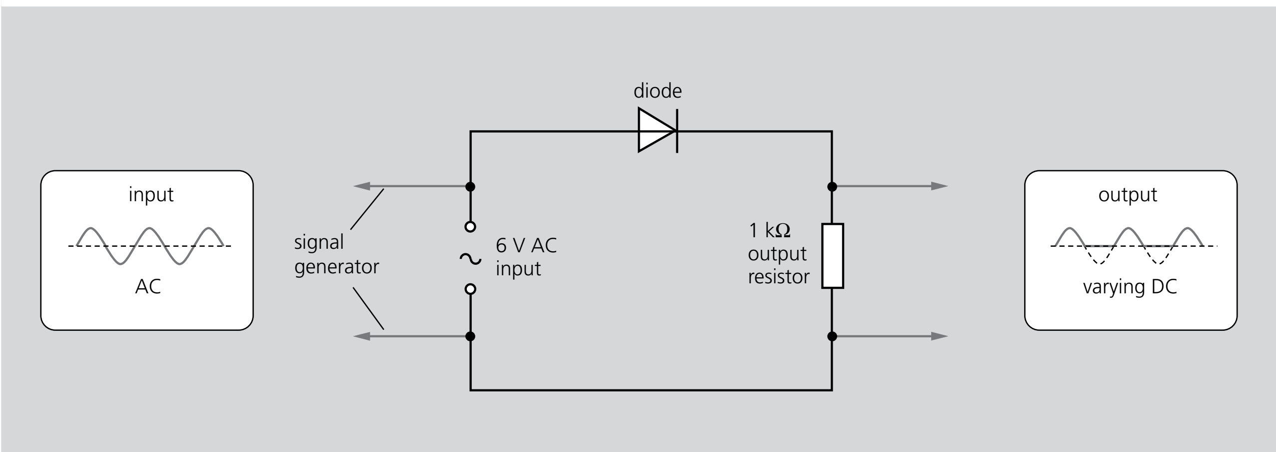
3 Switch off the generator and discharge it using the earthed sphere.

Explanation

The hairs on the volunteer's body become charged and repel one another. On the head they move as far as possible from one another by standing on end. In fact, they follow the electric field lines.

Rectification

This demonstration might be conducted in the classroom to support discussion on rectifying diodes.



Aim

To demonstrate the use of a diode as rectifier

Equipment

- wire cutters
- 9 V, 50 Hz sinusoidal signal generator
- oscilloscope with suitable cables and connectors
- diode
- 1 kΩ resistor

Demonstration

1 Construct the above circuit.

2 Observe the rectification on the oscilloscope.

Explanation
A single diode acts as a one-way gate, allowing current to flow in one direction only— forward bias. When the current is reversed the output is zero—reverse bias.

Cathode rays

This demonstration might be conducted in the classroom to support discussion on thermionic emission.

Warning
Take care when using high voltages.

Aim
To demonstrate the existence of cathode rays and to show that charged particles such as cathode rays can be deflected by electric and magnetic fields

Equipment
- cathode ray tube
- suitable power supply for the cathode
- voltage supply for the electric fields (acceleration and deflection)
- bar magnet

Method
1 Switch on the electron source.

2 Apply a sufficiently high voltage to the anode to accelerate the electrons so that they cause fluorescence when they hit the screen. This demonstrates the existence of particles that were created at the cathode, hence called cathode rays.

3 Apply a vertical electric field in the path of the cathode rays to the screen by applying a voltage to the horizontal deflection plates. Demonstrate that the beam is deflected in the vertical plane.

4 Reverse the direction of the field and demonstrate that the deflection is also reversed.

5 Bring a bar magnet close to the fluorescent screen so that its field is perpendicular to the beam direction to demonstrate that a magnetic field can deflect a charged beam.

Application
Cathode ray oscilloscope (see page 244 of the textbook).

Radioactivity (see page 253 of the textbook).

The nature of the radiation emitted in the decay of a radioactive particle can also be identified using electric fields. Alpha particles are deflected parallel to the field lines (towards the negative), beta particles anti-parallel to the field lines (towards the positive), and gamma rays are undeflected since they have no charge. Magnetic fields can also be used to identify the nature of the emitted radiation.

Investigating vector addition

A vector is a physical quantity that has magnitude and direction. It is represented by an arrow indicating the direction of the vector with the length of the arrow indicating the magnitude. The sum of two vectors originating at O can be obtained by drawing two more vectors of the same magnitude and direction to make a parallelogram. The diagonal of the parallelogram from O is the resultant vector and indicates the magnitude and direction of the resultant vector.

Ask the students to design and carry out an activity to investigate vector addition by the parallelogram rule.

Get your students started by thinking on the following:

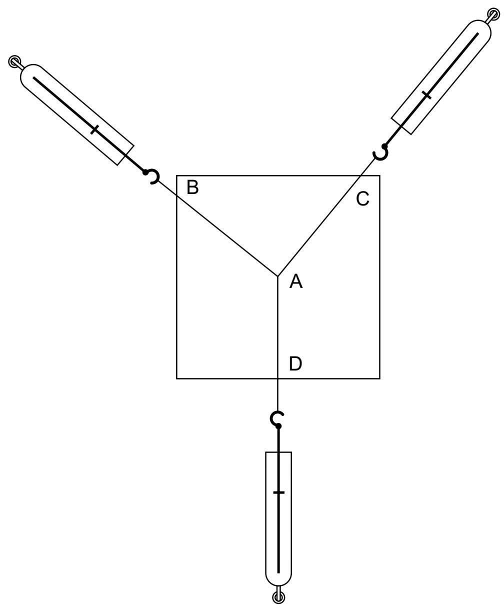
- What is a vector? Can you name some examples of vector quantities?
- How can two forces acting on an object be measured?
- How can the sum of these forces be measured?

Help students to identify the equipment they might need:

- three spring balances
- S-hooks
- cord
- paper
- thumb tacks
- pencil
- ruler
- nails

Help the students to plan out their investigation by suggesting the following steps:

1. Students might select three spring balances and fasten the ends of a longer piece of string to them with the help of S-hooks.
2. The rings of the spring balances should be slipped over nails that have been driven into the wooden surface about 50 cm apart.
3. One end of a smaller cord can be connected to the longer cord and the other end to a third spring balance with the help of S-hooks.
4. The third spring balance can be pulled to a reasonable distance and fixed in place by slipping its ring over a raised nail.
5. The intersection of the three cord sections might be marked as O and the three ends marked clockwise as A, B, and C. $\overrightarrow{OA}$, $\overrightarrow{OB}$, and $\overrightarrow{OC}$ are now three vectors.
6. A sheet of paper might be slipped under the cords and held in place with thumb tacks. A ruler and pencil might be used to carefully trace the three vectors on paper and arrows drawn to indicate their direction away from the origin O. The readings on the spring balances represent the magnitude of the three vectors.
7. Two more vectors $\overrightarrow{CD}$ and $\overrightarrow{DB}$ might be drawn parallel to $\overrightarrow{OB}$ and $\overrightarrow{OC}$ respectively to form a parallelogram OBDC.
8. The points O and D might be joined to form the diagonal $\overrightarrow{OD}$ of the parallelogram. The magnitude of the diagonal represents the magnitude of the resultant force and the direction represented by an arrow away from O.



Note:

This investigation illustrates the parallelogram rule for vector addition. Students should be able to follow a similar strategy for determining the resultant force for forces of varying magnitudes and direction.

Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on the following:
- the purpose of the investigation
- a brief description of vector addition and the parallelogram rule
- how the investigation was set up (including diagrams)
- a log of the activities conducted and the observations recorded
- a conclusion about the magnitude and direction of the resultant force/vector
- how the students might have performed the investigation better

Investigating the speed and acceleration of a bicycle rider

Speed is measured as the change in distance over time (m/s). It can be calculated by dividing the change in speed between two points with the time taken to cover the distance. Acceleration is the change in speed over time (m/s^2). It is calculated by dividing the change in velocity between two points by the time taken to cover the distance.

Ask the students to design and carry out an activity to investigate the speed and acceleration of a bicycle rider.

Get your students started by thinking on the following:

- What is speed? How can it be measured?
- What is acceleration? How can it be measured?
- Where in daily life do we need to measure speed and acceleration?

Help students to identify the equipment they might need:

- bicycle
- stopwatch
- calculator
- helmet
- gloves
- elbow pads
- kneepads

Help the students to plan out their investigation by suggesting the following steps:

1 Students might work in groups of two or three where one opts to ride the bicycle and the others time him or her.

2 Students might select two points A and B as the starting and finishing points and record the distance.

3 The starting and finishing times for the bicycle rider should be recorded and divided by the distance.

4 For measuring acceleration, additional points such as C and D might be fixed and the acceleration calculated by dividing the change in velocity by the time taken.

5 Students might take turns at the bicycle to compare their performance with one another.

6 The results might be tabulated and graphs plotted:

Distance / m	**Time / s**	**Speed / m/s**	**Acceleration / m/s^2**

Note:

Ensure that students wear adequate safety equipment and carry out the activity in a playground or a safe and protected area. Students might calculate acceleration by determining the speed at two points and divide the difference by the time taken to travel between them. They should also conclude that any decrease in speed or acceleration might be due to a decrease in energy over time.

Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on the following:

- the purpose of the investigation
- a brief description of speed, velocity, and acceleration
- how the investigation was set up

- a log of the activities conducted and the observations recorded in the form of tables and graphs
- a conclusion about the relationship between distance, time, speed, velocity, and acceleration
- how the students might have performed the investigation better

Investigating the factors in parachute design

A parachute helps to reduce the acceleration of a free-falling body by providing greater surface area for air resistance. As the air pushes against the parachute, it helps to reduce the force of gravity. Parachutes are designed so that they provide maximum air resistance for the falling body.

Ask the students to design and carry out an activity to investigate the factors in parachute design.

Get your students started by thinking on the following:

- What causes an object to fall downwards?
- What forces oppose this downward force?
- What factors might be involved in increasing the magnitude of these resisting forces?

Help students to identify the equipment they might need:

- polythene bags
- pair of scissors
- weights
- string
- stopwatch

Help the students to plan out their investigation by suggesting the following steps:

1. Students might begin by testing the effect of surface area on the air resistance provided by a parachute.
2. Square pieces of varying sizes might be cut out from the polythene bags.
3. Holes might be punched in the four corners and equal lengths of strings be tied. The loose ends of the four pieces of string might then be tied together in a knot.
4. Another piece of string might be tied to this knot with the other end tied to a piece of weight.
5. Equal lengths of string should be used to prepare parachutes with different surface area.
6. The parachutes might be dropped from the same height (such as a balcony) and the time taken to reach the ground be recorded in a table:

Parachute	**Surface area / cm^2**	**Time taken to reach the ground / s**
A	100	
B	200	
C	300	
D	400	
E	500	

- Repeated trials might be taken to account for variations such as failure of parachute to open.
- The investigation could be repeated for other factors such as weight of the load, height, string length, material, and shape.

Note:

The parachute with the greatest surface area will offer the greatest air resistance and will take the longest to reach the ground. Students should conclude that a parachute should be designed with a greater surface area to be effective. Students should similarly draw conclusions about the effect of height, weight of load, material, and shape on the effectiveness of a parachute.

Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on the following:

- the purpose of the investigation
- a brief description of balancing forces and air resistance
- how the investigation was set up (including diagrams)
- a log of the activities conducted and the observations recorded in the form of tables and graphs
- a conclusion about the ideal design of a parachute
- how the students might have performed the investigation better

Investigating the effectiveness of several lubricants in overcoming friction

Friction is a resisting force that is created when two surfaces rub against one another. Friction generates heat and can be both useful and damaging. One way of overcoming friction is by using lubricants. A lubricant provides a smooth surface that prevents the molecules of the two surfaces from rubbing against one another.

Ask the students to design and carry out an activity to test the effectiveness of several lubricants in overcoming friction.

Get your students started by thinking on the following:

- Why do your hands feel warm when they are rubbed against one another?
- What are some advantages of friction? What are its disadvantages?
- What materials can be used as lubricants?

Help students to identify the equipment they might need:

- carrom board with discs
- boric acid powder
- talcum powder

Help the students to plan out their investigation by suggesting the following steps:

1 Students might select boric acid powder, talcum powder, or any other substance commonly used to reduce friction on a carrom board.

2 Equal amounts of the substances might be applied over the surface of the board alternately and then tested by striking several discs one by one with an equal amount of force. These trials might be repeated to account for any variation caused by uncontrollable factors.

3 The time taken for the discs to strike the opposite end should be recorded and compared.

Note:

Boric acid powder should be handled carefully. Students will observe that the discs move faster when boric acid is sprinkled on the surface. They should conclude that the boric acid powder particles provide better lubrication than the talcum powder particles. Some students might have difficulty in keeping time on the carrom board. The activity might alternately be carried out on a marble floor.

Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on the following:

- the purpose of the investigation
- a brief description of friction and ways to overcome it
- how the investigation was set up
- a log of the activities conducted and the observations recorded
- a conclusion about the effects of various lubricating materials
- how the students might have performed the investigation better

Investigating centripetal force in circular motion

An object in circular motion experiences a force directed towards the centre of the circular path. This force is called the centripetal force. The magnitude of the centripetal force increases with an increase in the mass of the object, the speed of the object, and with a decrease in the radius of the circular path.

Ask the students to design and carry out an activity to investigate centripetal force in circular motion.

Get your students started by thinking on the following:

- What is circular motion?
- What forces act on a body in circular motion?
- How do planets stay in orbit around the Sun?

Help students to identify the equipment they might need:

- rubber bung with hole
- slotted weights and mass hanger
- paper clip
- long string
- plastic tube
- metre rule

Help the students to plan out their investigation by suggesting the following steps:

1 One end of the string might be tied to the rubber bung and the string passed through the plastic tube.
2 A mass hanger might be tied to the other end of the string and a paper clip attached to the string at a point below the tube that marks 0.5 m between the tube and the bung.
3 Students might then whirl the bung around their head in a circle. Care must be taken to maintain speed so that the paper clip stays below the tube.
4 Greater weights might be added to the other end and the effect on the speed of the bung noted.
5 The time taken to complete one orbit might also be recorded.

Note:

Make sure that the activity is performed in a large area to avoid injury. Students should observe differences in the radius of the orbit when the speed of the bung is increased or decreased. They should explain that as the mass is increased greater force is applied to maintain the radius and speed. As the radius is reduced greater force is applied to maintain the speed of motion.

Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on the following:

- the purpose of the investigation
- a brief description of circular motion and the forces at work
- how the investigation was set up (including diagrams)
- a log of the activities conducted and the observations recorded
- a conclusion about the factors affecting the motion of a body in a circular orbit
- how the students might have performed the investigation better

Investigating inertia in an object

Newton's first law of motion helps to explain inertia as the property of a body to resist any change in its state of rest or motion. Inertia is directly proportional to mass; so the more mass a body possesses the more difficult it is to change its state of rest or motion.

Ask the students to design and carry out an activity to investigate inertia in an object.

Get your students started by thinking on the following:

- What is meant by inertia?
- What factors does inertia depend upon?
- How can inertia be explained in terms of resultant force?

Help students to identify the equipment they might need:

- objects of mass 3–5 kg
- rope
- string

Help the students to plan out their investigation by suggesting the following steps:

1 Students might suspend one of the objects with the help of a rope so that the object is at a distance of one metre from the support.
2 One end of a piece of string might be tied to the object and the other held in the hand.
3 The object might then be given a push to set it in to and fro motion.
4 The students might tug at the string after a while to bring the swinging object to a stop.
5 The same might be repeated with objects of greater mass and by causing the objects to swing at greater speeds before bringing them to a stop.
6 Students should note the increasing difficulty in bringing the objects to a stop as the mass and velocity increase.

Note:

This is an exploratory activity and students should be able to make allowances for differences due to differing levels of physical strength among them. They should reason that objects possessing greater mass possess greater inertia which is why it is difficult to bring a larger object in motion to rest, or to bring about a change in velocity in one in motion.

Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on the following:

- the purpose of the investigation
- a brief description of inertia and resultant force
- how the investigation was set up (including diagrams)
- a log of the activities conducted and the observations recorded
- a conclusion about the factors upon which inertia depends
- how the students might have performed the investigation better

Investigating the density of regular shaped objects

Density is calculated by using the following formula: density = mass/volume. The SI unit of density is kg/m^3, but g/m^3 is also commonly used. The methods of calculating the volume of regular shaped objects are given in the table below:

Shape	**Volume / m^3**
Cube	$a \times a \times a$
Cuboid	$l \times b \times h$
Sphere	$4/3\ \pi r^3$
Cylinder	$\pi r^2 l$

Ask the students to design and carry out an activity to investigate the density of several regular shaped objects.

Get your students started by thinking on the following:

- What is density? How can it be measured?
- How does this property affect or help to predict the behaviour of a substance?

Help students to identify the equipment they might need:

- non-porous objects with regular shape made from the same material
- vernier calliper
- beam balance
- ruler

Help the students to plan out their investigation by suggesting the following steps:

1 Students might select any of the regularly shaped objects.

2 They might measure the mass of the object using the beam balance and record the value in a table:

Object	**Mass / g**	**Dimensions / cm**	**Volume / cm^3**	**Density / g/cm^3**

3 The dimensions of the object might be measured using a suitable instrument and its volume determined referring to the table above.

4 The density of the object might be calculated using the formula given in the table above.

5 The steps might be repeated for a different shaped object.

Note:

The densities of the objects will vary depending on their mass and volume. Students should be able to identify objects that have the same or similar density and think of reasons for the similarity.

Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on the following:

- the purpose of the investigation
- a brief description of mass, volume, and density
- how the investigation was set up
- a log of the activities conducted and the observations recorded in the form of a table
- a conclusion about the relationship between mass, volume, and density
- how the students might have performed the investigation better

Investigating the centre of mass of cards of different shapes

The centre of mass of a body is the point about which the turning effects of the gravitational forces acting on the particles cancel out. As a result, the body is in equilibrium and can be balanced about the centre of mass.

Ask the students to design and carry out an activity to investigate the centre of mass of pieces of card of different shapes.

Get your students started by thinking on the following:

- Why do objects seem to balance about one particular point only?
- When is a body balanced or in equilibrium?
- How might the centre of mass of a body be determined?

Help students to identify the equipment they might need:

- cardboard
- string
- pencil
- pair of scissors

Help the students to plan out their investigation by suggesting the following steps:

1 Students might cut out several shapes of varying number of sides from the cardboard.

2 One cardboard shape might be attached to the string at one point and suspended from a firm support.

3 Using a pencil, students might mark a vertical line on the card using the plumb line formed by the string as a guide.

4 The same piece of card might then be attached to the string at another point and a vertical line drawn again. This line would intersect the first line at a point O.

5 The card might be attached at various points and vertical lines drawn similarly. All the lines should intersect at the common point O. This would be the centre of mass of the card shape.

6 The centre of mass might be tested by balancing the card at the centre of mass on the point of a pencil held vertically.

Note:

The centre of mass can be identified for plane objects in a similar manner. The process could be repeated with card pieces of various sizes and shapes. You could also ask students to try balancing the card at a point other than the centre of mass. Students should conclude that the centre of mass is crucial in determining the stability of equilibrium of the body.

Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on the following:

- the purpose of the investigation
- a brief description of centre of mass and the turning effect of forces
- how the activity was set up (including diagrams)
- a log of the activities conducted and the observations recorded

- a conclusion about the influence of centre of mass on stability of equilibrium
- how the students might have performed the investigation better

Investigating the relationship between centre of mass and stability of a three-dimensional object

A three-dimensional object is in equilibrium when its centre of mass is located over the base. The centre of mass of such an object can be determined by finding out the angle at which the object loses equilibrium upon being tilted over the base.

Ask the students to design and carry out an activity to investigate the relationship between the centre of mass and stability of a three-dimensional object.

Get your students started by thinking on the following:

- What is meant by stable equilibrium?
- How is it related to the centre of mass?
- How might the centre of mass of a body be determined?

Help students to identify the equipment they might need:

- three-dimensional objects, e.g. a thick book, Bunsen burner, box, etc.
- protractor
- ruler

Help the students to plan out their investigation by suggesting the following steps:

1 Large three-dimensional objects might be chosen for this investigation.
2 The objects might then be made to stand vertically on a flat and level surface.
3 The objects might be tilted at increasing angles using a finger and the angle between the base and the tilted surface might be measured with a protractor before allowing the objects to return to their original position.
4 The angle might be increased until an angle is reached at which the object loses balance and tips over. This is the maximum angle at which it can regain stability.
5 The activity might be repeated using objects with broader and narrower bases and varying positions of centre of mass.

Note:

Students will observe that objects with a broader base and a lower centre of mass can regain their stability to a greater extent than others. They should reason that this is because the centre of mass remains over the base for a larger distance in objects with broad bases. They should conclude that stability is directly proportional to the distance of the centre of mass from the base.

Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on the following:

- the purpose of the investigation
- a brief description of equilibrium and the relationship between centre of mass and stability
- how the investigation was set up (including diagrams)
- a log of the activities conducted and the observations recorded
- a conclusion about the relationship between centre of mass and stability
- how the students might have performed the investigation better

Investigating the effect of material on elasticity

Spring balances function on the elasticity of the metal used in making the spring. The metal is elastic and can be stretched to indicate the weight of an object. The spring reverts to its original length once the weight is removed and can be used again. In comparison, rubber loses its proportionality relatively easily.

Ask the students to design and carry out an activity to investigate the effect of material on elasticity.

Get your students started by thinking on the following:

- What is meant by elasticity?
- Why is a spring used in spring balances?
- What other materials possess elasticity and might be used similarly?
- How might the suitability of rubber for such a purpose be investigated?

Help students to identify the equipment they might need:

- rubber bands
- ruler
- rectangular strip of wood
- weights
- hooks

Help the students to plan out their investigation by suggesting the following steps:

1. Students might make a rubber balance by fixing the ruler along the length of the rectangular strip fastening a hook to the top.
2. A rubber band might be hung from the hook and another hook be fastened to it from which a weight might be suspended.
3. The original length of the rubber band might be noted before any weight is attached to it.
4. The extension might be measured by reading on the ruler how far the rubber band stretches because of the weight.
5. The weight may be removed and the difference between the original length and the restored length be calculated:

Original resting length / cm	Load / N	Extension / cm	Restored resting length / cm

6 This might be repeated several times.

7 The same weight might be suspended from a regular spring balance and the change in spring length in resting position be calculated similarly.

Note:

It will be observed that the rubber band loses its original length and its proportionality sooner than the metal spring as the load is increased. Students should reason that the metal spring retains its proportionality longer and has a greater elastic limit. They should conclude that this makes rubber an unreliable material to be used in a weighing balance.

Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on the following:

- the purpose of the investigation
- a brief description of elasticity and deformity
- how the activity was set up (including diagrams)
- a log of the activities conducted and the observations recorded in the form of a table and a graph
- a conclusion about the factors affecting elasticity and proportionality
- how the students might have performed the investigation better

Investigating hydraulic pressure in a hydraulic press

A hydraulic press works under the principle of hydraulic pressure transmitted by liquids. A small force applied to a smaller piston in a hydraulic press is transmitted through the liquid to a larger piston in the form of a higher output force.

Ask the students to design and carry out an activity to investigate hydraulic pressure in a hydraulic press.

Get your students started by thinking on the following:

- What is hydraulic pressure?
- Why are liquids used in hydraulic machines?

Help students to identify the equipment they might need:

- two syringes of different sizes
- plastic tubing
- water

Help the students to plan out their investigation by suggesting the following steps:

1 The syringes and the plastic tubing might be filled with water.

2 A hydraulic system might be created by fitting the ends of the plastic tubing over the nozzles of the two syringes.

3 Two students might work at the machine by pushing in the piston of the smaller syringe and noting down the displacement caused in the larger syringe.

4 Next, the piston in the larger syringe might be pushed in and the displacement produced in the smaller syringe noted.

Note:

Students should interpret the displacement produced by applying pressure on the two pistons. They should be able to explain that the displacement is caused by a force multiplier that multiplies the input force to produce a larger output force in the larger piston.

Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on the following:

- the purpose of the investigation
- a brief description of hydraulic pressure and the working of a hydraulic press
- how the investigation was set up (including diagrams)
- a log of the activities conducted and the observations recorded
- a conclusion about the principle involved in the working of a hydraulic press
- how the students might have performed the investigation better

Investigating human power

Power is a measure of how quickly one can do work. Maximum power can be determined from mass, the vertical distance covered, and the time taken to do work. The formula is $P = W/t$ whereas work can be calculated by the formula $W = m \times g \times h$.

Ask the students to design and carry out an activity to investigate human power.

Get your students started by thinking on the following:

- What is power? How is it measured?
- In what way might power be increased?

Help students to identify the equipment they might need:

- electronic balance
- long rope
- tape measure
- stopwatch
- staircase

Help the students to plan out their investigation by suggesting the following steps:

1 Students might identify a suitable staircase and measure its height. This is the vertical distance h.

2 Students might ensure that the staircase is clear of people and obstacles.

3 Students might record the time it takes to climb the stairs.

4 Students might measure their mass using an electronic balance.

5 Students might calculate work done and power and share the results with the rest of the class:

Student	Mass / kg	Height climbed / m	Work done / kJ	Time taken / s	Power / W

Note:

Take care that students with a heart condition or other health problems do not participate in this activity. Students should be careful not to trip over whilst running up the stairs. Students should interpret the results and identify factors that can be controlled to increase their power. They should also suggest ways in which these factors might be controlled.

Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on the following:

- the purpose of the investigation
- a brief description of the relationship between work done and power along with other factors affecting power
- how the investigation was set up
- a log of the activities conducted and the observations recorded in the form of a table
- a conclusion about their power rating and who the most powerful student in the group class is
- how the students might have performed the investigation better

Investigating the effectiveness of air as an insulator

Heat loss can be prevented or minimized by the use of an insulator. Air is a good insulator. Materials like foam and polystyrene are used as insulators because they contain trapped air within their structure.

Ask the students to design and carry out an activity to investigate the effectiveness of air as an insulator compared with other insulating materials.

Get your students started by thinking on the following:

- How is heat lost from a liquid such as tea or coffee?
- How might heat loss or gain be measured? How might it be prevented?
- What materials might be used as insulators?

Help students to identify the equipment they might need:

- cups of different materials, e.g. glass, plastic, polystyrene, porcelain, etc.
- wooden covers
- thermometer
- stirrer
- hot water, tea, or coffee

Help the students to plan out their investigation by suggesting the following steps:

1. Students might select cups made of various materials—some containing trapped air and some without.
2. They might pour equal volumes of a liquid such as hot water, tea, or coffee into the cups.
3. The initial temperature in all the cups might be noted before covering them with lids.
4. The temperature might be noted at regular intervals and the decline used to determine the effectiveness of the various insulating materials. It is important to use a stirrer to distribute the temperature evenly before noting down the temperature.

Note:

The polystyrene cup will show the least decline in temperature compared to glass or plastic. The students should reason that this is because the trapped air in the polystyrene prevents heat from escaping and helps to keep the liquid warm. They should conclude that polystyrene is a better insulator of heat than other materials.

Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on the following:

- the purpose of the investigation
- a brief description of heat loss and insulation
- how the investigation was set up (including diagrams)
- a log of the activities conducted and the observations recorded in the form of a table and a graph
- a conclusion about the effectiveness of polystyrene as an insulating material
- how the students might have performed the investigation better

Investigating the insulating properties of various materials

Heat loss can be prevented or minimized by using an insulating material to coat the container or hot body. The insulating material traps the radiating heat and does not allow it to escape the body or container. In this way insulating materials help to save energy.

Ask the students to design and carry out an activity to investigate the insulating properties of various materials.

Get your students started by thinking on the following:

- How does heat escape from a body? How might this be prevented?
- What is an insulator?
- Name some materials commonly used as insulators around the house.

Help students to identify the equipment they might need:

- 1.5-litre glass bottles
- hot water
- thermometers
- various materials such as aluminium foil, bubble wrap, cotton cloth, woollen cloth, etc.

Help the students to plan out their investigation by suggesting the following steps:

1. The bottles might be filled with equal volumes of hot water.
2. Thermometers might be inserted into holes made in the bottle caps.
3. The bottles might be covered with the caps so that the bulbs of the thermometers are immersed in the water.
4. Each of the bottles might be covered on the outside with different materials such as aluminium foil, cotton cloth, bubble wrap, velvet, and so on.
5. The change in temperature might be observed in every bottle and tabulated:

Material	Initial temperature / °C	Temperature after 5 min / °C	Temperature after 10 min / °C	Temperature after 15 min / °C	Temperature after 20 min / °C

Note:

Students will observe that bottles wrapped in aluminium foil and woollen cloth retain more heat compared with bottles wrapped in cotton cloth. Students should reason that since other factors, i.e. volume of water, starting temperature, have been kept uniform the difference in heat loss is due to the insulating material chosen. They should conclude that because the aluminium foil and woollen cloth trap air (an insulator) they help to prevent heat loss from the bottles.

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Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on the following:
- the purpose of the investigation
- a brief description of conduction and insulation
- how the investigation was set up (including diagrams)
- a log of the activities conducted and the observations recorded in the form of a table
- a conclusion about the effect of various insulating materials on heat loss
- how the students might have performed the investigation better

Investigating the effect of salt concentration on the melting point of ice

Ice on the roads can be a problem in winter because it increases the risk of accidents caused by skidding. Salt is usually sprayed over the ice to melt it. Adding high concentrations of salt lowers the melting point of ice (0^oC) significantly, causing it to melt.

Ask the students to design and carry out an activity to investigate the effect of spraying salt on the melting point of ice.

Get your students started by thinking on the following:
- What is the melting point of ice?
- How might the melting point be lowered? What effect would it have on the ice?
- How might the effect of adding salt over ice be investigated?

Help students to identify the equipment they might need:
- salt
- ice cubes
- measuring cups
- thermometer
- salt solution in water

Help the students to plan out their investigation by suggesting the following steps:
1. Students might place equal masses of ice cubes in the measuring cups and record the temperature.
2. Differing amounts of salt might be added to the measuring cups taking care to cover the surface of ice with salt. Salt solution might be added in some of the cups instead of salt.
3. As the ice begins to melt, students should note the rate of melting by regularly measuring the volume of water.

Note:

Ice will melt the fastest in the cup containing the greatest amount of salt. The cups with lesser amounts of salt will show a slower rate of melting. The cups with the salt solution will also show slower melting rates. Students should reason that a decrease in the concentration of water molecules slows down the rate of freezing. They should conclude that adding greater concentrations of salt brings down the melting point of ice, causing it to melt.

Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on following:

- the purpose of the investigation
- a brief description of factors affecting melting point and freezing point
- how the investigation was set up (including diagrams)
- a log of the activities conducted and the observations recorded in the form of a table
- a conclusion about the factors affecting the melting point of ice
- how the students might have performed the investigation better

Investigating the effect of temperature on the rate of diffusion

Diffusion is the process by which molecules travel from a region of higher concentration to a region of lower concentration. The movement of molecules can be explained by the kinetic theory of matter in that at higher temperatures the molecules absorb energy and travel faster.

Ask the students to design and carry out an activity to investigate the effect of temperature on rate of diffusion.

Get your students started by thinking on the following:

- How does the kinetic model explain the motion of particles?
- How can we sense the motion of particles when a bottle of perfume is left open at one end of a room?
- What do you observe when tea leaves are put into a cup of boiling water?

Help students to identify the equipment they might need:

- potassium permanganate crystals
- water
- thermometer
- Bunsen burner, tripod, and wire gauze
- beaker

Help the students to plan out their investigation by suggesting the following steps:

1. Students might fill a beaker with water at room temperature and put some potassium permanganate crystals into it to observe the diffusion of crystals in the water.
2. The time taken for the purple colour to diffuse evenly throughout the water should be recorded.
3. The beaker might then be emptied and the activity repeated using water that has been heated to 40°C. The time taken for the colour to diffuse throughout might be recorded.
4. The time might be recorded by using water heated to 50°C, 60°C, 70°C, and so on.

Note:

The colour will diffuse faster throughout the water at higher temperatures. Students should reason that this is due to the faster movement of molecules because of the energy they have gained from the heat. Students should conclude that the motion of molecules and the rate of diffusion increases with the increase in temperature.

Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on the following:

- the purpose of the investigation
- a brief description of the kinetic theory of matter and Brownian motion
- how the study was set up (including diagrams)
- a log of the activities conducted and the observations recorded in the form of a table and a graph
- a conclusion about the relationship between temperature and the rate of diffusion
- how the students might have performed the investigation better

Investigating rates and effects of evaporation

Evaporation takes place when molecules on the surface of a liquid gain sufficient energy to overcome the intermolecular forces of attraction and escape into the air as vapour. The molecules carry away heat energy as they evaporate which makes the evaporating surface cooler.

Ask the students to design and carry out an activity to investigate the rates and effects of evaporation.

Get your students started by thinking on the following:

- What is meant by evaporation? Is it the same as boiling?
- Do all liquids evaporate at the same rate?
- What happens to the surface from where the liquid evaporates?

Help students to identify the equipment they might need:

- beaker
- water
- Bunsen burner, tripod, and wire gauze
- alcohol
- thermometer
- stopwatch

Help the students to plan out their investigation by suggesting the following steps:

1. Students might heat a little water without boiling it.
2. They might note the temperature and take some of the water on their palm.
3. The time taken for the water to evaporate might be recorded and the temperature of the skin noted after evaporation is complete.
4. The same quantity of alcohol might be taken on the palm of the other hand and the time taken for it to evaporate completely recorded.
5. The temperature of the skin might also be recorded at this point.

Note:

Students should be able to interpret the difference in the time taken for the two liquids to evaporate and the cooling effects on the skin. They should reason that evaporating molecules carry away heat energy from the skin and cool it down. They should also reason that some liquids evaporate faster than others.

Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on the following:

- the purpose of the investigation
- a brief description of evaporation in terms of the kinetic theory of matter
- how the investigation was set up (including diagrams)
- a log of the activities conducted and the observations recorded in the form of a table
- a conclusion about rate of evaporation and its cooling effects
- how the students might have performed the investigation better

Investigating the cooling effects of different brands of aftershave

Men use aftershave for its fragrance and to soothe the skin after shaving. The skin feels refreshed because aftershave cools the skin as it evaporates.

Ask the students to design and carry out an activity to investigate the cooling effects of several brands of aftershave.

Get your students started by thinking on the following:

- What is evaporation?
- What role does it play in regulating the temperature of a body?
- Why does spirit have a greater cooling effect than water on the skin?

Help students to identify the equipment they might need:

- cotton wool
- clamp stand
- thermometers
- dropping pipette
- samples of various aftershave brands
- stopwatch

Help the students to plan out their investigation by suggesting the following steps:

1 Students might prepare solutions of the various aftershave brands taking care that all solutions be of equal concentration and volume.

2 Cotton wool might be cut into equal sizes and each piece soaked in a different solution with the help of tongs.

3 The temperature of the cotton wool samples might be noted with the help of thermometers suspended from clamp stands.

4 The decline in temperature in all cotton wool samples might be recorded at regular intervals in a table:

Time / min	Brand X	Brand Y	Brand Z

The results obtained might then be used to plot a graph.

Note:

The experiment needs to be performed in a well-ventilated room, or ideally a fume cupboard. Students should neither inhale nor directly come into contact with the solutions. They should determine which of the brands has a greater cooling effect. They should also conclude that the cooling effect is caused due to the evaporation of the solution from the cotton wool.

Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on the following:

- the purpose of the investigation
- a brief description of evaporation in terms of the kinetic model of matter
- how the investigation was set up (including diagrams)
- a log of the activities conducted and the observations recorded in the form of a table and a graph
- a conclusion about the most effective aftershave and the reasons for it
- how the students might have performed the investigation better

Investigating the images produced by a converging lens

A converging lens is thicker in the middle than at the edges. It acts as a converging lens by causing rays passing through it to converge at a point called the focal point. Rays from a very distant object are considered parallel. As the object is brought nearer to the lens the image formed is larger and at a greater distance from the lens. If an object is placed closer to the lens than its principal focus a virtual image is formed.

Ask the students to design and carry out an activity to investigate the images produced by a converging lens.

Get your students started by thinking on the following:

- What does the term focal point indicate?
- What kind of image is produced by a converging lens?
- How might the focal point of a converging lens be determined?

Help students to identify the equipment they might need:

- converging lens
- support for lens
- cardboard screen
- lamp
- measuring tape

Help the students to plan out their investigation by suggesting the following steps:

1. Students might determine the focal point by holding up the convex lens in the sunlight to obtain an image on the screen. The screen is to be moved to and fro until the circle formed is as small as possible.
2. The distance from the lens to the screen might now be measured and termed the focal length.
3. The image of a relatively distant object such as a tree or pole outside the window might be obtained by keeping the lens in the same position and adjusting the position of the screen. The distance between the lens and the screen and the size of the image is to be recorded.
4. The image of the lit lamp might be obtained on the screen in such a way that the lens remain in the same position, and the lamp and the screen at equal distances on opposite sides of the lens. The size of the image should be recorded.
5. Now the lamp might be brought closer to the focal length and the distance between the lens and the image formed be recorded. The size of the image should also be recorded.
6. The distance between the lens and the image and the size of the image might also be recorded with the lamp placed at the focal point and in between the focal point and the lens. In the second case the image will not be obtained on the screen and students might have to look through the lens at the lamp to observe a virtual image.
7. The results might be tabulated as below:

Object	**Image**			
Position	**Upright or inverted?**	**Image Size / cm**	**Image Location**	**Real or virtual?**
Great distance				
Beyond *2F*				
At *2F*				
Between *2F* and *F*				
At *F*				
Between *F* and *O*				

Note:

Students should be able to determine that as an object is brought closer to the converging lens the image becomes larger and is formed further away from the lens on the opposite side. However, when the object is brought within the focal length of the lens a large, upright, virtual image is formed behind the object. Students should identify this as the principle used in magnifying glasses.

Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on the following:

- the purpose of the investigation
- a brief description of the relationship between object distance and image distance in a converging lens
- how the investigation was set up (including ray diagrams)
- a log of the activities conducted and the observations recorded in the form of a table
- a conclusion about the nature of images formed by a converging lens
- how the students might have performed the investigation better

Investigating the relationship between age and short sight/long sight

Short sight is a defect of vision in which rays from a distant object converge before the retina and a clear image cannot be obtained. This is because the lens of the eye cannot be stretched enough. This might be due to an inflexible lens or weak ciliary muscles. The opposite happens in long sight where the lens cannot be made thick enough. As a result, rays from near objects bend to converge beyond the retina.

Ask the students to design and carry out an activity to investigate the relationship between age and short sight/long sight.

Get your students started by thinking on the following:

- Why do some people suffer from short sight/long sight while others do not?
- Do young/old people typically suffer from long sight/short sight?
- How might this be determined with certainty?

Help students to identify the equipment they might need:

- friends, family, and other survey respondents

Help the students to plan out their investigation by suggesting the following steps:

1. Students should be encouraged to design and conduct a survey to determine any relationship between age and short sight/long sight.
2. Students might develop their hypothesis on the basis of common observations, e.g. 'more young people than old people suffer from short sight', 'more old people than young people suffer from long sight', and so on.

3 Students might select a reasonable number of respondents to question and study. These might include siblings, friends, relations, etc.

4 Students might develop specific and relevant questions to help them obtain qualitative and quantitative data from respondents.

5 Students might then analyze and interpret the data to arrive at a conclusion that supports, does not support, or does not support or disprove their hypothesis.

Note:

Students could perform this investigation in pairs or teams. They should be encouraged to chalk out a methodical plan for their study and interpret their results objectively more than arriving at conclusive results.

Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on the following:

- the purpose of the investigation
- a brief description of short sight and long sight along with possible causes
- how the study was set up (including hypothesis, statement of objective, etc.)
- a log of the activities conducted and the observations recorded in the form of tables
- a conclusion about whether the original hypothesis is supported by the study
- how the students might have performed the investigation better

Investigating the magnetic lines of force in a straight wire carrying a current

Current passing through a wire produces a magnetic field around the wire. This field can be investigated with the help of iron filings and a compass.

Ask the students to design and carry out an activity to investigate the magnetic lines of force in a straight wire carrying a current.

Get your students started by thinking on the following:

- What is a magnetic field?
- How might a magnetic field be created by a current?
- How might the magnetic lines of force be plotted?

Help students to identify the equipment they might need:

- power source or battery
- copper wire
- iron filings
- compass
- cardboard

Help the students to plan out their investigation by suggesting the following steps:

1 Students might set up a circuit by connecting the copper wire to the terminals of the power source or battery. This should set up an electric current in the circuit.

2 The magnetic field created by the current might be tested by placing the wire on a bed of iron filings and observing if the filings cling to the wire.

3 The wire might then be disconnected from the power source and then passed through a hole in a cardboard sheet so that the cardboard sheet lies horizontally and the wire is in a vertical position.

4 Iron filings might be sprinkled over the cardboard sheet and the circuit connected again.

5 The pattern formed by the iron filings as they are attracted by the magnetic field of the wire is to be observed.

6 A compass might be placed at points on the cardboard to identify the direction in which the north pole points to determine the direction of the magnetic field.

Note:

Students should observe that the iron filings form concentric rings around the wire indicating the magnetic lines of force. The compass readings should help students to identify the direction of the magnetic lines of force. They might also observe changes in direction caused by reversing the direction of the current.

Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on the following:

- the purpose of the investigation
- a brief description of magnetic lines of force and the magnetic field created by an electric current
- how the investigation was set up (including diagrams)
- a log of the activities conducted and the observations recorded
- a conclusion about the effect of changing direction and magnitude of the current on the magnetic field
- how the students might have performed the investigation better

Investigating hard and soft magnetic materials

Materials such as iron and steel can be magnetized by stroking them with a permanent magnet. Hard magnetic materials like steel are difficult to magnetize but do not lose their magnetism easily. Soft magnetic materials like iron are magnetized easily but lose their magnetism easily too.

Ask the students to design and carry out an activity to investigate hard and soft magnetic materials.

Get your students started by thinking on the following:

- What is a magnet? How does a material become magentized?
- How might hard and soft magnetic materials be identified?
- What useful applications might these different materials have?

Help students to identify the equipment they might need:

- nails and other metallic objects made of iron, steel, and other metals
- bar magnet

Help the students to plan out their investigation by suggesting the following steps:

1 Students might try to magnetize metallic objects such as nails by stroking them along a bar magnet.
2 The objects might then be tested by bringing them close to other magnetic materials.
3 The duration for which these induced magnets are able to retain their magnetic properties is recorded and compared.

Note:

Objects made of steel will retain their magnetic properties, i.e. attract nails, for a longer time than iron objects. Students should thus be able to separate hard magnetic materials from soft magnetic materials. They should also be able to suggest some applications of these materials.

Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on the following:

- the purpose of the investigation
- a brief description of temporary and permanent magnets
- how the investigation was set up (including diagrams)
- a log of the activities conducted and the observations recorded in the form of a table
- a conclusion about the difference between hard and soft magnetic materials
- how the students might have performed the investigation better

Investigating the production of electrostatic charge by friction

Electrostatic charge is produced when atoms lose or gain electrons upon being rubbed against another object. An electrostatic charge is different from an electric current because electrostatic charges remain stationary and do not move.

Ask the students to design and carry out an activity to investigate the production of electrostatic charge by friction.

Get your students started by thinking on the following:

- What is meant by charge? How is it created?
- How many types of charge might there be? How might they be tested?
- What is electrostatic charge and how is it different from electric current?

Help students to identify the equipment they might need:

- polythene rod
- Perspex rod
- woollen cloth
- bits of paper

Help the students to plan out their investigation by suggesting the following steps:

1 Students might test the charge on the two rods by bringing them close to small bits of paper and observing whether they are attracted to the rods.

2 The rods might then be rubbed with the woollen cloth and tested for charge again.
3 The nature of the charges on the two rods might be investigated by rubbing them with the woollen cloth and bringing them close to one another to see whether they attract or repel one another.

Note:

Upon being brought close to one another, the two rods will be repelled because they carry opposite charges. Students should reason that one of the rods lost electrons to the woollen cloth to become positively charged while the other gained electrons to become negatively charged.

Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on the following:

- the purpose of the investigation
- a brief description of electrostatic charge and the types of charge
- how the investigation was set up (including diagrams)
- a log of the activities conducted and the observations recorded
- a conclusion about how electrostatic charge is created
- how the students might have performed the investigation better

Investigating the effect of the length of a wire on its resistance

Resistance in a wire prevents current from passing through it easily. Wire with a lower resistance requires a lower potential difference to be applied across its ends to pass a given amount of current. Resistance increases with the length of the wire. Other factors influencing resistance include area of cross-section, material, and temperature.

Ask the students to design and carry out an activity to investigate the effect of increasing length on the resistance of wire.

Get your students started by thinking on the following:

- What is meant by resistance? How might it be measured?
- How might the resistance in a circuit be increased? Decreased?
- What factors would have to be controlled in an investigation to determine the effect of increase in length on resistance?

Help students to identify the equipment they might need:

- resistance wire
- voltage source
- connecting wire
- ammeter
- voltmeter
- crocodile clips

Help the students to plan out their investigation by suggesting the following steps:

1 Students might set up a circuit by connecting the resistance wire, ammeter, and voltmeter to the power source.
2 Copper wire might be selected for the resistance wire because of its high conductivity.
3 Crocodile clips might be used to adjust the length of resistance wire and the readings on the voltmeter and ammeter recorded.
4 The readings might be used to calculate the resistance.
5 The steps might be repeated by increasing the length of the resistance wire by 10 cm.
6 The results might be tabulated and a graph plotted.

Note:

As the length of the wire increases, the amount of current flowing through the wire decreases. Students should reason that since other factors have not changed, the decrease in current and subsequent increase in resistance is due to the increase in wire length. They should conclude that resistance increases with the increase in length of a wire.

Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on the following:

- the purpose of the investigation
- a brief description of resistance and its factors
- how the investigation was set up (including circuit diagrams)
- a log of the activities conducted and the observations recorded in the form of a table and a graph
- a conclusion about the effect of wire length on its resistance
- how the students might have performed the investigation better

Investigating the effect of temperature on the resistance of a thermistor

A thermistor is a device that has a high resistance when cool but as the temperature increases the resistance falls. This allows more current to pass through when the temperature increases than when it is low.

Ask the students to design and carry out an activity to investigate the effect of increasing temperature on the resistance of a thermistor.

Get your students started by thinking on the following:

- What is meant by resistance? How might it be measured?
- What is a thermistor?
- What hypothesis might be proposed for investigating the properties of a thermistor?

Help students to identify the equipment they might need:

- thermistor
- voltage source
- milliammeter
- thermometer
- hot water
- beaker
- connecting wire

Help the students to plan out their investigation by suggesting the following steps:

1 Students might set up a circuit by connecting the milliammeter and thermistor to the power source.

2 They might note the room temperature and the current passing through the milliammeter at that temperature.

3 Hot water might be poured into the beaker and the thermometer suspended in it.

4 The thermistor might be placed in the beaker when the thermometer shows a temperature of about 85°C and the reading on the milliammeter recorded.

5 The readings might be recorded as the temperature falls every ten degrees. Ice cubes might be added and stirred into the water to bring down the temperature faster.

6 The results might be tabulated and a graph plotted.

Note:

As the temperature falls the milliammeter will show less current flowing through it. Students should reason that the decline in temperature increases the resistance of the thermistor which is why less current is recorded by the milliammeter. They should conclude that the thermistor is a suitable component to be used in fire alarms.

Check the students' plans and suggest improvements.

Let the students carry out their investigations.

Ask the students to prepare a write-up on the following:

- the purpose of the investigation
- a brief description of the relationship between resistance and current, and the function of a thermistor
- how the investigation was set up (including circuit diagrams)
- a log of the activities conducted and the observations recorded in the form of a table and a graph
- a conclusion about the effect of temperature on the resistance of a thermistor
- how the students might have performed the investigation better

Name: ....

Metric ice breaker

The SI system of units has been adopted worldwide by physicists. There are seven base units from which all other units can be derived. In this experiment you will estimate and measure quantities using four of these base units: length (m), mass (kg), time (s), and temperature (K).

It is important when you measure any of these quantities that you use the instrument that will give you the most accurate and precise value. For example, you would use a micrometer screw gauge and not a ruler to measure the thickness of a strand of hair!

You need:

- pedometer
- tape measure
- metre rule
- 30 cm rule
- vernier caliper or micrometer screw gauge
- triple beam balance
- stopwatch
- pen
- set of keys
- coin

Length

1 What is the SI base unit for length? ________

2 Circle the BEST metric unit for each.

(a) the length of an eyelash
mm cm m km

(b) the height of a flagpole
mm cm m km

(c) the length of a pencil
mm cm m km

(d) the distance from Geneva to Paris
mm cm m km

3 A stack of ten coins measures 32 mm.

(a) How tall would a stack of 100 coins be in centimetres? ________

(b) How tall would a stack of 1000 coins be in centimetres? ________

4 Which of the instruments provided would be most suitable to measure:

(a) the length of a sports field? ________

(b) the thickness of a CD? ________

(c) your height? ________

(d) the thickness of a wire? ________

5 What does each unit represent? Express your answer as a power of ten with a base SI unit.

(a) km ________

(b) m ________

6 How much does each one equal?

(a) 1 km (in millimetres) ________

(b) 1 cm (in millimetres) ________

(c) 1 m (in milimetres) ________

7 Which measurement is the largest?

(a) 15 mm or 1 cm ________

(b) 234 m or 1 km ________

(c) 1 m or 990 cm ________

(d) 2.5 cm or 22 mm ________

(e) 20 km or 3000 cm ________

8 Using a pair of vernier calipers or a micrometer screw gauge, measure and determine:

(Hint: Make sure that the pair of vernier calipers or micrometer screw gauge reads zero when fully closed.)

(a) the thickness of a coin ________

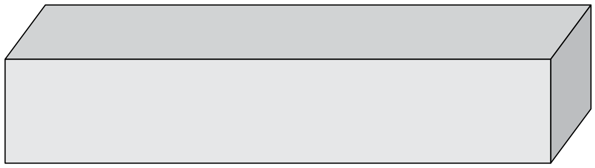
(b) the thickness of 100 coins ________

9 What is the surface area of your physics lab?

surface area = length × width

= ______ × ______ = ______ m^2

Name: ....

10 

(a) If the above box is 2 cm deep calculate its volume in cm^3.

volume = length × height × depth

= ________ × ________ × ________

= ________ cm^3

(b) What is the SI unit of volume?

11 Convert the following measurements:

(a) 280 ml into litres ________

(b) 23 kl into litres ________

(c) 456 cl into millilitres ________

(d) 120 ml into cm^3 ________

Mass

12 What is the base unit for mass? ________

13 Circle the best unit for measuring each mass:

(a) the mass of a bird's feather
mg g kg

(b) the mass of a baby at birth
mg g kg

(c) the mass of breakfast cereal in a bowl
mg g kg

14 Use a triple-beam balance to find each measurement:

(a) the mass of an ink pen ________

(b) the mass of a set of keys ________

15 Convert the following measurements:

(a) 61 mg into grams ________

(b) 6.7 kg into grams ________

(c) 12345 g into kilograms ________

(d) 7 g into milligrams ________

Time

16 What is the base unit for measuring time?
____

17 How many seconds are in:

(a) 5 minutes? ________

(b) 5 hours? ________

(c) 3 days? ________

18 Measure the time it takes you to breathe 10 times. ________

19 What is the period of time for an average breath? ________

Temperature

20 What is the SI base unit for temperature?
____

21 What is a more common unit used for measuring temperature? ________

22 What are the freezing and boiling points for water on this scale? ________

23 Circle the best choice:

(a) Temperature on a hot summer day:
0°C 35°C 70°C

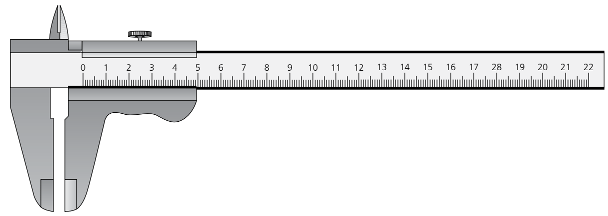
(b) Room temperature:
–20°C 0°C 20°C

PRACTICAL

Name: ....

Vernier calipers

Aim
To determine the average diameter of three marbles and estimate the experimental uncertainty in the average



You need:
- vernier calipers
- 3 similarly sized marbles

Introduction
When taking any experimental reading of a quantity that should not change, such as the diameter of a wire, you need to repeat the measurement at least three times to find an average value. Repeating the measurement helps you to spot mistakes and estimate the uncertainty in the measurement.

In this experiment you will become familiar with using vernier calipers.

If used correctly, most vernier calipers can be used to measure with a precision of 0.05 mm; the precision is usually printed on the caliper. Do not forget to check its zero with the jaws fully closed. If it does not read zero then this ‘zero reading’ should be subtracted from all other measurements you make using the calipers.

You will also learn a method to improve the accuracy of a measurement by taking several readings of the diameter of marbles and calculating an average reading. Multiple readings should be taken to reduce errors due to atmospheric conditions, e.g. temperature, humidity acting on the marbles, etc.

Method
1. Record the precision of the vernier calipers in the table on this page.
2. Measure the diameter of a marble using a vernier caliper, recording your results in the table.
   Note: You should be able to measure to the precision of your instrument, i.e. if your precision is 0.05 mm the diameter should be written as, for example, 16.30 mm.
3. Repeat the measurements an additional two times on the same marble.
4. Calculate the average diameter for the marble.
5. Repeat these measurements on three different marbles.
6. Calculate the average diameter for the three marbles.
7. Estimate the uncertainty in the average diameter using this formula for the average marble diameter:

$$\frac{\text{(maximum diameter – minimum diameter)}}{2}$$

Results

Precision of the vernier caliper			
	Marble 1	Marble 2	Marble 3
1st measurement/ cm			
2nd measurement/ cm			
3rd measurement/ cm			
Average/ cm			
Average of 3 marbles/ cm			
Uncertainty/ cm			

Observations
Circle the correct response.

The experimental uncertainty is (greater than / less than / equal to) the precision of the caliper.

Conclusions
(a) The average diameter of the marbles = ______________ ± ______________ mm.

(b) State and explain whether it would be better to have used a micrometer screw gauge with a precision of 0.01 mm rather than the vernier caliper with a precision of 0.05 mm.

Name: ....

Density of irregular shaped objects

Aim

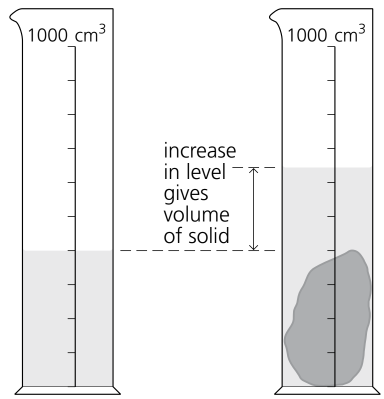
To determine the density of objects using the water displacement method

You need:

- non-porous objects with irregular shape each attached to a string, e.g. stone, irregular shaped piece of metal (large bolt)
- beam balance
- pencil to push the object underwater, if necessary
- measuring cylinder
- water

Theory

- The volume of displaced water is exactly the same as the volume of the solid.
- 1 ml = 1 cm^3
- density = $\frac{\text{mass}}{\text{volume}}$



Method

1 Record the mass of an irregular shaped object using the beam balance.

2 Partially fill the measuring cylinder with water, so that when the object is added it goes completely under the water, but the water does not overflow. Record the volume of water in the measuring cylinder.

3 Add the object carefully to the water so that the object is completely submerged. If the object is not completely submerged, use a pencil to push the object just below the surface of the water without putting any of the pencil into the water. Record the combined volume of the water and the object.

4 Determine the density of the object.

Results

Object	**Mass of object / g**	**Volume of water / ml**	**Volume of water and object / ml**	**Volume of object / ml**	**Density of object /g/ cm^3**

Questions

1 List the objects in order of increasing density.

2 Compare the densities of your objects with the densities of some common materials given on page 17 of your textbook. Can you identify which material these objects are made from?

3 Compare the densities of your objects with the density of water (1 g/cm^3). Do the solids sink or float? Why?

Name: ....

Estimating and 'guesstimating'

Aim

To estimate SI quantities

You need:

- marbles in a jar
- metre rule
- stopwatch
- electronic balance

Introduction

The SI unit for length is the metre (m).

The SI unit for mass is the kilogram (kg).

The SI unit for time is the second (s).

These units are therefore called the MKS (metre-kilogram-second) system.

In this practical we are going the estimate the size of each of these SI units. By measuring the quantity with an appropriate instrument we can determine the uncertainty or error in our estimation.

Theory

$$\text{Uncertainty of estimation (\%)} = \frac{\text{Estimation} - \text{Measurement}}{\text{Measurement}} \times 100$$

Note: If the uncertainty is less than zero (negative), the value is said to be an underestimate. For example, an uncertainly of –14% means the value has been underestimated by 14%.

If the uncertainty is greater than zero (positive), the value is said to be an overestimate.

Method

1. Complete the first column of the table below by estimating each of the quantities. You should use as many of your senses to make your estimate, e.g. you should look closely and pick up the jar of marbles to estimate the number of marbles, and so its mass.
2. Once complete, your teacher will tell you the measured values. Add these values to your table.
3. Determine the percentage uncertainty in your estimations and define whether or not you have overestimated or underestimated.

Results

Quantity	Estimate, with SI unit	Measurement, with SI unit	Uncertainty %	Overestimate or underestimate
Example: Teacher's height	1.5 m	1.73 m	$\frac{1.5 - 1.73}{1.73} \times 100$ = −13%	underestimate
The number of marbles in the jar				
The height of the teacher's desk				
Mass of jar of marbles				
A time interval defined by your teacher				
Your overall accuracy = average of % uncertainties				

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PRACTICAL

Name: ....

Investigating motion using a ticker-tape timer

Aim

To understand how to interpret ticker-tape timer data

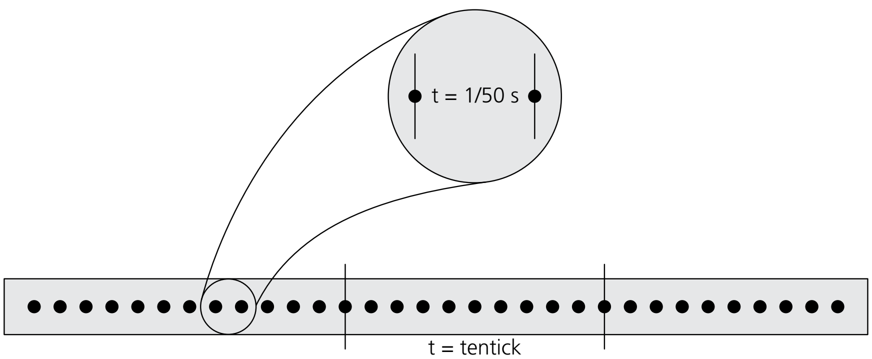
You need:

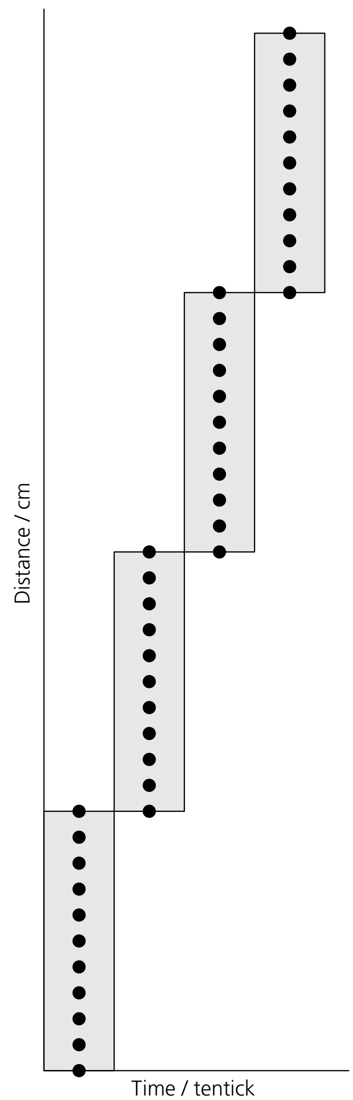
- ticker-tape timer
- ticker-tape
- slope (should be as frictionless as possible)
- 30 cm rule
- scissors
- glue

Introduction

The ticker-tape timer produces marks or dots at regular intervals on special tape that is sensitive to pressure. It takes its timing from the mains frequency and therefore prints 50 dots per second. It allows us to measure precisely short intervals of time corresponding to short distances travelled.

Time interval between 2 dots = 1/50 seconds

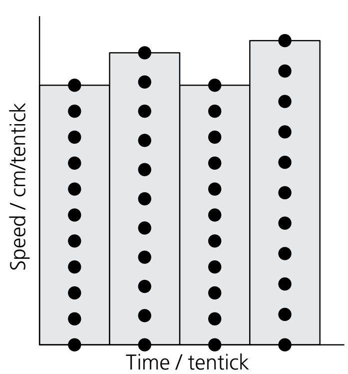




The time interval between 10 dots is called a tentick length. A tentick length corresponds to 0.2 seconds.

Theory

- The speed is given by the gradient of a distance-time graph.
- The acceleration is given by the gradient of a speed-time graph.
- When an object moves at constant speed its acceleration is zero.



Name: ....

Method

1 Hold one end of the tape and pull it through the timer relatively quickly but at constant speed.

2 Use scissors to cut out the tape into eight tentick lengths, labelling the lengths as you cut them.

3 Glue the first four lengths onto the result sheet below, building a distance-time graph.

(a) Is the slope a straight line?

(b) What does the slope represent?

(c) Calculate the slope of the line.

slope = ____________ = ____________ cm/s

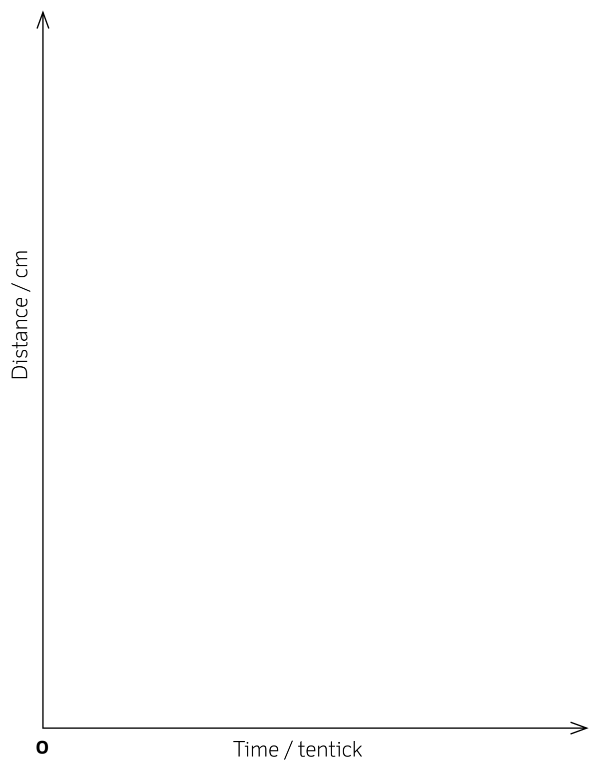
4 Glue the second four lengths onto the result sheet below building a speed versus time graph.

(d) What does the slope of the graph represent in this case?

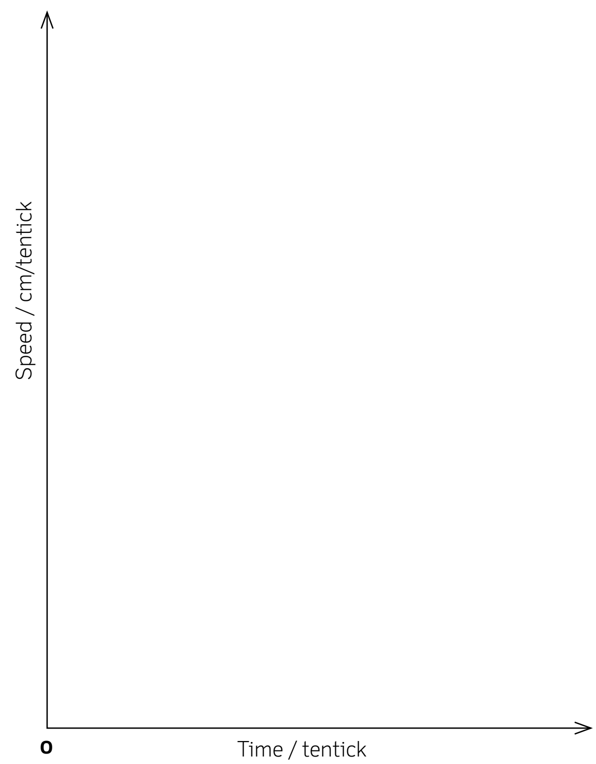
(e) How, from this plot, can you determine whether or not you were able to pull the tape through the ticker-tape timer at a constant speed?

Result sheet

Distance-time graph



Speed-time graph



Name: ....

Acceleration of a trolley using a ticker-tape timer

Warning
Be careful with falling masses. Allow masses to fall onto a soft object or into a tray of sand.

Aim
To determine a value for the acceleration of a trolley from the slope of a velocity-time graph

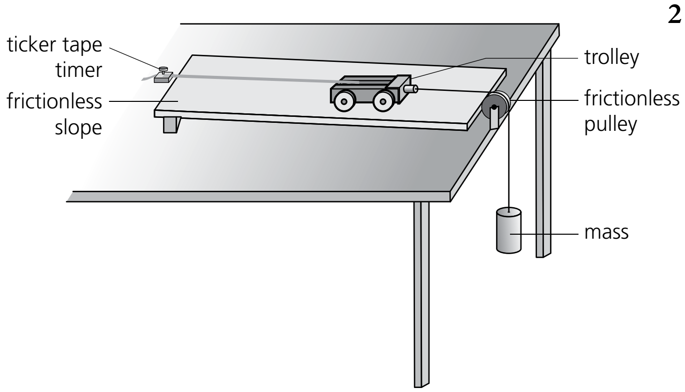
You need:
- ticker-tape timer
- ticker-tape
- pulley
- trolley
- long, flat wooden board
- mass
- string
- adhesive tape
- 30 cm rule
- scissors
- glue
- graph paper

Introduction
A constant force may be applied to a trolley by allowing a mass, attached to the trolley by a string passing over a pulley, to fall vertically under the influence of gravity. See the diagram.

Theory
- The time interval between 10 dots is called a tentick length.
- A tentick length corresponds to 0.2 seconds.

Method
1 Adjust the slope so that the trolley moves at an approximately constant speed, resulting in a frictionless slope.

2 Set up the apparatus as shown:



3 Attach a ticker-tape to the trolley with adhesive tape and pass the tape through a ticker-tape timer.

4 Allow the falling mass to pull the trolley via the string over the pulley. Record the motion of the trolley using the ticker-tape timer.

Results and analysis
1 Cut, label, and glue the tentick lengths side-by-side on a velocity-time graph.

2 Deduce the slope (gradient) of the curve.

Conclusions
1 State the value of the acceleration of the trolley from your experiment.

2 How does the ticker-tape timer affect the value of acceleration that you found?

Name: ....

The principle of moments

Aim

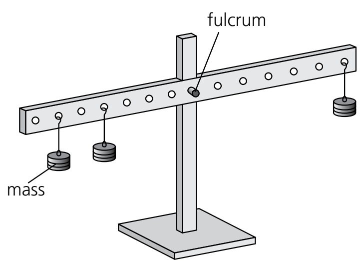
To understand and apply the principle of moments using a lever

You need:

- stand, boss, and short metal rod to act as the fulcrum
- 50 cm rigid metal strip with holes drilled and labelled every centimetre along its length to act as a balance bar
- 6 × 20 g slotted or hanging masses

Introduction

The turning effect of a lever depends not only on the magnitude of the force but also the length of the lever arm. The length of the lever arm is the perpendicular distance between the pivot point (fulcrum) and the line of application of the force.



Theory

The turning effect of a force is called its moment. When an object is in equilibrium, the sum of the clockwise moments is equal to the sum of the anticlockwise moments at that point.

The moment of a force about a pivot point is the force multiplied by the perpendicular distance from the pivot point. For two forces, F_1 and F_2, both acting downwards at perpendicular distances, d_1 and d_2, either side of the fulcrum:

$$F_1 \times d_1 = F_2 \times d_2$$

A lever is a simple machine that requires a rigid beam and a pivot point. It is usually used to amplify a force to lift a load. The mechanical advantage, or amplification factor, is defined as the ratio between the load and the effort.

$$\text{mechanical advantage} = \frac{\text{load}}{\text{effort}}$$

Method

Set up the balance bar with the fulcrum at its centre. The balance bar should be free to rotate about the pivot point.

Experiment number	Load (masses to the left of fulcrum)	Effort (masses to the right of fulcrum)	Is the lever in equilibrium?	Mechanical advantage of the lever
1	20 g at 10 cm	20 g at 10 cm		
2	2 × 20 g at 5 cm	1 × 20 g at 10 cm		
3	3 × 20 g at 4 cm and 1 × 20 g at 12 cm	2 × 20 g at 12 cm		
4	3 × 20 g at 6 cm and 1 × 20 g at 12 cm		yes	

If the bar is not horizontal (balanced) a small mass may need to be attached to the back of the rule with adhesive tape to balance it.

Add masses to the balance bar according to the table above and complete the empty boxes.

Question

Using the principle of moments, calculate the position of a 20 g mass to counterbalance four masses: 1 × 50 g at 6 cm, 1 × 20 g at 8 cm, 1 × 10 g at 10 cm, and 1 × 5 g at 12 cm. Show your working.

PRACTICAL

Name: ....

Hooke's law experiment

Aim
To investigate Hooke's law and to measure the spring constant of a spring

You need:
- clamp stand, boss, and clamp
- steel spring
- 10 × 100 g slotted or hanging masses
- 30 cm rule

Introduction
Robert Hooke discovered that under certain conditions the extension, or the increase in length, of most materials is directly proportional to the load applied.

$$F = kx$$

F is the applied load (N)
k is the spring constant (N/m)
x is the extension (m)
One condition was that the force should not exceed a certain value, called the limit of proportionality, labelled X on the graph. If the limit of proportionality is exceeded then the material may still return to its original length or shape when the load is removed. If, however, the material does *not* return to its original shape, it is permanently deformed and we know that the load has exceeded a limit called the elastic limit, labelled E on the graph.

Method
1 Measure the natural length of the spring. When measuring the length of the spring ignore parts of the spring, such as end loops, that do not extend when a load is added.

2 Hang the spring from the clamp and add a 50 g mass to the spring.

3 Measure and record the length of the spring. We will call this the starting length of the spring, and assume that there is zero load attached.

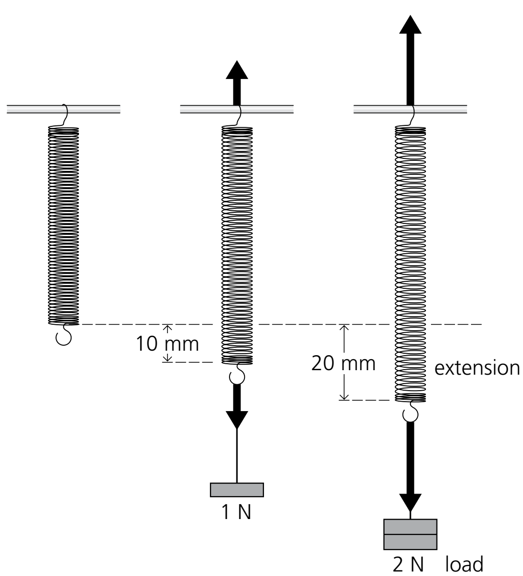
4 For every 50 g mass you add to the spring, measure the new length of the spring.

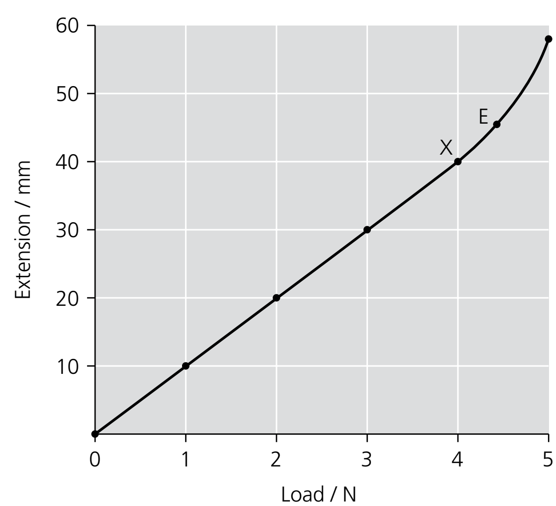
5 Record your results in a table.

6 Remove the loads from the spring. Did the spring exceed the elastic limit?

7 Calculate, in a separate column of the table, the extension of the spring for each load applied.

extension = new length − starting length





Name: ....

Analysis

1 Plot a graph of extension (y-axis) against load (x-axis) on graph paper.
   - **(a)** Make the plot as large as possible.
   - **(b)** Carefully label the axes (including units) and give the graph a title.
   - **(c)** Plot the data points as dots with circles or crosses.
   - **(d)** If the points fall on a straight line then draw a 'best fit' line through those data points.

2 Mark the limit of proportionality on the graph, if visible.

3 From the graph, determine the spring constant of the spring.

4 What load would give an extension of 30 mm?

5 What would be the spring length for a 4.7 N load?

Name: ....

Hydrostatic pressure

Aim

To determine the relationship between the height of a water column and its pressure, and deduce the density of water from the hydrostatic pressure

You need:

- 1.5 m long transparent plastic tube, open at one end with a tap at the other
- tape measure
- absolute pressure gauge

Introduction

You might have noticed that your ears 'pop' when coming down from the mountains in a car or a train. This is because your ears are pressure sensors and they face some difficulty adapting quickly to differences in atmospheric pressure.

Similarly, it is essential for scuba divers to be aware of the effects of changes in pressure on the body—not only on the ears, but more importantly, on the lungs. They learn that for every 10 m they descend, the pressure goes up by approximately 1 atmosphere (1.01×10^5 Pa at sea level).

You will investigate the relationship between pressure and the height of a column of water. You will also be able to find a value for the density of the water from the hydrostatic pressure.

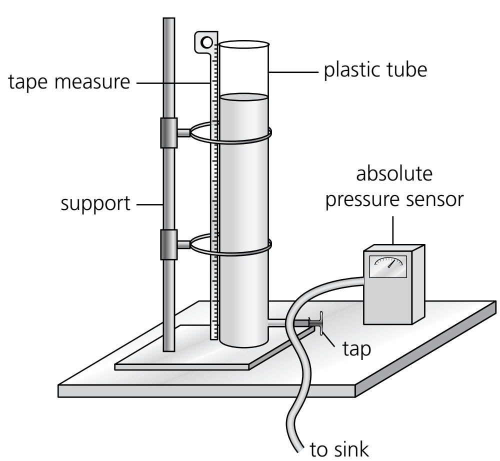
Theory

The absolute pressure or total pressure, P, at a depth, h, below the surface of the water is given by:

$$P = P_0 + h\rho g$$

P_0 is the atmospheric pressure

g is the acceleration due to gravity



Method

1 Mount the clear plastic tube vertically and support firmly.

2 Fill the tube with water using a plastic pipe connected to a water supply. Close the tap and allow any air bubbles to escape.

3 Record the height of the column of water and the reading on the pressure sensor.

4 Open the second valve and record the pressure.

5 Allow some water out of the plastic tube and record the new column height and associated pressure.

6 Collect sufficient data and record it in a table.

7 Plot a graph of absolute pressure (y-axis) against water column height (x-axis).

Analysis

1 How are the pressure and water column height related?

2 With reference to the equation $P = P_0 + h\rho g$: what does the intercept of a pressure versus column height graph correspond to? Find the value of the intercept from your graph.

3 What does the gradient of a pressure versus column height graph correspond to? Determine the slope of your graph.

4 Using the results from your graph, calculate a value for the density of water. How does this compare with the accepted value of 1000 kg/m^3?

Name: ....

Properties of water

Aim

To use water to explore the kinetic theory of molecular motion

You need:

- small, clean, flat dish
- needle
- pair of pincers
- detergent
- potassium permanganate crystals
- glass capillaries of different diameters
- colouring

Questions

1

(a) Which objects can you find in the classroom that would float on water?

(b) Why would they float on water?

(c) For how long would they float?

2

(a) Use a clean pair of pincers to place a needle carefully on the surface of the water. Can you make the needle float on the water?

(b) What property of water allows this to happen?

(c) How does the kinetic theory explain this?

3

(a) How would you prove that water expands upon freezing?

(b) How would you determine the degree to which it expands?

4

(a) What happens when a crystal of potassium permanganate is put in the water?

(b) What is this process called?

5

(a) What can you see inside the different sized glass straws when they are placed in a beaker of coloured water?

(b) What is this phenomenon called and how is it explained?

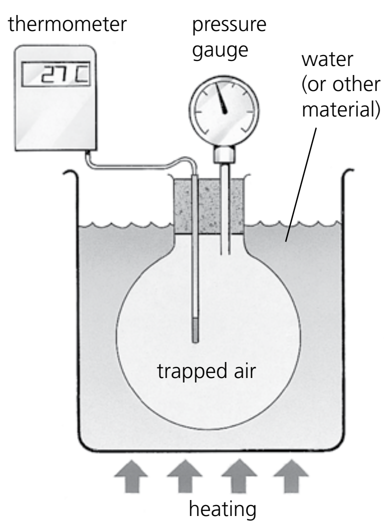
Name: . . . .

Determining absolute zero

Aim
To plot data for the pressure law and determine a value for absolute zero

Theory
Atmospheric pressure at sea level: 1 atmosphere $= 760$ mm Hg $= 76$ cm Hg $= 1.01 \times 10^5$ Pa.
According to the kinetic model, as the temperature of a gas is reduced the molecules in the gas move more slowly. By moving more slowly they are less likely to collide with the walls of the container, so the pressure is also reduced. Absolute zero is the temperature at which the molecules in the gas stop moving and hence stop colliding with the chamber walls, resulting in zero pressure.

Method
A fixed mass of a gas is kept in a rigid container so that the volume of the gas stays constant. A pressure gauge is used to measure the pressure inside the container.



The gas is both heated and cooled, and its temperature is measured with a thermometer.

Results
The results of the pressure as a function of temperature obtained are shown in the table below:

Temperature / °C	Pressure / cm Hg
150	108
100	96
50	83
0	71
–50	58
–100	46

Analysis
1 On a piece of graph paper, plot a graph of temperature (x-axis) versus pressure (y-axis). Start your horizontal axis at –300°C and your vertical axis at zero pressure.

2 Using a ruler, draw the line of best fit through your data points.

3 Continue your line of best fit to the horizontal axis.

4 What is the value for the temperature corresponding to this intercept?

5 How does your value compare with the accepted value of –273°C?

6 Why does this experiment provide evidence for absolute zero? (Hint: what is the lowest possible value for the pressure of a gas?)

Name: ....

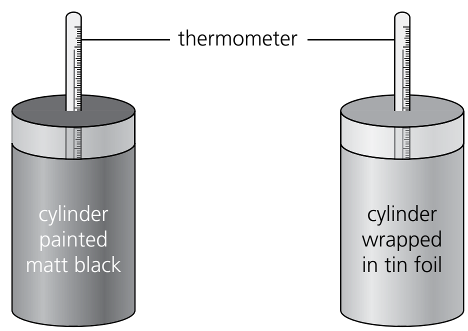
Transfer of heat by radiation

Warning
Be careful when handling boiling water as it can burn badly.

Aim
To discover what type of surface emits radiation more efficiently

You need:
- electric kettle
- metal can with a volume of about 120 ml, painted dull black
- metal can with a volume of about 120 ml, tightly wrapped in aluminium foil
- two thermometers
- insulating mat
- stopwatch

Introduction
Heat can be transferred in three ways—conduction, convection, and radiation. In this experiment, you will investigate which surfaces are the most efficient at emitting heat by radiation.



Method
1 Fill both the cans with about 100 ml boiling water.
2 Insert the thermometers into the cylinders, and record the temperatures of the water inside the two cylinders at one-minute intervals. Remember to stir the water before each reading.
3 On separate graphs, plot the temperature of the water in each cylinder over a period of 10–15 minutes. Be careful to label the graphs correctly.

Observations
1 List the precautions you have made to ensure that this is a fair test. You should be able to think of at least four.
2 Which can cools the quickest? Why?
3 Where else could you use the effect you have found?
4 Can you predict which surface would be the most efficient absorber of heat by radiation?

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Name: ....

Keeping hot drinks hot

Aim

To plan an investigation and to design an apparatus to minimize heat loss

You need:

- polystyrene foam
- aluminium foil
- bubble wrap
- styrofoam beads
- cardboard box
- polystyrene cup
- paper cup
- cardboard
- scissors
- adhesive tape
- cork mats
- thermometers

Introduction

A pizza delivery company delivers hot drinks as part of its home delivery service. You have been hired to investigate the best way of keeping the drink warm over the 15 minute delivery period.

In your group, discuss how you might carry out the investigation. See pages 108–113 in your textbook and think about:

- what apparatus you will use
- how you will carry out the investigation
- what you will measure (the variables)
- how you will make it a fair test (what you will keep the same each time)
- how you will present your results to help you find a conclusion

Note: A good science investigation begins with a control experiment. This gives you a set of results you can compare all the others to. In this case it would be the set of results with no insulating material at all.

Design

1 List the apparatus you think you will use.

2 Draw a diagram of how you will use the apparatus. Make this diagram clear so that you could give it to someone else and they would know what to do.

3 List the variables you will measure in the experiment.

4 List the things you will try to control and keep the same each time, to make it a fair test.

5 What is your hypothesis—what do you predict you will find out in your investigation?

Before you start your experiment show your design to your teacher.

The experiment

1 Describe your experimental method in words and diagrams.

2 Design and complete a result table.

3 Plot the results of your investigations on graph paper. Make sure you label your axes and plot the points carefully. If the points fall on a straight line, use a rule to draw a line of best fit.

Conclusion

1 What do you discover?

2 Is your hypothesis correct? Why?

3 What could you do to make your experiment more accurate?

Name: ....

Specific heat capacity of water

Aim

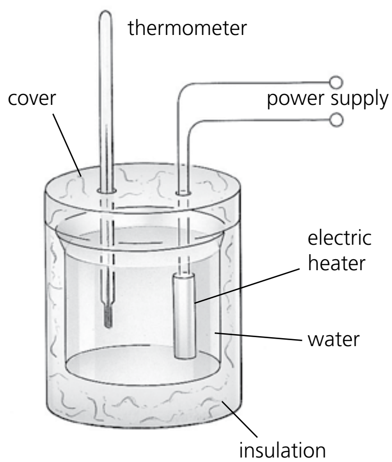
To determine the specific heat capacity of water using an electrical method

You need:

- small calorimeter with known power consumption
- thermometer
- measuring cylinder
- insulating mat

Theory

Equal quantities of different substances require different amounts of heat to raise their temperatures by the same amount. The specific heat capacity (symbol c) of a substance is the heat required to produce a one degree rise in temperature in one kilogram of the substance. The unit for specific heat capacity is J/kg °C.



Method

1. Pour 50 ml of water into the calorimeter container. Stir the water while heating it up to distribute the heat evenly, and record its temperature every 30 seconds.
2. Plot the readings on a graph, with time along the x-axis and temperature rise, from the initial temperature, on the y-axis.
3. Repeat the experiment using 100 ml of water from the same initial temperature.
4. Plot the new readings on the same axes.

Analysis

1. What do you notice about the two graphs?
2. From each experiment, calculate an approximate value for the specific heat capacity of water.

Heat energy is measured in joules (J). The heater has a certain power rating. In other words it supplies a given amount of heat energy every second. This will allow you to calculate an approximate value for the specific heat capacity of water from your graph.

We assume that the heat transfer is perfectly efficient. In other words,

the heat given out by the heater = the heat gained by the water

$$Pt = mc\Delta T$$

P is the power rating of the heater

t is the time for which the heater was on (s)

c is the specific heat capacity of water (J/kg °C)

m is the mass of the water (kg)

ΔT is the rise in temperature (°C)

3. Is your value for c an overestimate or an underestimate? Compare it with the accepted value (4186 J/kg °C).
4. What could you do to improve the experiment and obtain closer agreement with the accepted value?

Name: ....

Latent heat of water

Warning
Do not eat the ice as it may not be clean and is not meant for consumption.

Aim
To determine the latent heat of fusion of ice

You need:
- 300 ml measuring cylinder
- glass beaker
- 200 ml water at about 50°C
- about 4 ice cubes (at 0°C)
- paper towels
- thermometer
- insulating mat

Theory
The latent heat of fusion is the energy required to change the state of one kilogram of a substance at its melting point. The latent heat of vapourization is the energy required to change the state of one kilogram of a substance at its boiling point.

When you add ice to hot water, heat is taken from the hot water. This energy melts the ice and then raises the temperature of the water produced from 0°C to the final temperature of the warm water.

Density of water = 1 g/cm^3 or 1 g/ml

Specific heat capacity of water = 4186 J/kg °C

Method
1 Briefly put the ice cubes under running water to bring their temperature close to 0°C. Wipe them dry with paper towels and record their mass.

2 Pour 200 ml of warm water (at about 50°C) into the glass beaker and record the temperature of the water.

3 Add four ice cubes to the hot water and stir with a thermometer.

4 When all the ice has melted, record the final temperature.

5 Measure and record the final volume of water in the beaker.

Results

Initial volume of hot water / ml	Mass of ice / g	Temperature of hot water / °C	Final temperature once all the ice has melted / °C	Final volume of water / ml
200				

Calculations
Perform these calculations in order to find the latent heat of water.

1 Heat taken from the hot water = mass of hot water × c × temperature change of the hot water.

2 The heat taken to warm the water at 0°C to the final temperature = mass of ice × c × temperature change of water from 0°C.

3 The heat taken to melt ice = (the heat taken from the hot water) – (the heat taken to warm the water at 0°C).

This is mass of ice × latent heat of fusion (L_f).

4 $L_f = \dfrac{\text{the heat taken to melt ice}}{\text{mass of ice}}$

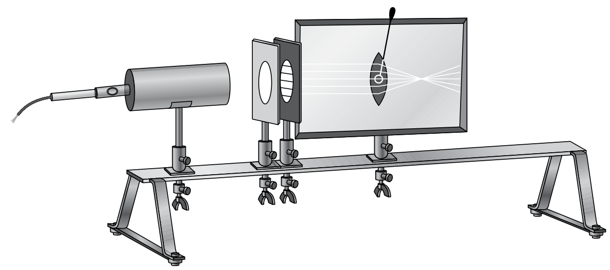
Observations
Upon repeating the experiment with varying volumes of water and masses of ice, how does your value for the latent heat of water compare with the accepted value of 330 000 J/kg?

Name: ....

The biconvex lens

Aim
To determine the focal length of a biconvex lens

You need:
- lamp
- +12cm lens and holder
- shield with 5 slits and holder
- image screen and holder
- flat biconvex lens
- clip



Introduction
A lens consists of a transparent medium—such as glass—bounded by two surfaces. A convergent lens or convex lens is a piece of transparent medium that is thicker in the middle than at the edges, causing rays of light to converge or come together.

Theory
Parallel rays of light incident on a biconvex lens converge to a single point called the focal point of the lens. A lens has two focal points on either side of the lens. The distance between the centre of the lens and the focal point is called the focal length. The greater the curvature of the lens, the shorter the focal length of the lens.

An object placed at the focal point of a lens produces parallel rays of light.

Method
1 Set up the apparatus as shown in the diagram above.

2 Position the lamp at the focal length of the +12 cm lens, i.e. at 12 cm from the lens.

3 Position the shield with 5 slits a few centimetres beyond the lens.

4 Position the image screen at 15 cm from the shield and turn it so that it is almost parallel to the lamp-shield axis. You should now have five parallel beams of light on the image screen.

5 Using a clip, fasten the biconvex lens to the image screen so that it intercepts the five beams.

6 Draw a ray diagram to show the path that each ray follows as it passes through the lens.

7 Label the point at which the rays converge as the focal point. If they converge on the principal axis label this point as the principal focal point.

8 Measure the distance from the centre of the lens to the focal point. This is the focal length.

The focal length is measured in cm or m. The optical strength of a lens is measured in dioptres, found by dividing 100 by the focal length in cm. If the lens is convex, its focal length is positive, and negative if the lens is concave.

9 Calculate the optical strength of the lens in dioptres.

Name: ....

Building an electroscope

Aim

To build and test a simple electroscope

You need:

- transparent plastic cup with a hole drilled in the centre of its base
- paper clip
- aluminium foil
- modelling clay
- scissors
- polythene rod
- wool cloth

Method

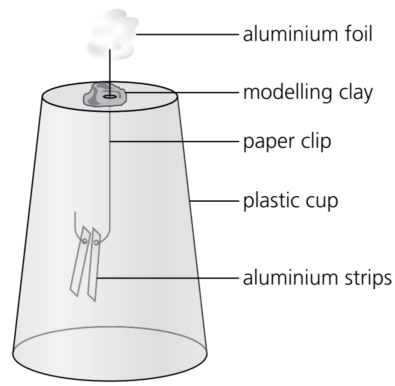
1 Using the scissors, cut out two strips of aluminium foil, each 2 cm long and 0.5 cm wide.

2 Bend a paper clip into the shape of a letter 'J'.

3 Use the paper clip to make a hole at the end of each strip of aluminium foil.

4 Hang the strips on the curved bottom of the clip. Secure with a piece of modelling clay.

5 Crumple some aluminium foil into a small ball and secure it to the top of the extending paper clip.



Assignment

Use your electroscope to investigate one aspect of electrostatics. Remember to include an aim, a hypothesis, a method, observations, and conclusions. You should draw conclusions about your electroscope as well as about the experiment you have performed.

Name: . . . .

Which materials conduct electricity?

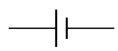
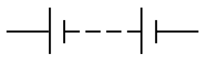
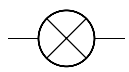
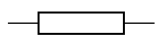
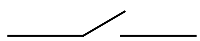
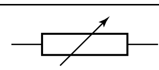
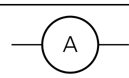
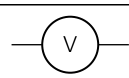
Aim

To draw and build a simple circuit, and to use the circuit to test which materials are electrical conductors

You need:

- three cells
- lamp
- switch
- six insulated wires
- two crocodile clips
- strips of plastic, copper, stainless steel, wood, card, glass, etc.

Circuit symbols

cell	
battery	
lamp	
resistor (fixed)	
switch	
variable resistor	
ammeter	
voltmeter	

Instructions

1 (a) Using the correct symbols from the above list and *a rule*, draw a simple circuit diagram consisting of a cell, a lamp, and a switch. Label the positive and negative terminals of the cell and the lamp.

(b) Set up the circuit you have just drawn and let your teacher check it before you close the switch. Describe what happens when you open and close the switch.

(c) Move the lamp to the other side of the switch and describe what happens when you open and close the switch.

2 (a) Draw a circuit diagram consisting of three cells, two lamps in series, and a space in which to connect the different strips.

(b) Set up the circuit you have drawn. Note the different types of material to be tested and note what happens when each is connected into the circuit.

(c) Make two lists, one of conductors (the materials which allow electric current to flow), and one of insulators (the materials which do not allow electric current to flow).

Name: ....

I-V characteristics of electrical components

Warning

Open the switch to avoid the battery from overheating when not in use.

Aim

To measure the *I-V* characteristics of Ohmic and non-Ohmic components

You need:

- 6 cells
- 10 Ω resistor
- 20 Ω resistor
- switch
- 9 V lamp
- diode
- rheostat (variable resistor)
- voltmeter
- ammeter
- connecting wires

Method

1 Draw a circuit diagram consisting of 6 cells, a switch, a rheostat, a lamp, one of the components to test, and an ammeter, all in series. Add a voltmeter to record the voltage across the test component.

2 Set up the circuit and let your teacher check it. This is very important!

3 Record values of voltage across the component and current passing through it in a table by varying the setting on the rheostat. Values should also be recorded after reversing the polarity of the cells.

4 Repeat the measurements for all four components (two resistors, a diode, and a lamp).

Analysis

1 Plot your results on a graph with voltage, *V*, on the vertical axis and current, *I*, on the horizontal axis.

2 Which of these components are Ohmic and which are non-Ohmic? How did you work this out?

3 Using your graphs, find a value of the resistance for the Ohmic components.

Name: ....

Wiring a plug

Warning

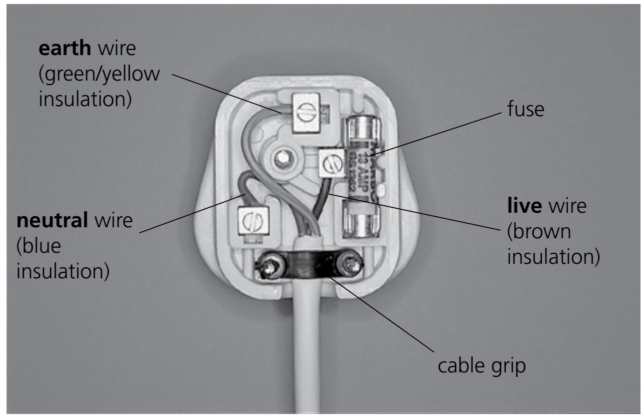
Be careful when using sharp knives, wire strippers, and wire cutters.

Aim

To teach students how to wire a plug

Risk assessment

Ensure that a full risk assessment has been made before conducting this experiment. It is meant for teaching purposes only and under no circumstances should students be allowed to wire plugs that will eventually be connected to a mains supply, unless supervised and approved to do so by a qualified engineer.



You need:

- plug
- three-strand cable compatible with the plug used
- wire stripper or sharp knife
- screwdriver
- multimeter

Theory

There is no standard plug in the world. The following are instructions for a three-wire plug, with neutral, earth, and live connections. They may therefore need to be adapted to local standards, such as colour codes and plug design.

Method

1. Open the plug with the screwdriver and loosen, without removing, the connection screws and cable grip.
2. Position the wire on top of the plug in its correct location to estimate the length of outer insulation to be removed. This will typically be around 30 mm.
3. Use the wire stripper, adjusted correctly, to remove only the outer insulation. If a wire stripper is not available and a sharp knife is used instead, make sure that the cut around the wire to remove the outer insulation does not also cut the inner insulation. It is better to cut through half of the outer insulation and bend the wire backwards and forwards to break through the other half. If the inner insulation has been damaged in attempting to remove the outer insulation then use the wire cutters to cut off the damaged length and start again.
4. Position the wire on top of the plug in its correct location again, ensuring that the cable grip will fasten down on to the outer insulation. Estimate the length of wires required to make a connection inside its respective terminal. In the UK, the blue wire is connected to the neutral connector, labelled N, the yellow/green wire is connected to the earth connector, labelled E or the sign for earth, and the brown wire is connected to the live connector, labelled L.
5. Cut the wires to their correct length with the help of wire cutters.

Name: ....

6 Strip 5 mm of insulation off the end of the wires using the wire strippers or sharp knife.

7 Twist the end of each wire so that no strands are out of place.

8 Pass the three wires under the cable grip (and on some plugs through the plug outer cover) and connect the three wires to their respective terminals, screwing down on the bare wire to make the electrical connection. Ensure that the wires are neatly routed to avoid kinks or excessive pressure on them when the plug cover is screwed on.

9 Tighten down hard the cable grip so that pulling on the cable does not pull the wires out of their terminals.

10 Double check that the wires are connected to the correct terminal.

11 If included in the plug, ensure that the correct fuse is installed in the fuse holder.

12 Fit the plug cover and screw down tightly.

Swap plugs with another student and perform the following checks.

Checks

Remove the plug cover and check that the wires are connected to the correct terminals.

Pull on the cable to test that the cable grip functions correctly.

Pull on each wire gently to ensure that the connectors are tight enough.

Using a multimeter, check that the electrical connections have been made.

PRACTICAL

Name: ....

Ohm's law

Aim

To investigate the relationship between the current and voltage for an 'Ohmic material'

You need:

- four cells
- three 10 Ω resistors
- switch
- eight insulated wires
- ammeter
- voltmeter

Theory

Georg Ohm discovered that the current flowing through certain materials is directly proportional to the potential difference placed across them. Mathematically, we write:

$V \propto I$

or

$V = \textit{constant} \times I$

We call this constant the resistance, R.

Hence, $V = I \times R$.

In recognition for this discovery we call such materials Ohmic materials and call the unit of resistance the Ohm (Ω). Those materials that do not exhibit this characteristic are called non-Ohmic materials.

Method

1. Using a rule, draw a series circuit consisting of a cell, an ammeter, a switch, and two resistors.
2. Construct the circuit. Let your teacher check it.
3. Use your circuit to measure the current through the circuit and the voltage across the lamps.
4. Add another cell in series to the circuit and measure the current and voltage across the lamps.
5. Repeat the measurements with three, then four, cells in the circuit.
6. Plot a graph of your data with voltage, V, on the horizontal axis and current, I, on the vertical axis.

   Are the resistors Ohmic or non-Ohmic components?
7. By rearranging the equation $V = I \times R$ and using your graph, calculate the resistance of the resistors.
8. Repeat the whole experiment using three resistors. Plot the results on the same axes and compare the two graphs.

PRACTICAL

Name: ....

Magnetic fields of permanent magnets

Warning

Do not touch the iron filings directly. If you do touch them accidentally, wash your hands thoroughly.

Aim

To investigate the magnetic fields around permanent magnets

You need:

- two bar magnets
- horseshoe magnet
- keeper
- soft iron ring
- transparent plastic sheet from overhead projector or (if a plastic sheet is not available, a plain piece of paper is a good substitute)
- iron filings
- plotting compass

Theory

All magnets have a north and a south pole. *Like* poles repel each other. *Unlike* poles attract. A magnetic field is a region of space where a charged particle, or a magnetic material, experiences a force. The magnetic field lines go from the north pole of a magnet to the south pole.

When iron filings are put into a magnetic field they experience a force that pulls them into position around the magnet. So iron filings can be used to plot the shape of the magnetic field. Similarly, a plotting compass will feel a force and can be used to indicate the direction of the magnetic field.

Method

1 Place the transparent plastic sheet (or paper) over a bar magnet and sprinkle iron filings onto the sheet. Carefully tap the edge of the sheet. Note where the filings accumulate and draw the pattern using continuous lines. Be careful not to get the iron filings on the magnet as they are difficult to remove afterwards!

2 Repeat the experiment using a horseshoe magnet.

3 Place the keeper on the horseshoe magnet.

(a) What does the field look like now?

(b) What is the purpose of the keeper?

4 Put the soft iron ring between the poles of the horseshoe magnet and repeat the experiment.

(c) What is the effect of the iron ring on the magnetic field pattern?

5 Place two bar magnets under the transparency so that *like* poles are pointing to each other. Sprinkle with iron filings and draw the pattern you see.

(d) The point in the middle is called a neutral point. Can you work out why?

6 Place two bar magnets end-to-end under the transparency so that they are touching, *unlike* poles together.

(e) What does the field look like now?

(f) What would it look like if you could cut a magnet in half?

7 Look at the plotting compass while it is far away from any magnet. In which direction does it point?

8 Bring the plotting compass close to one of the poles of the bar magnet.

(g) What happens?

9 Move the plotting compass around the bar magnet and draw the magnetic field around the magnet.

Name: ....

Building an electric motor

Aim

To build an electric motor and, in doing so, understand how it works

You need:

- 1 m insulated wire
- cell
- adhesive tape
- sandpaper
- two paper clips
- two flat magnets
- modelling clay
- plastic straw
- scissors
- two crocodile clips
- two connecting cables

Theory

The electric motor operates on the principle of electromagnetism. A current-carrying wire produces a magnetic field. If this current carrying wire is placed inside an external magnetic field, then as a result of these two competing magnetic fields, a force is generated.

This force generates a turning effect if the wire is formed into a coil. A commutator is required to keep the coil rotating in the magnetic field. A split ring commutator is usually used for commercial electric motors. (see page 212 in your textbook).

To build a simple electric motor it is sufficient to simply strip the insulation off one side of the wire such that when the wire rotates on its support, half the time it makes electrical contact and the other half there is an insulation layer between the contacts.

Method

1 Wrap the wire carefully around the cell about 10 times, without creating sharp bends in the wire, and leaving about 5 cm of free length at either end.

2 Remove the wire from the cell with the free lengths coming out of either side of the loops and secure the loops tightly together with the adhesive tape, ensuring that the resulting coil is symmetrical about its rotation axis.
To check this, hold the coil by the free ends between your thumbs and first fingers and try to rotate it. If it does not rotate freely you will need to make some adjustments to the coil.

3 Place the coil on a flat surface and rub the insulation off only the last centimetre of the upper side of the free ends. This is the commutator.

4 Bend two paper clips into a ‘p’ shape. Push the paper clips into the modelling clay. Position them so that the commutator makes contact with the clip at either end.

5 Mount the magnets in some more modelling clay so that the north and south poles are facing each other and the coil can be mounted between them rotating freely.

6 Make the electrical connections between the cell and base of the paper clips using the crocodile clips.

7 Give the coil a gentle push and watch it turn!

8 To keep the coil centred, cut some short lengths of plastic straw to fit between the paper clips and the coil.

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PRACTICAL

Name: ....

Logic gates

Aim
To design and construct various circuits based on logic gates

You need:
- logic board
- 4.5 V DC supply
- connecting wires
- cell
- DC motor

Method
1 Construct and draw a circuit to switch the light on when there is no light and the switch is pressed. What could be the use of this circuit?

2 Construct and draw a circuit such that the buzzer does not sound when the temperature rises and there is light.

3 Construct and draw a circuit such that the motor turns when the push switch is pressed down or when the temperature is low.

4 Construct and draw a circuit to make the buzzer sound when:

(a) there is not enough light outside, and the temperature is high

(b) the press switch is pressed

Name: ....

Radioactive decay

Aim
To understand radioactive decay

You need:
- 10 dice

Theory
The decay of radioactive nuclei is a completely random process; it is not possible to predict which nuclei will decay next, or when a particular nucleus will decay.

The half-life of a radioactive nucleus is the time it takes for half of the nuclei to have decayed.

Method
1. Start with 10 dice. Everyone else in your class will also have 10 dice. A 6 represents a nucleus that has decayed to a daughter nucleus.
2. Everyone should roll the dice and put those that show 6's to one side.
3. Record the number of dice remaining. This represents the remaining parent nuclei.
4. Try and predict which die will turn up with a 6 next time.
5. Repeat this process for about 30 throws.
6. Share your results with everyone in your class.
7. Plot the number of dice that remain after each throw for your results only.
8. Plot the number of dice that remain after each throw for the whole class.

Analysis
1. Was it possible to predict precisely which die would show a 6?
2. From the graph of your results, determine the half-life of the radioactive decay.
3. Compare your half-life with other students in your class.
4. Compare your half-life with the half-life of the combined class results.

Conclusions
If the radioactive process is random, can you predict anything at all about the process? Explain your answer as fully as you can.

Name: ....

Kinematics and dynamics

1 A car starts at rest from point O and travels to point A. The velocity of the car is recorded at various points along the path.

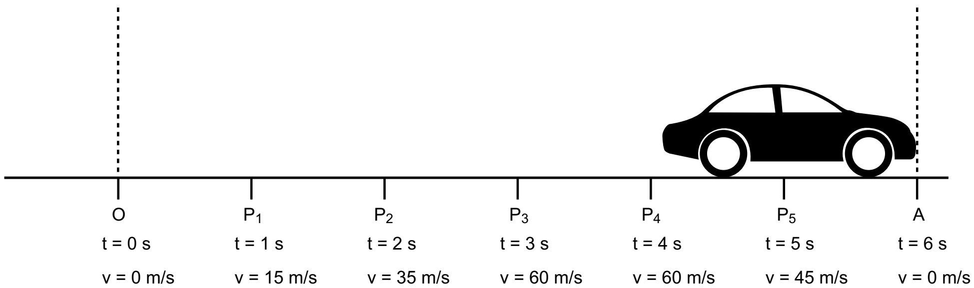

Fig. 1.1

(a)

(i) What is the acceleration of the car at point P_2? .... **[1]**

(ii) Calculate the acceleration at points P_4 and P_5. Explain the difference between the two?

....

.... **[2]**

(iii) Complete the table below for Fig. 1.1

Table 1.1

Point	Speed / m/s	Time / s	Acceleration / m/s²
O			
P_1			
P_2			
P_3			
P_4			
P_5			
A			

[1]

Name: ....

(iv) Plot a speed-time graph for the data in Table 1.1:

[4]

(v) What is the total distance travelled by the car?

.... **[1]**

(vi) What is the average speed of the car? The maximum speed?

....

.... **[2]**

(vii) Explain the flat region of the curve.

....

.... **[1]**

[Total: 12]

Name: ....

2

(a) The acceleration of a trolley of mass 2 kg is measured in the set-up shown in Fig. 2.1:

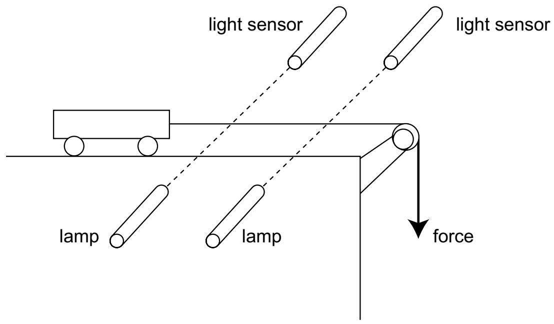

Fig. 2.1

(i) State the equation that connects mass, force, and acceleration.

....

.... **[1]**

(ii) Explain how the acceleration would be affected if a trolley of mass 4 kg were substituted for the original trolley.

....

.... **[1]**

(iii) Explain why light sensors are used in the experiment.

....

.... **[1]**

(b)

(i) Draw a labelled diagram showing the forces acting on a body in circular motion.

[2]

Name: ....

(ii) In what forms is the centripetal force manifested in a satellite orbiting the Earth and an electron orbiting the nucleus of an atom?

....

.... **[1]**

(c) Two objects are shown in Fig. 2.2 with the arrows showing the forces acting on them.

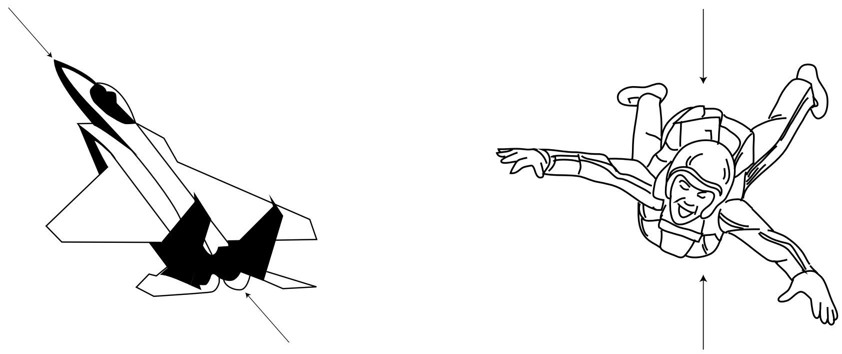

Fig. 2.2

(i) Label the forces acting on both the objects. .... **[1]**

(ii) Which forces have greater magnitude on each object?

.... **[1]**

(iii) In the case of the parachutist what would the curve of a speed-time graph look like?

[1]

(iv) What would the curve look like if there were no upward force acting on the parachutist?

[1]

(v) Write down the equation for determining the downward force acting on the two objects?

.... **[1]**

(vi) What is the magnitude of the downward force on the parachutist if mass = 60 kg?

.... **[1]**

[Total: 12]

3

(a)

(i) Explain how the kinetic energy of a car is related to the braking distance.

....

....

....

.... **[3]**

(ii) What is the force of friction acting on an object of mass 100 kg if it is being pulled with a force of 2000 N and the resultant force is 1300 N?

....

....

....

.... **[1]**

(iii) Suggest two ways of reducing friction in heavy machinery.

....

.... **[2]**

[Total: 6]

Name: ....

Turning effect of force

1

(a)

(i) State the equation for calculating the turning effect about O.

....[1]

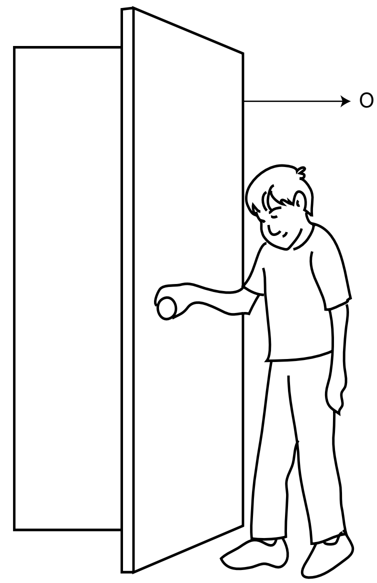

Fig. 1.1

(ii) What is the moment about O in Fig. 1.1?

....[1]

(iii) What force would have to be applied at a distance of 40 cm from the hinges if the moment about O were to be maintained?

....

....[1]

(iv) Suggest two ways of increasing the moment about O.

....

....[2]

(b)

(i) State the principle of moments for an object in equilibrium about the pivot.

....

....[1]

Name: ....

(ii) Calculate the clockwise and anticlockwise moments about A in Fig. 1.2.

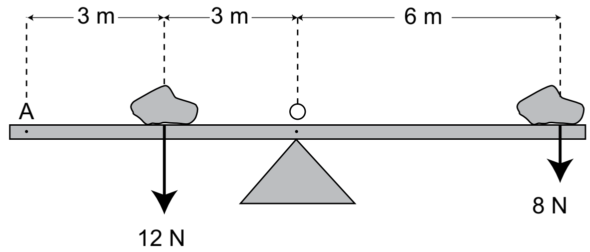

Fig. 1.2

....

.... **[2]**

(iii) State two practical applications of the principle of moments.

.... **[2]**

[Total: 10]

2 Fig. 2.1 shows a uniform bar of mass 3 kg is in balance when an object A is tied to its right end.

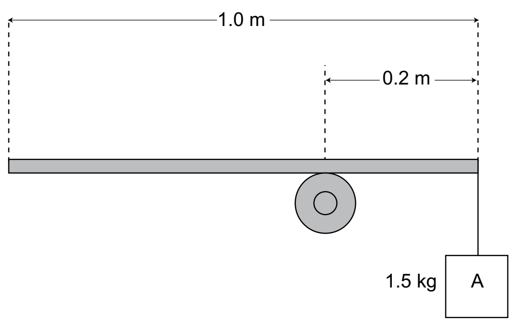

Fig. 2.1

(a)

(i) Calculate the clockwise moment. .... **[1]**

(ii) If object A is replaced with one having twice the mass, how far from the support would it need to be suspended from to balance the rod?

....

....

....

.... **[3]**

Name: ....

(b)

(i) What happens to the position of the centre of mass when an object is in neutral equilibrium? When it is moved?

....

.... **[2]**

(ii) Locate the centre of mass on the following plane shapes:

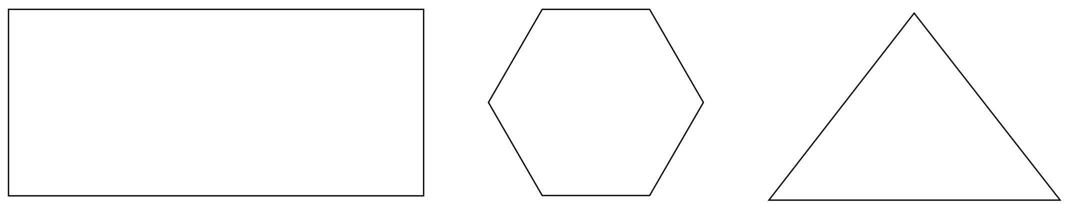

Fig. 2.2

[3]

(iii) Explain, with the help of diagrams, why a book placed vertically on a table drops flat when tilted beyond a certain angle.

[4]

(iv) Suggest two design features that enable high-speed racing cars to maintain stability.

.... **[2]**

[Total: 15]

Name: ....

Pressure

1 The apparatus in Fig. 1.1 has been set up to increase the pressure on the fixed volume of air trapped in the glass tube.

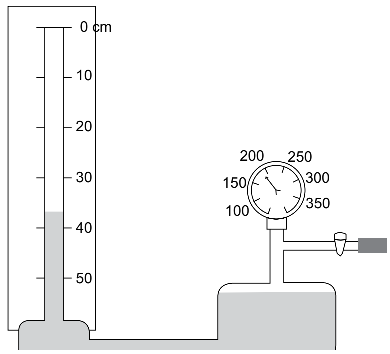

Fig. 1.1

(a)

(i) Read and state the current pressure and volume of the gas from Fig. 1.1.

.... **[2]**

(ii) Why is oil used in the set-up?

.... **[1]**

(iii) Assuming temperature is constant, what would the volume be if pressure were increased to 270 kPa?

....

.... **[1]**

(iv) Complete Table 1.1 below:

Table 1.1

Pressure / kPa	Volume / cm³
280	50
300	
320	
340	
360	

[1]

Name: ....

(v) State the equation used to complete Table 1.1.

.... **[1]**

(vi) Which law is explained by the equation in part (v)?

.... **[1]**

(vii) Plot a graph for the data in Table 1.1 and draw the curve:

[4]

(viii) What pressure would have to be applied to achieve a volume of 20 cm^3 for the gas?

.... **[1]**

(ix) Explain the relationship between pressure and volume on the basis of the shape of the curve.

....

.... **[1]**

Name: ....

(x) Calculate the gradient of the curve.

.... **[2]**

(xi) Explain why the air warms up when the pressure is increased.

....

.... **[1]**

[Total: 16]

2 Fig. 2.1 shows a water tank filled with 120 dm^3 water.

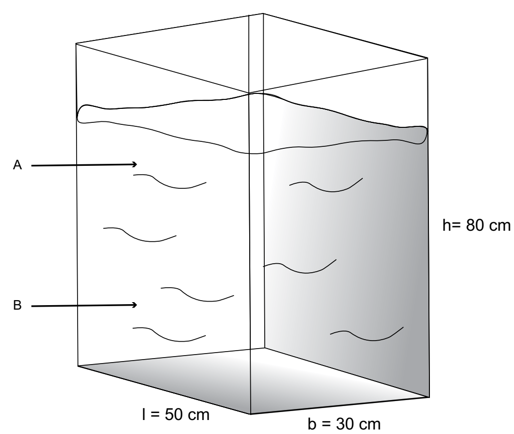

Fig. 2.1

(a)

(i) Calculate the pressure acting on the base of the tank if the density of water is 1000 g/cm^3.

....

.... **[1]**

(ii) What would the pressure on the base be if the tank were only half-filled?

....

.... **[1]**

Name: ....

(iii) Draw arrows on Fig. 2.1 to show the direction in which pressure would be transmitted if a piston with a surface area equal to that of the tank were pushed in from the top.

[1]

(iv) Would an object experience greater pressure when placed at point A in the tank or at point B? Explain your answer.

....

.... **[2]**

(v) Identify two practical problems arising due to the property identified in part (iv).

....

.... **[2]**

[Total: 7]

3 A student wants to determine the efficiency of the hydraulic jack shown in Fig. 3.1.

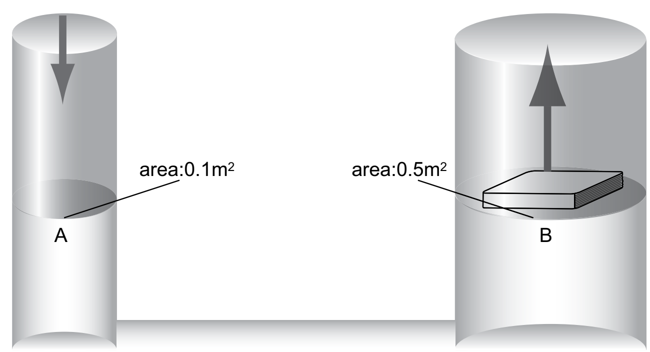

Fig. 3.1

(a)

(i) Calculate the pressure on the hydraulic fluid if the student applies a force of 10 N on the input cylinder.

.... **[1]**

(ii) Calculate the output force.

.... **[1]**

Name: ....

(iii) How high would the book be lifted if a force of 1 N lifts it through 5 cm?

.... **[1]**

(iv) What is the force multiplier for this machine?

.... **[1]**

(v) Assuming an output force of 90 N, calculate the efficiency of the machine.

....

....

.... **[2]**

(vi) What would the output force be if the area of the output piston were reduced by half?

....

....

.... **[1]**

[Total: 7]

Name: ....

Work, energy, and power

1 A student constructs the crane shown in Fig. 1.1.

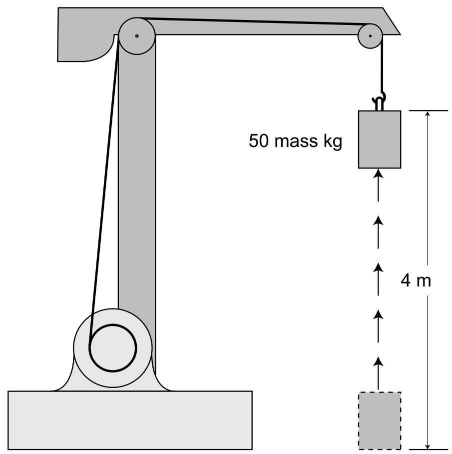

Fig. 1.1

(a)

(i) How much force would be applied in raising the block to the top of the crane?

.... **[1]**

(ii) How much work would be done in lifting the block all the way to the top?

.... **[1]**

(iii) What is the potential energy of the block before being raised? The kinetic energy?

....

.... **[2]**

(iv) What is the potential energy of the block halfway to the top? The kinetic energy?

....

....

.... **[2]**

Name: ....

(v) How much potential energy is gained in moving the block from the halfway mark to the top of the crane? How much kinetic energy is lost?

....

.... [2]

(vi) Explain the relationship between potential energy and kinetic energy with the help of a diagram.

....

....

.... [3]

(vii) Calculate the power output of the machine if it takes 5 s to raise the block to the top.

.... [1]

(viii) If the power input is 10 W, what is the efficiency of the crane?

.... [1]

(ix) Suggest two ways to enhance the efficiency of the crane.

....

.... [2]

[Total: 15]

Name: ....

2 Fig. 2.1 shows a trolley attached to a spring fixed at one end.

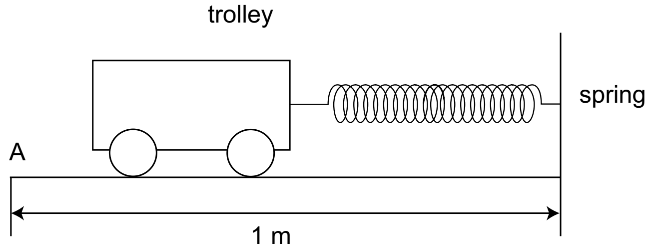

Fig. 2.1

(a)

(i) Calculate the work done on the trolley when it is pulled to point A with a force of 5 N.

....

.... **[1]**

(ii) Assuming spring constant k = 0.1 how much potential energy is stored in the trolley at point A? (Elastic PE = ½ x k x x)

....

.... **[1]**

(iii) Draw diagrams to show the positions of the block where the potential energy would be:

Maximum

[1]

Minimum

[1]

Name: ....

(iv) Draw diagrams to show the positions of the block where the kinetic energy would be:

Maximum

[1]

Minimum

[1]

(v) Identify two forces acting on the trolley during its motion.

.... **[2]**

(vi) Which of the two forces in part (v) would be greater / lesser if the trolley were replaced by a wooden block of the same mass.

.... **[2]**

[Total: 10]

3 A student wants to compare the efficiency of a petrol engine and a diesel engine.

(a)

(i) The student provides 150 J of energy to each engine. The petrol engine gives an output of 30 J whereas the diesel engine gives an output of 40 J. What is the efficiency of both the engines?

....

.... **[2]**

Name: ....

(ii) Give two reasons for the greater efficiency of one engine over the other.

....

.... **[2]**

(iii) In what form is energy wasted in the two engines?

....

.... **[1]**

[Total: 5]

Name: ....

Kinetic model of matter

1 50 g samples of two solid substances A and B are subjected to heat from a Bunsen burner in the laboratory causing them to melt. Fig. 1.1 shows the graphical representation of the rates of melting for each:

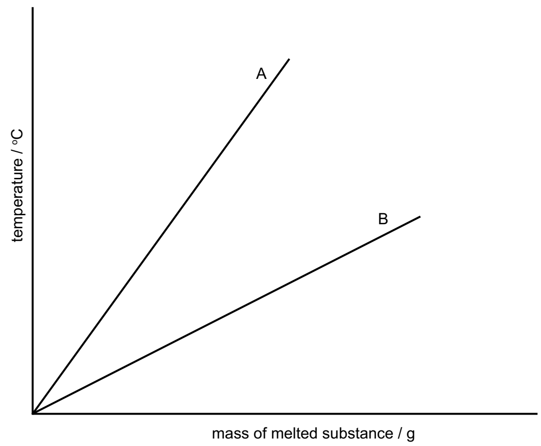

Fig. 1.1

(a)

(i) Which of the substances has a higher melting rate? How can you determine this from the graph?

....

.... **[2]**

(ii) Explain, with the help of diagrams, what happens to the molecules of the two substances.

[3]

Name: ....

(iii) Draw a similar diagram to show the changes that would occur if the substances were heated further.

[1]

(iv) Suggest one practical use of melting point in the laboratory.

.... **[1]**

[Total: 7]

2 Heat is provided to an inflated tire and the pressure inside it monitored.

(a)

(i) What happens to the gas pressure inside the tire?

.... **[1]**

(ii) Why does the change identified in part (i) take place?

.... **[1]**

(iii) State two precautions that need to be taken while performing this experiment.

.... **[2]**

(b) A beaker of water is boiled in the laboratory and the rise in temperature noted.

(i) What happens to the water molecules when the water is boiled?

.... **[1]**

(ii) The thermometer is placed above the water surface instead of being submerged into it. Explain why this is so?

.... **[1]**

Name: ....

(iii) State one precaution that must be taken during this experiment.

.... **[1]**

(c) Fig. 2.1 shows a gaseous and a solid form of carbon dioxide (dry ice):

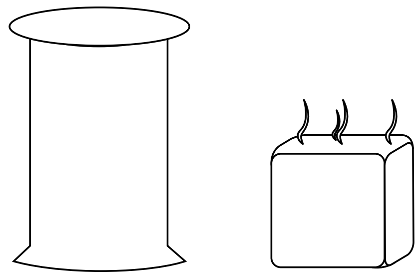

Fig. 2.1

(i) State how dry ice is prepared from gaseous carbon dioxide.

.... **[1]**

(ii) What do the vapours on the surface of the dry ice indicate? Explain in terms of the kinetic model of matter.

....

....

.... **[1]**

(iii) It is never advisable to touch dry ice without protective covering. Why is this so?

....

.... **[1]**

(iv) State one practical use of the property identified in part (iii).

.... **[1]**

[Total: 11]

Name: ....

3 Fig. 3.1 shows equal masses of two different liquids placed in dishes in open air. Sample A is placed in a closed room while sample B is exposed to the wind.

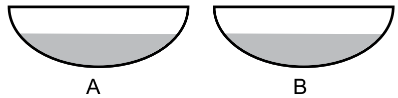

Fig. 3.1

(a)

(i) In which of the two samples would the liquid evaporate faster?

.... **[1]**

(ii) Explain your answer to part (i) in terms of the kinetic model.

....

....

....

.... **[1]**

(iii) Identify two additional factors that affect the rate of evaporation.

.... **[2]**

(iv) Suggest one commercial use of evaporation.

.... **[1]**

Name: ....

(b)

(i) Table 3.1 is based on the observations in part (a):

Table 3.1

Time / min	Mass of liquid A / g	Mass of liquid B / g
5	50	50
10	45	48
15	40	45
20	35	42
25	30	39

Plot a graph for the two sets of data.

[6]

(ii) Interpret the slope of the curve for the two liquids.

....

....

.... **[1]**

[Total: 12]

Name: ....

Light

1 Fig. 1.1 shows light rays falling on a plane surface:

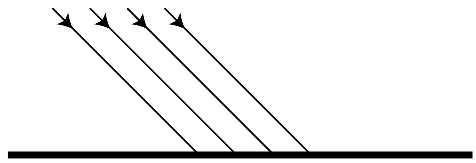

Fig. 1.1

(a)

(i) Identify whether the plane surface is a mirror or a smooth black surface.

.... **[1]**

(ii) Explain how the surface was identified.

....

.... **[1]**

(iii) Draw a labelled diagram of light rays incident on and being reflected from a plane mirror.

[1]

(iv) Draw an image of the car as it would appear in the plane mirror in Fig. 1.2:

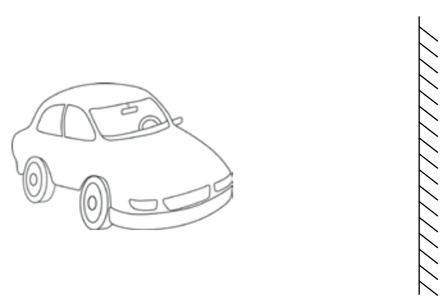

Fig. 1.2

[1]

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Name: ....

(v) State the orientation of the image in part (iv).

.... **[1]**

(b) In Fig. 1.3, a student is trying to locate the position of the pin behind the mirror.

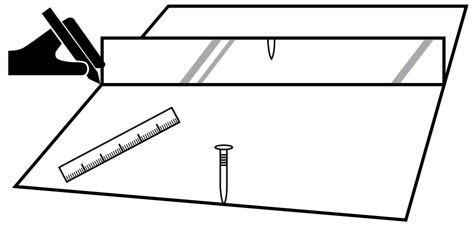

Fig. 1.3

(i) Use the ruler to trace the image of the pin on Fig. 1.3.

....

.... **[1]**

(ii) Draw the position of the eye from where the pin should be observed.

....

.... **[1]**

(iii) Identify one source of error in this experiment.

.... **[1]**

(iv) Suggest one way in which this error can be removed.

.... **[1]**

[Total: 9]

Name: ....

2

(a) Fig. 2.1 shows a ray of light incident on a glass slab:

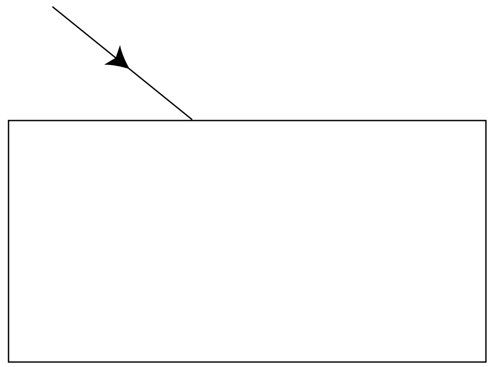

Fig. 2.1

(i) Draw the refracted ray as it passes through the glass and into the air. **[1]**

(ii) Measure the angle of incidence and the angle of refraction.

....

.... **[2]**

(iii) State the law that describes the relationship between the angle of incidence and the angle of refraction.

....

....

.... **[1]**

(iv) Explain why ∠ r is less than ∠ i.

....

....

.... **[2]**

(v) Calculate the refractive index of glass.

....

....

.... **[1]**

Name: ....

(b) Fig. 2.2 shows a ray of light being refracted from glass into air:

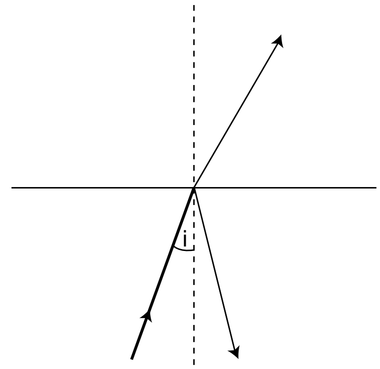

Fig. 2.2

(i) Measure the angle of the incident ray and the angle of the refracted ray.

....

.... **[2]**

(ii) Calculate the critical angle of glass.

....

.... **[1]**

(iii) Draw diagrams to show the path of the incident and refracted rays when ∠ i is 42° and when it is 50°.

[2]

[Total: 12]

Name: ....

3

(a) Fig. 3.1 shows an object placed a little beyond the focal length of a converging lens:

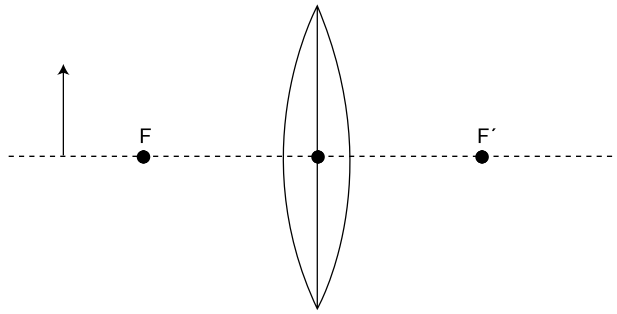

Fig. 3.1

(i) Draw rays on Fig. 3.1 to show where two rays passing through the lens converge. **[1]**

(ii) What is the magnification of the image?

....

.... **[2]**

(iii) What would happen to the image if the object were moved further away from the lens?

....

.... **[1]**

(b) Fig. 3.2 shows an object placed in between the focal length and the optical centre of a converging lens.

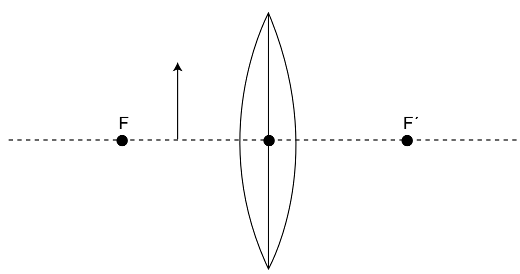

Fig. 3.2

(i) Draw rays on Fig. 3.2 to show where the image would form. **[1]**

(ii) Calculate the linear magnification of this image.

....

.... **[2]**

Name: ....

(iii) How is this image different from the one obtained in part (a)?

....

....

.... **[2]**

[Total: 9]

Name: ....

Waves and sound

1

(a) Fig. 1.1 shows a 'Slinky' spring being moved so that a wave is set up:

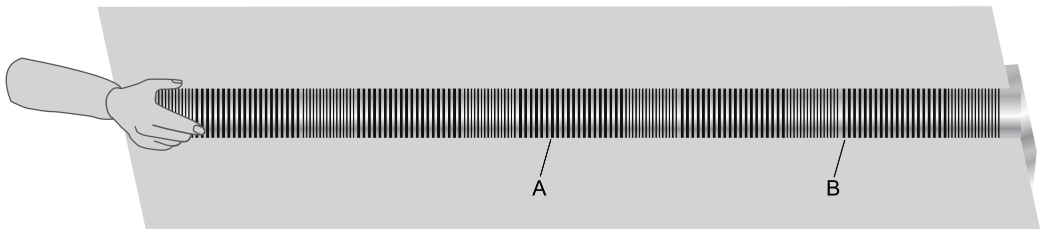

Fig. 1.1

(i) Identify the type of wave created in the spring.

.... **[1]**

(ii) How is this wave different from a transverse wave?

....

.... **[1]**

(iii) Identify the sections marked A and B in Fig. 1.1.

.... **[2]**

(b)

(i) Complete Table 1.1 below assuming that the wave travels at a velocity of 40 m/s:

Frequency / Hz	**Wavelength / m**
2	
4	
5	
10	
20	

[1]

Name: ....

(ii) Plot a graph for the data in part (i):

[4]

(iii) Use the graph to determine the frequency of a wave having a wavelength of 6 m.

.... **[1]**

(iv) Interpret the relationship between frequency and wavelength on the basis of the curve of the graph.

....

.... **[1]**

[Total: 11]

2

(a) Fig. 2.1 shows a reading on a CRO:

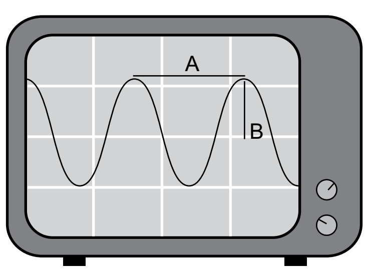

Fig. 2.1

Name: ....

(i) Identify the visual appearing on the screen.

.... **[1]**

(ii) What information about sound waves does the visual provide?

....

.... **[1]**

(iii) What is indicated by A? Measure it on the CRO.

.... **[1]**

(iv) What is indicated by B? What is its value?

.... **[1]**

(v) What would the visual in Fig. 2.1 look like if the frequency of the wave were increased? If the amplitude were increased? Show diagrammatically.

.... **[2]**

(b)

(i) State the wave equation.

.... **[1]**

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Name: ....

(ii) Calculate the frequency of a sound wave of wavelength 10 m. What would happen to the frequency if the wavelength were halved? (Speed of sound in air = 330 m/s)

....

.... **[2]**

[Total: 9]

3

(a) Fig. 3.1 shows an electric bell covered with a bell jar:

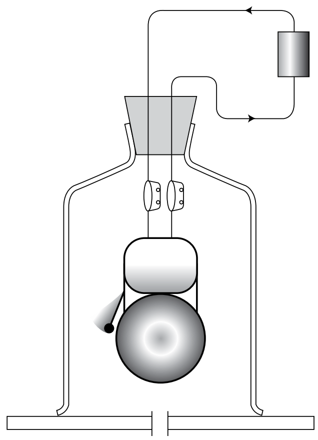


Fig. 3.1

(i) What causes the bell to ring in Fig. 3.1?

.... **[1]**

(ii) What is the purpose of the rubber bands?

.... **[1]**

(iii) Why is air removed from the bell jar? What does it help to test?

....

.... **[1]**

(iv) Is it possible for some sound to be heard even after all the air has been removed? Why or why not?

....

.... **[2]**

[Total: 5]

Name: ....

Electromagnetic waves

1

(a) Fig. 1.1 shows a spectrum obtained by passing white light through a prism:

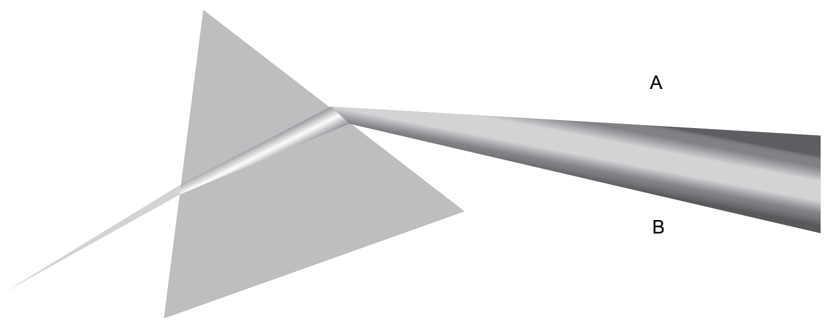


Fig. 1.1

(i) Mark the following regions on the spectrum: visible light, infrared, ultraviolet.

.... **[3]**

(ii) What happens to the wavelength of the radiation moving from A to B?

.... **[1]**

(iii) What happens to the frequency of the radiation moving from A to B?

.... **[1]**

(b)

(i) State two uses of ultraviolet radiation.

....

.... **[2]**

(ii) State two dangers of ultraviolet radiation.

....

.... **[2]**

Name: ....

(iii) Suggest two safety precautions to be taken while working with ultraviolet radiation.

....

.... **[2]**

(c)

(i) Calculate the wavelength of radio waves travelling at 3×10^8 m/s with a frequency of 10^7 Hz.

....

.... **[1]**

(ii) A radiation monitor detected waves ranging 10^{-9} m to 10^{-7} m in a room. What type of radiation does this indicate?

.... **[1]**

(iii) Identify the symbol shown in Fig. 1.2 below and state what it communicates:

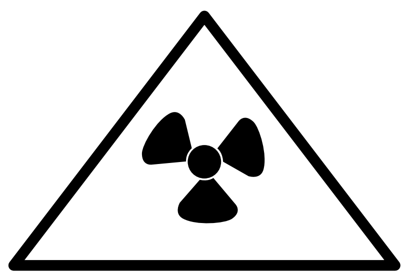


Fig. 1.2

.... **[1]**

(iv) What type of radiation might be present in an area where the sign in part (iii) is displayed?

.... **[1]**

[Total: 15]

Name: ....

Electricity and electromagnetism

1

(a) Fig. 1.1 shows a polythene rod and a woollen cloth:

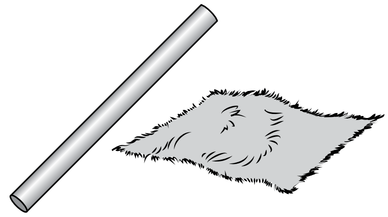


Fig. 1.1

(i) How can electrostatic charge be produced in the polythene rod?

.... **[1]**

(ii) Would a similar charge be produced in a steel rod in the same way? Explain why or why not.

....

....

.... **[3]**

(iii) Draw the charge that will be produced in the rod in Fig. 1.1. How would you determine whether the charge is positive or negative?

.... **[2]**

(b) Fig. 1.2 shows a current passing through a Van de Graaff generator:

Fig. 1.2

Name: ....

(i) Explain the behaviour of the girl's hair.

....

.... **[1]**

(ii) Does the current pose any danger to the girl? Why or why not?

....

.... **[2]**

(iii) Draw a circle around the area lying within an electric field and the charge on the Van de Graaff generator. **[2]**

[Total: 11]

2

(a) Fig. 2.1 shows a bulb connected in a circuit:

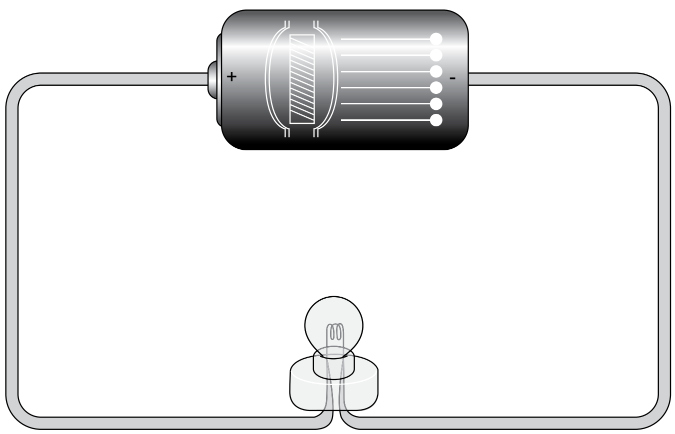


Fig. 2.1

(i) How would you represent the flow of current in a circuit diagram? Why do some diagrams show the flow of current by drawing arrows in the opposite direction?

....

....

.... **[3]**

(ii) Calculate the resistance in the circuit when a current of 5 A flows through it.

.... **[2]**

Name: ....

(iii) What would happen to the current if a second bulb were connected in series with the first one?

....

.... **[1]**

(iv) Draw a diagram to show how you would double the potential difference around the circuit in part (i).

[3]

[Total: 9]

3

(a) Fig. 3.1 shows current passing through two different coils of wire:

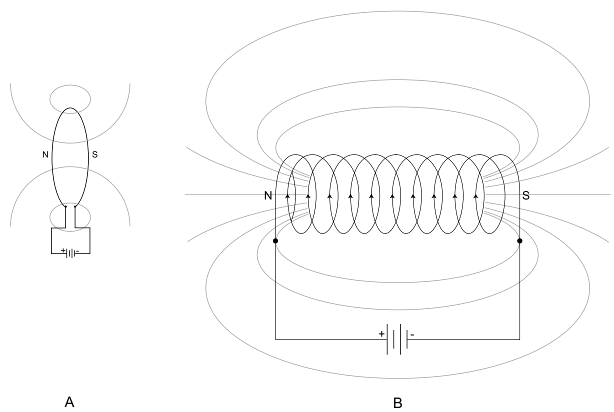


Fig. 3.1

(i) What is the set-up in B called?

.... **[1]**

(ii) Draw arrows on A and B in Fig. 3.1 to indicate the flow of conventional current and the direction of the magnetic lines of force.

....

....

.... **[4]**

Name: ....

(iii) What would happen to the magnetic field if a stronger power source were substituted in the circuit?

.... **[1]**

(b) Fig. 3.2 shows a moving-coil meter:

Fig. 3.2

(i) State the reading shown by the meter. What does it indicate?

.... **[1]**

(ii) Describe the mechanism that causes the pointer to move.

....

.... **[2]**

(iii) What would happen to the pointer if the current passing through the meter were increased?

.... **[1]**

[Total: 10]

Name: ....

Electronics

1

(a) Fig. 1.1 shows a component commonly used in electrical circuits:

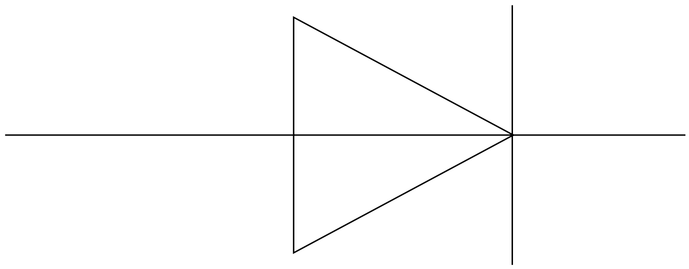


Fig. 1.1

(i) Identify and name the component.

.... **[1]**

(ii) What purpose does the component serve in an electrical circuit?

....

.... **[1]**

(iii) Draw a circuit where the component is forward biased.

[3]

(b) Fig. 1.2 shows a reading produced by a CRO:

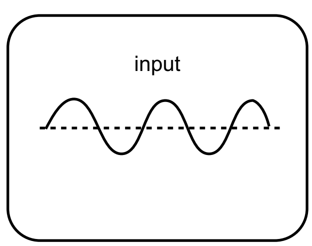


Fig. 1.2

Name: ....

(i) Identify the type of current.

.... **[1]**

(ii) How can a diode be used to change the type of current?

....

.... **[1]**

(iii) Draw the waveform that the CRO would produce after rectification.

[1]

(c) Fig. 1.3 shows an electrical component:

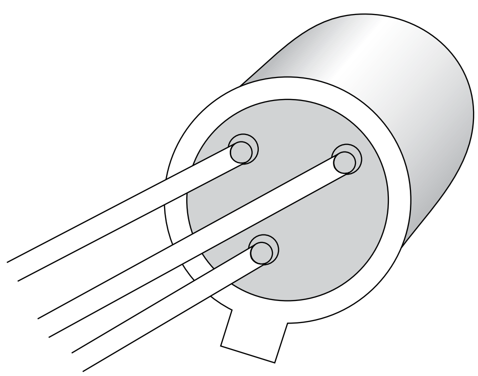


Fig. 1.3

(i) Identify the component.

.... **[1]**

(ii) State the principle under which it operates.

....

.... **[2]**

Name: ....

(iii) State two practical applications of the component in electrical circuits.

....

.... **[2]**

[Total: 13]

2

(a) Fig. 2.1 shows two logic gates:

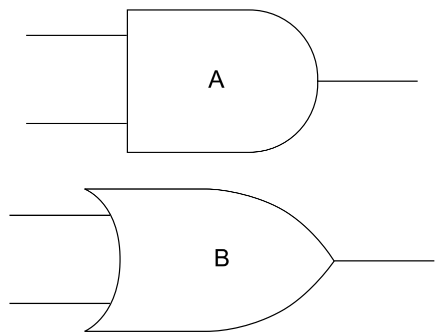


Fig. 2.1

(i) Identify logic gates A and B.

.... **[2]**

(ii) Draw a logic table for each of the gates using two inputs.

[2]

(iii) Suggest one practical application of each of the two gates.

....

.... **[2]**

Name: ....

(b) Fig. 2.2 shows a deflection tube:

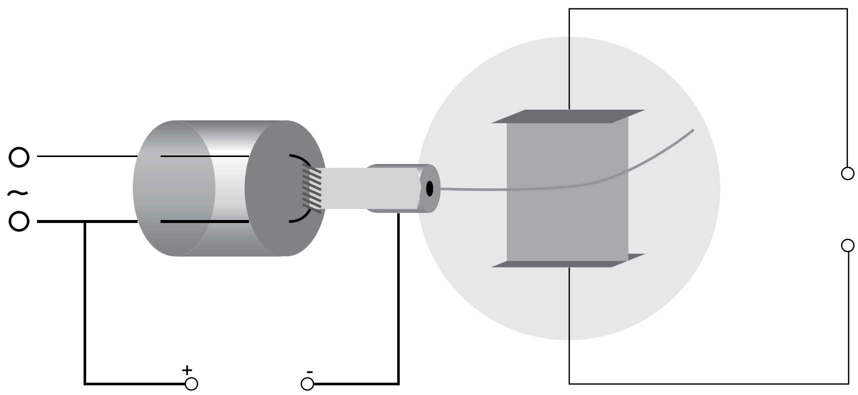


Fig. 2.2

(i) Mark the following on Fig. 2.2: anode, cathode, positive terminal, negative terminal.

.... **[3]**

(ii) State how the positive and negative terminals were identified in part (i).

.... **[1]**

(iii) How is the path of the electron beam traced in the experiment?

....

.... **[1]**

(iv) State one precaution to be undertaken while performing the deflection tube experiment.

....

.... **[1]**

[Total: 12]

Name: ....

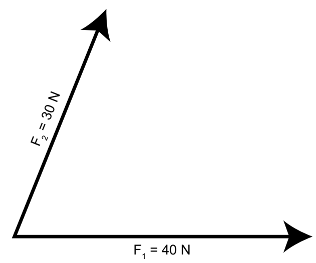
Physical quantities and measurement

1 Which component differentiates a vector quantity from a scalar quantity? Is speed a scalar or a vector quantity?

....

.... **[2]**

2 Find the magnitude of the resultant of two forces F_1 and F_2 acting on an object as shown below. (Use the parallelogram rule.)



[2]

3 Write the SI units of the following:

(a) speed

.... **[1]**

(b) mass

.... **[1]**

(c) length

.... **[1]**

4 A seconds pendulum takes two seconds to complete one swing. On one occasion a seconds pendulum is kept in motion for two minutes. How many swings does the pendulum complete?

.... **[1]**

5 A physicist wants to measure the thickness of a piece of copper wire and a metal chip. She uses a micrometer to measure the thickness of the wire and a pair of vernier calipers to measure the thickness of the chip. Explain her choice of instrument.

....

.... **[2]**

[Total: 10]

Name: ....

Speed and linear motion

1 A car travels at a speed of 80 km/h on the motorway between two cities. If the car takes two hours to complete the journey, determine the velocity of the car in m/s and the distance between the two cities.

....

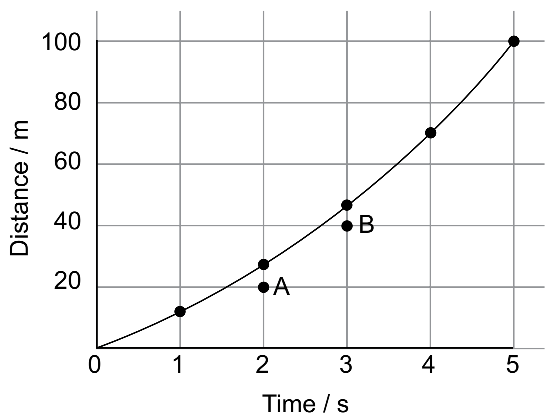
....

.... **[2]**

2 What is meant by uniform acceleration? How is it linked to velocity?

....

.... **[2]**



3 Look at the graph below:

(a) Determine the speed at points A and B.

....

.... **[1]**

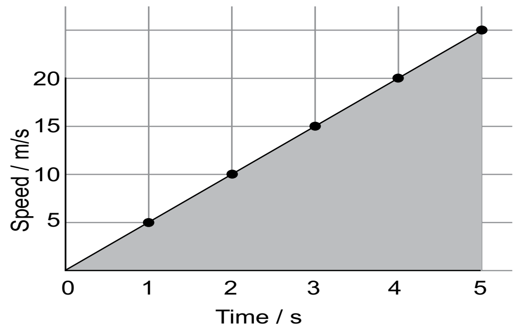
(b) Interpret the shape of the curve.

....

.... **[1]**

Name: ....

4 The acceleration of a car travelling between two cities is shown on the graph below:



What distance does the car cover travelling at a speed of 10 m/s?

....

....

.... **[2]**

5 A train was travelling between Station A and Station B at constant acceleration. Complete the table below:

Speed / m/s	**Time / s**
75	5
225	
	20
450	
	45

[2]

[Total: 10]

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WORKSHEET

Name: ....

Circular motion and friction

1 Identify the opposing force in each of the following situations:

(a) sawing the trunk of a tree

.... [1]

(b) jumping on a bouncing castle

.... [1]

(c) a skydiver falling from a helicopter and opening a parachute

.... [1]

2 A ball of mass 3 kg is rolled on the floor with a force of 15 N. If the resultant force is 12 N, what is the force of friction acting on the ball? What is the acceleration?

....

.... [2]

3 Explain how a space rocket is able to escape the strong gravitational field of the Earth.

....

.... [2]

4 An object moves at steady speed in a circular path because of centripetal force acting at a perpendicular to the direction of travel. What changes would necessitate a change in the centripetal force?

....

.... [2]

5 Why does a machine heat up if it is kept running for several hours?

....

.... [1]

[Total: 10]

WORKSHEET

Name: ....

Mass, weight, and density

1 A block of mass 0.5 kg is dropped into a 0.1 dm^3 pool containing liquid of mass 50 kg. If the block measures 3.0 cm x 2.0 cm x 2.0 cm, determine whether the block will float or sink in the liquid.

....

....

....

....

.... **[2]**

2 State any two differences between mass and weight. Why is the newton (N) an appropriate unit for weight?

....

....

....

....

.... **[2]**

3 A person has a mass of 45 kg. What would his weight be on Earth? On a planet where the gravitational field is half of that on Earth?

....

....

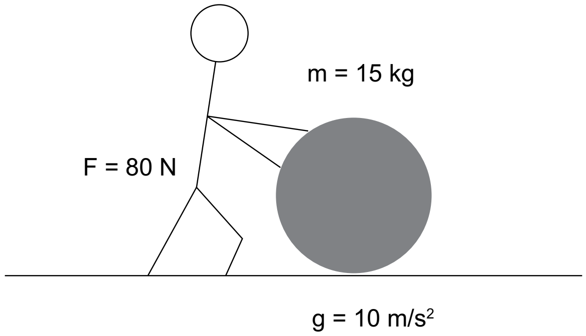
....

....

.... **[2]**

Name: ....

4 Why might it be difficult for the boy to make the ball move from its position of rest? What force would he need to apply to cause the ball to move?



....

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....

....

.... **[2]**

5 A strange object from space crashed into a pool causing some of the water to splash out over the sides. The mysterious object then fizzled away. How would you be able to determine the volume of the object?

....

.... **[2]**

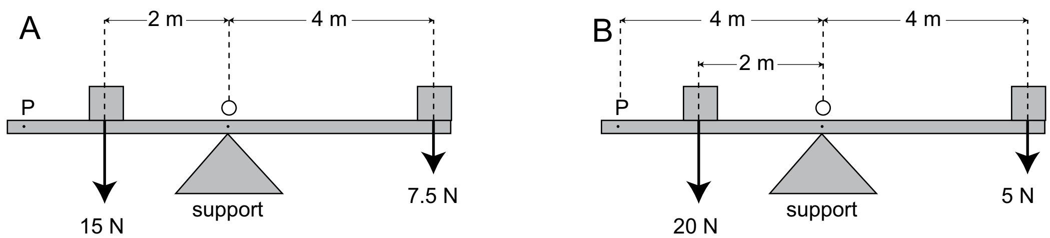
[Total: 10]

WORKSHEET

Name: ....

Turning forces

1 Which of the two beams should not be in equilibrium? Give reasons.



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....

....

.... **[2]**

2 What is meant by centre of mass? Why is it crucial for a tightrope walker?

....

....

.... **[2]**

3 Successive loads were hung from one end of a spring that had the other end fixed to the ceiling. The following changes in length were obtained:

Load / N	**Change in length / mm**
0	0.0
2	15.0
4	30.0
6	45.0
8	65.0
10	90.0

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Name: ....

Plot a graph for the data using suitable axes labels. Identify the limit of proportionality.

[2]

4 Calculate the spring constant for the data in question 3. What would be the change in length of the spring caused by a load weighing 5 N?

....

....

....

....

.... **[2]**

5

(a) One reason why steel is used in building skyscrapers is its strength. Give one other reason.

....

.... **[1]**

(b) Why is it easier to open a door by pushing farther from, rather than close to, the hinges?

....

.... **[1]**

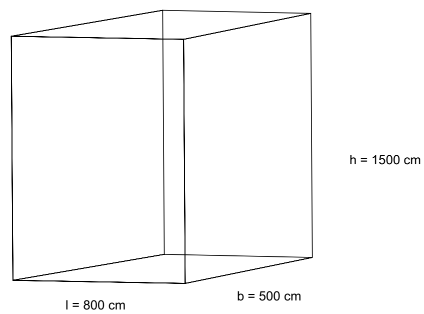
[Total: 10]

WORKSHEET

Name: ....

Pressure

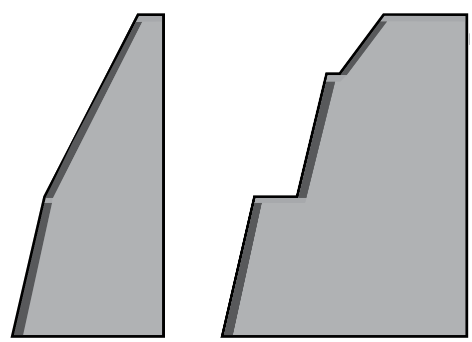
1 Find the pressure exerted by the block on the surface. How would you increase the pressure applied?



....

.... **[2]**

2 An engineer has come up with two designs for a dam. Which of these would you recommend? Why?



....

....

.... **[2]**

3 An aquarium maker wants to decide between making a glass aquarium and a fibreglass one. The customer prefers a glass aquarium 0.5 m tall. The glass aquarium can withstand a pressure of 4800 Pa and the fibreglass one can withstand 5200 Pa. Which material should the aquarium maker use assuming the density of water is 1000 kg/m^3 and g = 10 N/kg?

....

....

....

....

.... **[2]**

Name: ....

4 A mercury barometer shows a reading of 760 mm at sea level. When it is taken to the top of a mountain, the barometer reads 800 mm. Why might the barometer be defective?

....

.... **[2]**

5 How does a manometer help to measure pressure difference?

....

....

.... **[3]**

6 Why is temperature assumed to be constant when explaining Boyle's law?

....

.... **[2]**

7 A closed container with a piston contains 10 cm^3 of gas at 2 atm pressure. By how much should the pressure be increased to reduce the volume to 8 cm^3?

....

....

....

.... **[2]**

[Total: 15]

WORKSHEET

Name: ....

Energy I

1 Identify the change of energy from one form to another in each of the following:

(a) a car running on CNG

.... **[1]**

(b) providing heating with solar cells

.... **[1]**

(c) crushing corn in a windmill

.... **[1]**

2 How is the law of conservation of energy related to work?

....

....

.... **[2]**

3 A ball has a mass of 5 kg and is placed on the edge of a table 1 m tall. What is its gravitational potential energy? If the ball is pushed over the edge what would the kinetic energy of the ball be one-third of the way to the ground?

....

....

....

....

.... **[2]**

Name: ....

4 Why is it important to determine the efficiency of a machine? Machine A performs 900 J of work when supplied with 1000 J of energy. Machine B performs 800 J of work when supplied with 900 J of energy. Which machine wastes less energy?

(a) ....

....

....

....

.... **[2]**

(b) In part **(a)** above machine A performs the work in one hour and machine B performs work in 45 minutes. Which machine gives the greater power output?

....

....

....

....

.... **[2]**

5 State two criticisms against the use of fossil fuels.

....

.... **[2]**

6 Draw a block diagram to show how electricity is produced at a thermal power plant.

[2]

[Total: 15]

WORKSHEET

Name: ....

Energy II

1 State the difference between conductors and insulators. Name two good conductors of heat.

....

....

.... **[2]**

2 State three factors that determine the amount of heat transferred across the ends of a metal bar.

....

....

.... **[3]**

3 Metals possess free electrons that are able to move about freely. Non-metals do not possess free electrons. Explain how this difference makes metals good conductors of heat.

....

....

....

.... **[2]**

4 Liquid A has a density of 1049 kg/m^3, liquid B has a density of 874 kg/m^3, and liquid C has a density of 1025 kg/m^3. Assuming their boiling points are the same, in which of these would it be the most difficult to set up a convection current? Give reasons.

....

....

.... **[2]**

5 Give reasons for the following:

(a) black saucepans are preferred over white ones

.... **[1]**

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Name: ....

(b) the inner walls of a vacuum flask have silvery surfaces

.... **[1]**

6 Suggest two ways of reducing heat losses from a house during winter.

....

.... **[2]**

7 Describe how a day breeze is set up near the coast.

....

....

....

.... **[2]**

[Total: 15]

WORKSHEET

Name: ....

Temperature

1 Why is mercury used instead of dyed water in a thermometer?

....

....

.... **[2]**

2 What are the fixed points on the Celsius scale? What is the value of absolute zero on the Celsius scale?

....

....

.... **[2]**

3 Complete the following table:

Celsius scale / °C	**Kelvin scale / K**
0	273
25	
	310
102	

[3]

4 State two differences between a clinical thermometer and a thermocouple thermometer.

....

....

.... **[2]**

Name: ....

5 How is thermal energy transferred between two objects of different temperatures? Explain in terms of the kinetic model.

....

....

....

....

.... **[2]**

6 A mercury thermometer with a narrower tube was used to measure minute changes in temperature. Explain why?

....

.... **[2]**

7 Explain why a clinical thermometer would not be used in a science laboratory?

....

.... **[2]**

[Total: 15]

Name: ....

Matter and heat

1 Why does evaporation result in a lowering of the temperature?

....

....

.... **[2]**

2 Why is heat necessary for boiling but not for evaporation of a liquid?

....

....

.... **[2]**

3 Define the following terms:

(a) condensation

.... **[1]**

(b) specific heat capacity

.... **[1]**

(c) specific latent heat

.... **[1]**

4 How much energy was transferred to 5 kg water if it caused the water to heat up from 50°C to 90°C upon heating, assuming the specific heat capacity of water is 4200 J/(kg °C).

....

....

.... **[2]**

Name: ....

5 How would you determine the melting point of an unknown solid? The boiling point of an unknown liquid?

....

....

....

....

.... **[2]**

6 What does the latent heat of vapourization tell you about boiling a given mass of water?

....

.... **[2]**

7 What would happen to the gas inside a closed container fitted with a piston if it were heated and no additional pressure were applied? If pressure were applied to the piston to control increase in volume?

....

.... **[2]**

[Total: 15]

WORKSHEET

Name: ....

Kinetic model of matter

1 Why does a solid possess a definite shape whereas a gas does not?

....

....

.... **[2]**

2 Complete the table for comparing the properties of solids, liquids, and gases:

Solid	Liquid	Gas
definite shape and volume		
	weaker bonds between molecules	
		very large space between molecules
	particles slide over one another	
molecules have the least potential energy		

[5]

3 Explain why a solid melts upon heating.

....

....

.... **[2]**

4 In what ways might you speed up the evaporation of water from a container?

....

....

....

.... **[3]**

Name: ....

5 What is meant by the internal energy and thermal energy of a material?

....

.... **[2]**

6 Why does the body produce sweat in warm weather?

....

.... **[2]**

7 Why does water boil at a lower temperature at high altitudes?

....

.... **[2]**

8 Describe how mist forms on a glass surface.

....

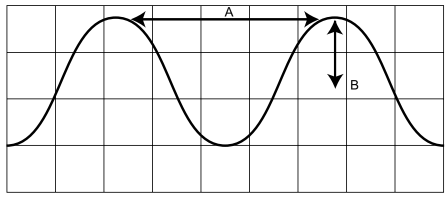
.... **[2]**

[Total: 20]

Name: ....

Waves

1 Identify the following marked on the diagram below:



(a) A

.... **[1]**

(b) B

.... **[1]**

2 State the difference between transverse waves and longitudinal waves.

....

.... **[2]**

3 What is meant by frequency? Calculate the frequency when waves of wavelength 3 m travel across water with a speed of 12 m/s.

....

....

.... **[3]**

4 Name three examples of waves. State two points of evidence to prove your answer.

....

....

....

.... **[5]**

Name: ....

5 Describe, with the help of a diagram, how refraction occurs in waves.

....

....

....

....

.... **[5]**

6 What is a wavefront? Draw a wavefront to show increasing wavelength of a transverse wave.

....

.... **[3]**

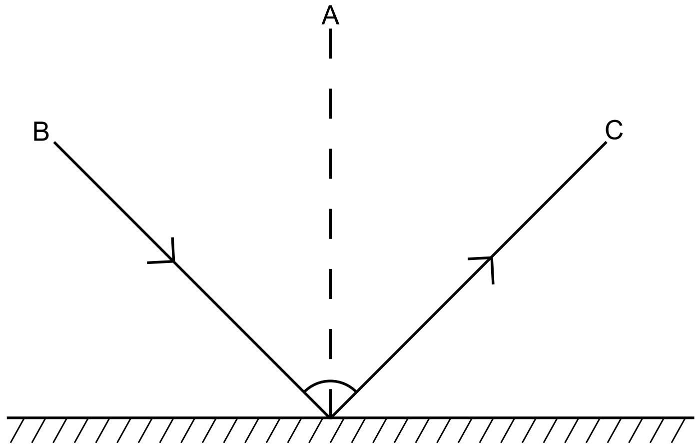
[Total: 20]

WORKSHEET

Name: ....

Light

1 Identify the following marked on the diagram below:



(a) A

.... **[1]**

(b) B

.... **[1]**

(c) C

.... **[1]**

2 State the two laws of reflection.

....

.... **[2]**

3 State the difference between a real image and a virtual image. Is the image viewed in a mirror a virtual one?

....

....

.... **[3]**

Name: ....

4 Why does water in a bucket seem to be shallower than it really is? Explain with the help of a diagram.

....

....

....

....

.... **[5]**

5 What is meant by refractive index? Calculate the speed of light in diamond when the speed of light in air is 300 000 km/s and the refractive index of diamond is 2.42.

....

....

....

.... **[4]**

6 Show, with the help of diagrams, where the image would be formed if:

(a) the object is placed at the focal length of a convex lens

[1]

Name: ....

(b) the object is placed beyond the focal length of a convex lens

[1]

(c) an appropriate lens is placed before the eye to correct short sight

[1]

[Total: 20]

Name: ....

Electromagnetic waves

1 List three types of electromagnetic radiation, in ascending order of wavelength, that are part of the electromagnetic spectrum.

....

.... **[3]**

2 Explain how electromagnetic waves are produced. Are they the same as longitudinal waves?

....

....

.... **[3]**

3 State four properties of electromagnetic waves.

....

....

....

.... **[4]**

4 State one practical application of each of the following:

(a) microwaves

.... **[1]**

(b) infrared radiation

.... **[1]**

(c) ultraviolet radiation

.... **[1]**

Name: ....

(d) gamma rays

.... **[1]**

(e) X-rays

.... **[1]**

5 Describe, with the help of a diagram, how a prism is able to disperse white light into its component colours.

....

....

....

....

.... **[5]**

[Total: 20]

Name: ....

Sound waves

1 Describe the movement of sound waves through air.

....

....

.... **[3]**

2 How would you prove that sound waves are not electromagnetic waves?

....

.... **[2]**

3

(a) State the speed of sound in air. How far is a wall if an echo is reflected off it and returns to the source in 3 seconds?

....

....

....

.... **[3]**

(b) Why does a moving train far away seem to be closer at night?

....

....

.... **[2]**

4 Which characteristic of sound would you use to differentiate between the sounds of two different musical instruments?

.... **[1]**

Name: ....

5

(a) State the hearing range for humans in terms of frequency.

.... [1]

(b) What is the name given to sound waves beyond the hearing range of humans? State three applications of these sounds.

....

.... [2]

6

(a) How would you identify a high-pitched sound from its waveform on a cathode ray oscilloscope?

....

.... [2]

(b) How would you identify a sound that is louder than another from its waveform on a cathode ray oscilloscope?

....

.... [2]

7 The speed of sound in concrete is 5000 m/s. How far will sound travel through it in 0.005 seconds?

....

.... [2]

[Total: 20]

Name: ....

Magnets and electricity

1 What is meant by induced magnetism? Name one hard and one soft magnetic material.

....

....

.... **[3]**

2 Why does a magnet become demagnetized when dropped to the ground? How can it be magnetized again?

....

....

.... **[3]**

3

(a) Electricity can be used to create a magnetic field. Draw a diagram to show the magnetic field patterns in a solenoid.

[4]

(b) What would happen if the direction of the current were reversed?

....

....

.... **[2]**

Name: ....

(c) How would you determine the poles of the solenoid?

....

....

.... **[2]**

4 State three applications of electromagnets.

....

.... **[3]**

5 How can the force in a current-carrying wire in a magnetic field be increased?

....

....

.... **[3]**

[Total: 20]

WORKSHEET

Name: ....

Static electricity

1 A plastic comb was able to attract small bits of paper after being run through hair several times. What made this possible?

....

....

.... **[2]**

2 Why do metals conduct electricity while rubber does not? How can this difference be useful when making electrical wiring?

....

....

....

.... **[3]**

3 Identify the charge on the following:

(a) proton

.... **[1]**

(b) electron

.... **[1]**

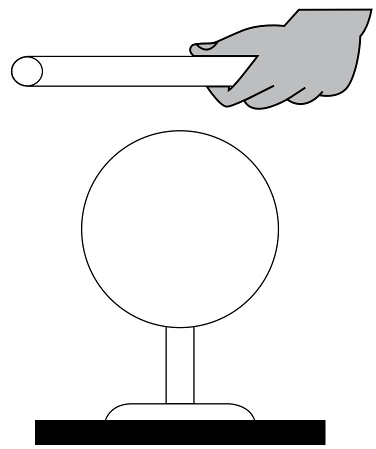
(c) neutron

.... **[1]**

Name: ....

4

(a) In the diagram below, a charged rod is brought close to a metal sphere. What will happen to the sphere after some time? Explain how this happens.



....

....

....

....

.... **[5]**

(b) What might happen if charges continue to build up at one end of a pole? What technique can be used to avoid it?

....

....

.... **[2]**

5 When does air act like an insulator? When does it act like a conductor?

....

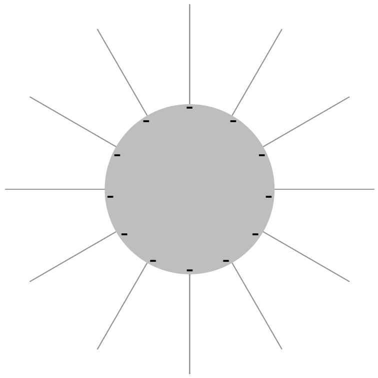
....

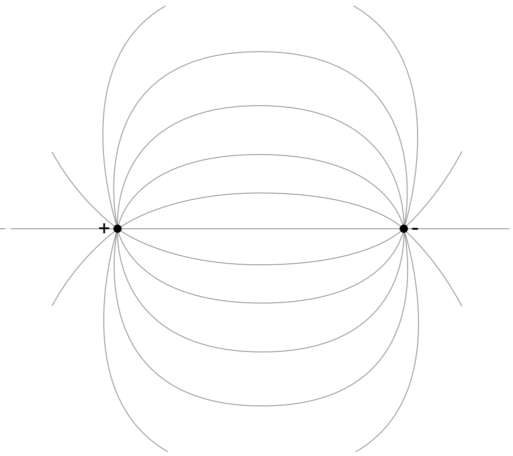
....

.... **[3]**

Name: . . . .

6 Draw arrows to indicate the direction of magnetic field in the diagrams below:





[2]

[Total: 20]

Name: ....

Current electricity

1 What is meant by electric current? How would you determine if current is flowing along a circuit?

....

....

.... **[2]**

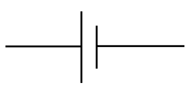
2 What reading would an ammeter show if a charge of 100 C flows along a circuit in 5 seconds?

....

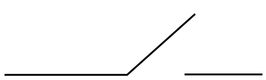
....

.... **[2]**

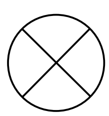
3 Identify what the following symbols stand for:

(a) 

.... **[1]**

(b) 

.... **[1]**

(c) 

.... **[1]**

Name: ....

4 Do electromotive force and potential difference mean the same thing?

....

....

....

....

.... **[4]**

5

(a) State the formula for resistance. List four ways in which the resistance of a wire might be increased.

....

....

....

....

.... **[5]**

(b) Calculate the resistance of a resistor with a potential difference of 9 V and a current of 3 A flowing through it.

....

.... **[2]**

(c) What would happen to the current passing through a resistor of unknown resistance if the potential difference across it were increased from 3 V to 6 V?

....

.... **[2]**

[Total: 20]

WORKSHEET

Name: ....

Using electricity

1 Draw a complete circuit showing the following components in their proper positions: cell, electric motor, switch, ammeter, resistor, and voltmeter. Draw arrows to indicate both the conventional current direction and electron flow.

[5]

2

(a) Two bulbs are connected in series in a circuit and a current of 3 A is passed through it. How much current would pass through each bulb? How would the potential difference across both the bulbs be determined?

....

....

.... **[2]**

(b) If the PD across both the bulbs is the same and they are connected in parallel, how much current would pass through each bulb if a total current of 8 A were passed through the circuit?

....

....

.... **[2]**

3

(a) What is meant by energy dissipation in a resistor?

....

....

.... **[3]**

Name: ....

(b) If a 60 W light bulb is connected to a 12 V power supply, determine the current passing through it.

....

....

.... **[2]**

4

(a) What is the purpose of earthing? Why are some appliances not earthed?

....

....

.... **[3]**

(b) If the cost of energy is 12cu per unit, calculate the cost of running two 100 W bulbs for 8 hours.

....

....

.... **[3]**

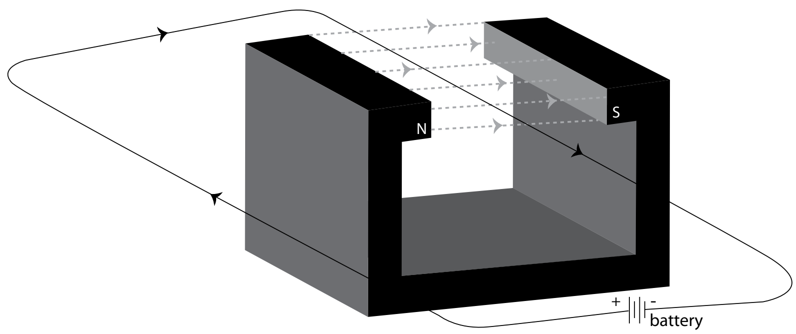
[Total: 20]

WORKSHEET

Name: ....

Electromagnetism

1 A force is being experienced in the wire in the set-up below:



(a) Draw an arrow to show the direction of the force. **[1]**

(b) How is the force created?

....

.... **[2]**

(c) State three ways in which the force could be increased.

....

....

.... **[3]**

(d) What would the direction of force be if the current and field were flowing in the same direction?

.... **[1]**

Name: ....

(e) What is Fleming's left hand rule? How does it help to understand the turning effect on a coil?

....

....

....

....

.... **[6]**

2

(a) What role does the commutator play in a simple DC motor?

....

....

.... **[2]**

(b) How can the turning effect on a coil be increased?

....

....

....

.... **[4]**

(c) Why is iron used instead of steel in the armature of a practical motor?

....

....

.... **[1]**

[Total: 20]

WORKSHEET

Name: ....

Electromagnetic induction

1

(a) What is meant by induced EMF? How can it be produced in a wire?

....

....

....

....

.... **[5]**

(b) What would happen to the induced EMF if the wire were moved faster?

.... **[1]**

(c) In what other ways can the magnitude of the induced EMF be changed?

....

.... **[2]**

2 A bar magnet is pushed N-pole first into a coil of copper wire and an EMF is induced.

(a) What would happen to the current if the bar magnet were pulled out of the coil?

.... **[1]**

(b) What would happen if the bar magnet were now introduced S-pole first into the coil?

.... **[1]**

3 At what position of the coil is the maximum current produced in an AC generator? Why is this so?

....

....

.... **[2]**

Name: ....

4

(a) A step-up transformer has a turns ratio of 3 with 200 turns in the primary coil. The AC output voltage is 30 V which powers a 60 W bulb. Determine the value of the current in the primary coil.

....

....

....

....

.... **[4]**

(b) Draw a labelled diagram of the transformer in part (a).

[5]

5

(a) State two advantages of using AC current instead of DC current for the mains electricity.

....

.... **[2]**

(b) State one advantage and one disadvantage of using overhead cables instead of land lines for electricity transmission.

....

.... **[2]**

[Total: 25]

WORKSHEET

Name: ....

Introduction to electronics

1

(a) Why is a vacuum tube used in the experiment on electron beams?

....

.... **[2]**

(b) How can it be deduced that the particles given off in the experiment are negatively-charged electrons?

....

.... **[2]**

(c) State an equation to express the relationship between charge and current.

.... **[1]**

2

(a) What is the function of the Y-plates and X-plates in the cathode ray oscilloscope?

....

.... **[2]**

(b) State the function of the timebase and the fluorescent screen.

....

.... **[2]**

(c) How would you interpret the peak voltage and peak-to-peak time in a waveform produced by an oscilloscope?

....

....

.... **[2]**

Name:

(d) On a waveform, the amplitude of the wave measures 4.0 cm when the gain control is set at 20.0 V/cm. Calculate the peak voltage.

[2]

(e) On the same waveform the distance between two consecutive peaks is 3.0 cm. What is the peak-to-peak time if the timebase is set at 10 ms/cm?

[2]

(f) Draw a labelled waveform for parts (d) and (e) on the grid below:

[3]

3

(a) Draw a circuit diagram to show how a thermistor can be used to create an automatic fire alarm system.

[3]

(b) What is the function of the reed relay in the alarm system?

[2]

(c) What role does the thermistor play in the fire alarm system?

[2]

[Total: 25]

WORKSHEET

Name: ....

Electronic systems

1

(a) Draw a labelled diagram of an npn transistor.

[4]

(b) State the function of an npn transistor in a circuit.

....

.... **[2]**

(c) Explain, with the help of a circuit diagram, how a transistor and light-dependent resistor can be used to design a light-sensitive switch.

....

....

....

....

....

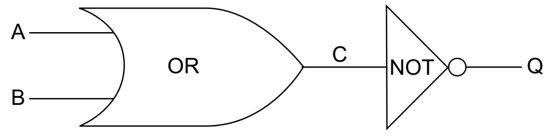
....

....

.... **[7]**

Name: ....

2 Complete the truth table for the following logic gate:



Inputs			**Output**
A	**B**	**C**	**Q**

[4]

3 Draw the symbols for the following logic gates:

(a) AND

[1]

(b) NOT

[1]

(c) OR

[1]

Name: ....

(d) NAND

[1]

4

(a) Would a bistable be used in developing the memory system of a computer? Give reasons.

....

....

.... **[2]**

(b) Explain why an astable is used in developing the control system of a computer.

....

....

.... **[2]**

[Total: 25]

WORKSHEET

Name: ....

Radioactivity

1

(a) Explain why some materials undergo radioactive decay while others do not.

....

....

....

.... **[3]**

(b) List the three main types of nuclear radiation.

....

.... **[3]**

(c) Arrange the three types identified in part **(b)** in ascending order of:

ionizing effect

.... **[1]**

penetrating effect

.... **[1]**

2

(a) Differentiate between nuclear fission and fusion.

....

.... **[2]**

(b) How is the chain reaction controlled in a nuclear fission reactor?

....

....

.... **[3]**

Name: ....

(c) State two advantages of using nuclear fusion reactors over fission reactors. What is the biggest hurdle scientists are currently facing in building one successfully?

....

....

.... **[3]**

3

(a) Calculate the activity of a sample of radon-220 after 21 seconds if the present activity is 500 Bq.

....

....

.... **[2]**

(b) Explain why carbon dating is used to estimate the age of fossils.

....

....

.... **[3]**

4

(a) Identify two risks people who work with nuclear materials are exposed to.

....

.... **[2]**

(b) Suggest two safety precautions that can help to minimize the risks identified in part **(a)**.

....

.... **[2]**

[Total: 25]

Name:

The atom

1

(a) Draw a labelled model of an atom identifying the protons, neutrons, and electrons.

[4]

(b) What is meant by the terms atomic number and mass number? State the atomic number and mass number of helium.

[3]

(c) One atom of lithium has atomic number 3 and mass number 6. Another atom of lithium has the same atomic number but mass number 7. Explain the difference.

[2]

2

(a) Explain what happens to the nucleon number and charge during alpha decay. What are the products?

[2]

(b) Explain what happens to the nucleon number and charge during beta decay. What are the products?

[2]

Name: ....

(c) Write down the equation to show a radon-226 atom undergoing alpha decay.

.... **[1]**

(d) Write down the equation to show an iodine-131 atom undergoing beta decay.

.... **[1]**

3

(a) Rutherford conducted an experiment on alpha particles and concluded that the atom is largely empty space with the positive charge and most of the mass in the centre. List three observations during the experiment that led him to this conclusion.

....

....

....

.... **[3]**

(b) How did Rutherford's discovery help to enhance our understanding of the structure of the atom?

....

....

.... **[2]**

[Total: 20]

Name: ....

Physical quantities and measurement

For questions 1 to 4, choose the correct answer by circling the letter.

1 The SI unit of speed is …

(a) m/s (b) m/s^2 (c) km/s (d) ms [1]

2 A micrometer can measure lengths as small as …

(a) 0.1 cm (b) 0.01 cm (c) 0.001 cm (d) 0.0001 cm [1]

3 Which of these is not a scalar quantity?

(a) velocity (b) speed (c) mass (d) time [1]

4 Two forces of 40 N and 20 N act in opposite directions. What is the magnitude of the resultant force?

(a) 60 N (b) 20 N (c) 800 N (d) 40 N [1]

5 Express the following in scientific notation:

(a) 1 000 000

.... [1]

(b) 0.0005

.... [1]

(c) 2650

.... [1]

6 A rectangular field measures 4 m by 3 m. Calculate the area and express it in km^2.

....

.... [2]

Name: ....

7

(a) What is meant by zero error? State the reasons why zero error arises in a pair of vernier calipers.

....

....

.... **[3]**

(b) Explain, with the help of an example, how zero error might be corrected.

....

....

.... **[3]**

8

(a) Calculate the average speed of a car travelling between two points A and B in two hours. The distance between A and B is 40 kilometres.

....

....

.... **[2]**

(b) Is speed a scalar or a vector quantity? State the difference between scalars and vectors.

....

....

.... **[2]**

(c) State the formula for average acceleration. When does a moving car experience uniform acceleration? Negative acceleration?

....

.... **[3]**

Name: ....

9 Two forces of magnitude 30 N and 20 N originate from O and make an angle of 40° with each other. What would the resultant force be?

....

....

.... **[3]**

[Total: 25]

Name: ....

Kinematics

For questions 1 to 4, choose the correct answer by circling the letter.

1 Which of the following is correct?

(a) final velocity = mass x additional velocity

(b) final velocity = original velocity x time

(c) final velocity = original velocity + (acceleration x time)

(d) final velocity = original velocity x acceleration [1]

2 A speed-time curve parallel to the horizontal axis indicates …

(a) increasing speed

(b) increasing acceleration

(c) decreasing speed

(d) uniform speed [1]

3 Deceleration on a speed-time graph is represented by …

(a) an upward sloping curve

(b) a downward sloping curve

(c) a horizontal curve

(d) a vertical curve [1]

4 The force pushing an aircraft forward is called …

(a) thrust

(b) upthrust

(c) gravity

(d) air resistance [1]

5

(a) Draw a distance-time graph for the following data:

Distance / m	Time / s
0	0
2	10
5	20
12	30
30	40

Name: ....

[2]

(b) Interpret the slope of the curve.

.... **[1]**

(c) What would the shape of the curve be if the same distance were covered during each time interval?

.... **[1]**

6

(a) Draw a ticker-tape below showing how the dots would appear to show the following:

(i) acceleration

[1]

(ii) steady speed

[1]

(iii) retardation

[1]

Name: ....

7

(a) A ball is thrown upwards with a velocity of 20 m/s.

(i) What is the velocity of the ball at $t = 0$ s?

....

.... **[1]**

(ii) What is the velocity of the ball at the maximum height?

....

.... **[1]**

(iii) What is the velocity of the falling ball just before it is caught by the thrower? Explain your answer.

....

.... **[2]**

8

(a) What is meant by uniform acceleration? Explain with the help of a graph.

....

....

.... **[4]**

Name: ....

(b) What is meant by non-uniform acceleration? Explain with the help of a graph.

....

....

.... **[3]**

9

(a) State Newton's first law of motion.

....

.... **[2]**

(b) State one example of balanced forces in nature.

.... **[1]**

[Total: 25]

Name: ....

Dynamics

For questions 1 to 4, choose the correct answer by circling the letter.

1 The two forces acting on a skydiver as she falls to the Earth are …

(a) gravity and acceleration

(b) weight and mass

(c) thrust and air resistance

(d) gravity and air resistance **[1]**

2 The SI unit of force can also be written as …

(a) kg.m/s^2 **(b)** kg/m^2 **(c)** kg/s^2 **(d)** km/s **[1]**

3 Force can cause objects to …

(a) accelerate **(b)** bend **(c)** stop **(d)** a–c **[1]**

4 Stopping distance is the sum of …

(a) reaction time and speed

(b) thinking distance and braking distance

(c) braking distance and speed

(d) stopping time and braking distance **[1]**

5

(a) Explain how a skydiver arrives at a terminal velocity while falling through the air.

....

....

.... **[3]**

(b) What happens to the air resistance

(i) before the skydiver opens the parachute?

.... **[1]**

Name: ....

(ii) after the skydiver opens the parachute?

.... **[1]**

6

(a) State the equation expressing the relationship between force, mass, and acceleration.

.... **[1]**

(b) Calculate the acceleration of a car of mass 100 kg if the force from the motor is 150 N and the force of friction is 30 N.

.... **[2]**

(c) What is meant by static friction? How is it different from dynamic friction?

....

.... **[2]**

(d) State one disadvantage of dynamic friction.

.... **[1]**

7

(a) State Newton's third law of motion.

....

.... **[2]**

(b) In the light of Newton's third law of motion, explain how a rocket is propelled to escape the gravitational field of the Earth.

....

....

.... **[3]**

Name: ....

8

(a) Draw a labelled diagram to show the forces acting on an object in circular motion held by a string.

[3]

(b) Draw an arrow on your diagram to indicate the direction the object would take if the string were let go off. **[1]**

(c) How would the inward force need to be changed if the mass were increased?

.... **[1]**

[Total: 25]

Name: ....

Mass, weight, and density

For questions 1 to 4, choose the correct answer by circling the letter.

1 What is the volume of a mass 15 g having a density of 3 g/cm^3?

(a) 5 cm^3 **(b)** 15 cm^3 **(c)** 45 cm^3 **(d)** 9 cm^3 **[1]**

2 Weight is measured in …

(a) grams **(b)** kilograms **(c)** newtons **(d)** m/s^2 **[1]**

3 The volume of a cylinder is measured by …

(a) $\pi r^2 h$ **(b)** l x b x h **(c)** l x l **(d)** r^2 x h **[1]**

4 An object weighs less on the Moon because of …

(a) a change in mass

(b) a change in gravity

(c) greater distance from the Earth

(d) less air on the Moon **[1]**

5 Explain why a large iceberg floats on water but a steel pin does not.

....

.... **[2]**

6 State three main features of gravitational force.

....

....

.... **[3]**

7

(a) If the density of concrete is 2.4 g/cm^3 calculate the mass of glass having the same volume as 100 g of concrete.

....

.... **[2]**

Name: ....

(b) An aquarium can hold 1000 ml of water. How much is this volume in:

(i) litres?

....

.... **[1]**

(ii) m^3?

....

.... **[1]**

(c)

(i) Calculate the weight on Earth of an object of mass 2 kg.

....

.... **[2]**

(ii) How much would the object weigh on a planet where the value of g is one-third than that on Earth?

....

.... **[2]**

8 A truck has a mass of 250 kg. What is the force of friction acting on the truck if it accelerates at 10 m/s^2 when the engine provides a force of 3500 N?

....

....

.... **[3]**

[Total: 20]

Name: ....

Turning forces

For questions 1 to 4, choose the correct answer by circling the letter.

1 The moment of a force is calculated as …

(a) force x moment arm

(b) force x displacement

(c) distance x mass

(d) force x mass [1]

2 A beam is in equilibrium when …

(a) forces are equal

(b) masses are equal

(c) sum of clockwise moments = sum of anticlockwise moments

(d) there is no gravity [1]

3 The moment of a force is also called …

(a) displacement

(b) torque

(c) force

(d) acceleration [1]

4 A 1000-page book placed vertically on a flat surface is in …

(a) stable equilibrium

(b) unstable equilibrium

(c) neutral equilibrium

(d) complete equilibrium [1]

5

(a) State the principle of moments.

....

....

.... [2]

(b) State the two conditions necessary for equilibrium.

....

.... [2]

Name: ....

6

(a) Explain how a tightrope walker is able to balance himself.

....

....

.... **[2]**

(b) Explain why it is easier to balance oneself on a broad metal beam than on a tightrope.

....

....

.... **[2]**

7

(a) Calculate the weight of a uniform metal bar 2 m long if it is balanced over a point 30 cm from one end when a 2 kg mass is attached to that end.

....

.... **[2]**

(b) State the three types of equilibrium.

....

....

.... **[3]**

8 Describe how a crane is able to lift heavy loads without toppling over.

....

....

....

.... **[3]**

[Total: 20]

Name: ....

Pressure

For questions 1 to 4, choose the correct answer by circling the letter.

1 Pressure can be measured by the formula …

(a) mass/volume (b) mass/area (c) force/area (d) force/volume **[1]**

2 Which of the following is not true about pressure in liquids?

(a) pressure acts in all directions

(b) pressure depends on the shape of the container

(c) pressure increases with depth

(d) pressure increases with density **[1]**

3 Atmospheric pressure is measured with a …

(a) barometer (b) manometer (c) spring balance (d) beam balance **[1]**

4 Boyle's law explains the relationship between …

(a) volume and temperature of a gas

(b) pressure and volume of a gas

(c) temperature and volume of a gas

(d) volume and number of molecules of a gas **[1]**

5

(a) Calculate the pressure exerted by a block of 8 kg mass measuring 2.5 m x 1 m x 0.5 m placed flat on the floor.

.... **[2]**

(b) What is the mass of a cube of side measuring 1 m if it exerts a pressure of 5 N on the ground?

....

.... **[2]**

(c) What would happen to the mass of the cube in part **(b)** on the Moon? What would happen to the pressure? (value of g on the Moon = 1/6 of g on the Earth)

....

....

.... **[2]**

Name: ....

6

(a) Explain why dams are built broader at the base.

....

.... **[2]**

(b) Explain how a hydraulic press acts as a force multiplier.

....

....

.... **[3]**

7

(a) Explain how air pressure is controlled to work a vacuum cleaner.

....

....

.... **[2]**

(b) State Boyle's law and explain it with the help of a graph.

....

....

....

.... **[4]**

Name: ....

(c) State two problems caused by low air pressure at high altitudes.

....

.... **[2]**

(d) Suggest how the problems identified in part (c) might be overcome.

....

.... **[2]**

[Total: 25]

Name: ....

Energy I

For questions 1 to 4, choose the correct answer by circling the letter.

1 Energy due to motion is called …

(a) moving energy

(b) kinetic energy

(c) thermal energy

(d) potential energy **[1]**

2 Which of these is a source of radiated energy?

(a) the Sun

(b) a light bulb

(c) a warm object

(d) all of the above **[1]**

3 The efficiency of an engine is determined by …

(a) useful work done/total energy output

(b) useful energy output/total work output

(c) total energy input/useful energy output

(d) useful energy output/total energy input **[1]**

4 Where does the maximum energy loss occur in energy production?

(a) boiler **(b)** turbine **(c)** generator **(d)** pylon **[1]**

5

(a) State the SI unit of work. Calculate the work done when a force of 5 N moves an object 4 m.

....

.... **[3]**

(b) Describe potential energy and elastic potential energy.

....

.... **[3]**

6

(a) State the law of conservation of energy.

....

.... **[2]**

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Name: ....

(b) How is energy conserved when a ball is dropped to the ground from a certain height?

....

....

.... **[2]**

(c) State two forms in which energy might be converted in part **(b)**.

....

.... **[2]**

(d) What is the potential energy in a crate of mass 20 kg when it is lifted by a crane to a height of 15 m? What will the kinetic energy be if the cable snaps and the crate drops to one-third of the height?

....

....

....

.... **[4]**

7

(a) An engine was provided with 150 J energy and it raised a container weighing 2 tonnes to a height of 5 m in 5 minutes. Calculate the power output of the engine.

....

....

.... **[3]**

(b) What is the efficiency of the engine in part **(a)** if 1000 W power input was provided?

....

.... **[2]**

[Total: 25]

Name: ....

Energy II

For questions 1 to 4, choose the correct answer by circling the letter.

1 Which of these is a renewable source of energy?

(a) timber (b) coal (c) wind (d) oil **[1]**

2 Car batteries convert …

(a) chemical energy into kinetic energy

(b) potential energy into kinetic energy

(c) mechanical energy into chemical energy

(d) chemical energy into electrical energy **[1]**

3 Energy is produced in the Sun as a result of …

(a) nuclear fission (b) nuclear fusion (c) nuclear emission (d) nuclear energy **[1]**

4 The rate of a reaction in a nuclear reactor is controlled by the use of …

(a) temperature sensors (b) control rods (c) cool water (d) timers **[1]**

5 State the functions of the following in a thermal power plant:

(a) turbine

.... **[1]**

(b) generator

.... **[1]**

6

(a) State two pollution problems caused by burning fossil fuels.

....

.... **[2]**

(b) Describe one method of controlling emission of sulfur dioxide from power stations.

....

.... **[1]**

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(c) Suggest two alternatives to burning fossil fuels for producing electricity.

....

.... **[2]**

(d) State three factors that must be considered when building a power plant.

....

.... **[3]**

7

(a) Differentiate between nuclear fission and nuclear fusion.

....

.... **[1]**

(b) State one advantage and one disadvantage of nuclear fission over nuclear fusion as an alternative to burning fossil fuels.

....

.... **[2]**

(c) State one problem each with the following renewable sources of energy:

(i) solar energy

.... **[1]**

(ii) biofuel

.... **[1]**

(iii) geothermal energy

.... **[1]**

Name: ....

(d) What is the difference between tidal energy and wave energy?

....

.... **[1]**

8 Describe how a chain reaction takes place inside a nuclear reactor.

....

....

....

.... **[4]**

[Total: 25]

Name: ....

Temperature

For questions 1 to 4, choose the correct answer by circling the letter.

1 The steam point on the Celsius scale is …

(a) 100°C (b) 0°C (c) 273°C (d) 50°C **[1]**

2 Absolute zero on the Kelvin scale is equal to …

(a) 373°C (b) 273°C (c) -273°C (d) -373°C **[1]**

3 Thermal energy transfers from …

(a) a cooler body to a warmer body

(b) a warmer body to a cooler body

(c) atoms to molecules

(d) water to steam **[1]**

4 The average body temperature of human beings is …

(a) 20°C (b) 25°C (c) 37°C (d) 50°C **[1]**

5 Why is mercury used in thermometers?

....

.... **[1]**

6

(a) Describe how a thermistor thermometer works.

....

....

.... **[2]**

(b) How is a thermistor thermometer safer than a mercury thermometer?

.... **[1]**

7 Use the kinetic model of matter to explain how temperature rises upon heating.

....

....

.... **[3]**

Name: ....

8 Convert the following:

(a) 50 K into °C

.... [1]

(b) 200°C into K

.... [1]

(c) 273 K into °C

.... [1]

9

(a) What is meant by a linear scale?

....

.... [1]

(b) Describe how an instrument is calibrated.

....

....

....

.... [3]

(c) Compare mercury and coloured alcohol thermometers in terms of:

(i) sensitivity

.... [1]

(ii) range

....

.... [1]

[Total: 20]

Name: ....

Heat and its effects

For questions 1 to 4, choose the correct answer by circling the letter.

1 When the temperature of a gas is increased the volume …

(a) increases **(b)** decreases **(c)** stays the same **(d)** decreases rapidly **[1]**

2 Which of these is not a good conductor of heat?

(a) steel **(b)** copper **(c)** air **(d)** steel **[1]**

3 Metals are good conductors because they possess …

(a) greater density **(b)** more mass **(c)** large spaces **(d)** free electrons **[1]**

4 A liquid evaporates at …

(a) $100^{\circ}C$

(b) $0^{\circ}C$

(c) a temperature below its boiling point

(d) low temperatures **[1]**

5

(a) Explain, with the help of a diagram, why ice is less dense than water.

....

....

.... **[3]**

(b) What happens to a gas when it is heated at constant volume? Explain in terms of the kinetic model of matter.

....

....

.... **[2]**

Name: ....

(c) Why do solids expand less than liquids and gases over a similar increase in temperature?

....

....

.... **[2]**

7

(a) Metal bar A conducts heat faster than metal bar B. Identify the features of metal bar A to account for its high conductivity.

....

....

.... **[3]**

(b) What feature common to most insulators causes them to be poor conductors of heat?

.... **[1]**

(c) Suggest four ways of reducing heat losses from a house during winter.

....

....

....

.... **[4]**

8 Describe how a convection current is set up in a liquid.

....

....

....

.... **[3]**

Name: ....

9

(a) What is meant by specific heat capacity?

....

.... **[1]**

(b) If the specific heat capacity of water is 4200 J/(kg-^{o}C) calculate the energy transferred in heating 4 kg water from room temperature (20^{o}C) to its boiling point?

....

.... **[2]**

[Total: 25]

Name: ....

Kinetic model of matter

For questions 1 to 4, choose the correct answer by circling the letter.

1 Molecules of solids …

(a) have strong intermolecular forces of attraction

(b) vibrate about their positions

(c) do not travel long distances

(d) all of the above **[1]**

2 Internal energy is the sum of …

(a) kinetic energy of all the molecules

(b) potential and kinetic energies of all the molecules

(c) potential energy of all the molecules

(d) mass of all the molecules **[1]**

3 A liquid …

(a) has a fixed shape and volume

(b) has a fixed volume but no fixed shape

(c) has a fixed shape but no fixed volume

(d) has neither fixed shape nor fixed volume **[1]**

4 When a gas changes to a liquid, it is called …

(a) boiling **(b)** evaporation **(c)** condensation **(d)** sweating **[1]**

5

(a) Compare solids, liquids, and gases on the basis of the following:

(i) shape

.... **[1]**

(ii) volume

.... **[1]**

(iii) intermolecular forces of attraction

.... **[1]**

Name: ....

(iv) motion of molecules

.... **[1]**

(b) Describe how molecules come to posses:

(i) potential energy

....

.... **[2]**

(ii) kinetic energy

....

.... **[2]**

6

(a) What is meant by evaporation?

....

.... **[1]**

(b) State four factors that affect the rate of evaporation.

....

....

....

.... **[4]**

(c) How is evaporation different from boiling? Explain why water boils faster at high altitudes.

....

....

.... **[3]**

Name: ....

7 Describe how a refrigerator helps to store food at a low temperature.

....

....

....

.... **[3]**

8 Explain why sweating causes us to feel cooler.

....

.... **[2]**

[Total: 25]

Name: ....

Waves

For questions 1 to 4, choose the correct answer by circling the letter.

1 The movement of oscillations in transverse waves is …

(a) parallel to the direction of travel

(b) at right angles to the direction of travel

(c) opposite to the direction of travel

(d) dependent on the direction of travel [1]

2 The number of waves passing through a point per second is known as its …

(a) wave number (b) wavelength (c) frequency (d) amplitude [1]

3 Waves are refracted when they …

(a) enter a medium of a different density

(b) strike a smooth surface

(c) enter a small space

(d) come across an obstacle [1]

4 Which of the following are waves?

(a) sound (b) light (c) infrared (d) a–c [1]

5

(a) How would you set up a transverse wave in a 'Slinky' spring?

.... [1]

(b) Describe how you would set up a longitudinal wave in a 'Slinky' spring?

.... [1]

(c) How is a longitudinal wave different from a transverse wave?

....

.... [1]

6

(a) What is a wavefront?

....

.... [2]

Name: ....

(b) How would you measure the following on a wavefront?

(i) wavelength

.... **[1]**

(ii) frequency

.... **[1]**

(iii) amplitude

.... **[1]**

7

(a) State the wave equation and describe what it represents.

....

....

.... **[2]**

(b) Use the wave equation to calculate the speed of waves travelling through air with a frequency of 25 Hz and wavelength equal to 0.5 m.

....

....

.... **[2]**

(c) Calculate the frequency when sound waves of wavelength 1 m pass through a point A with a speed of 200 m/s.

....

.... **[2]**

Name: ....

(a) Draw diagrams to show how reflection and refraction of waves take place.

[4]

(b) List three behaviours of waves in addition to those in part **(a)**.

....

....

.... **[3]**

[Total: 25]

Name: ....

Light

For questions 1 to 4, choose the correct answer by circling the letter.

1 Light rays are randomly scattered upon striking …

(a) a plane mirror

(b) paper

(c) smooth black surfaces

(d) glass **[1]**

2 Lasers emit light …

(a) of a single wavelength

(b) of a single colour

(c) of two different colours

(d) a & b **[1]**

3 An image formed by a plane mirror is …

(a) laterally inverted (b) real (c) enlarged (d) diminished **[1]**

4 When a ray of light strikes a plane mirror the angle of incidence …

(a) is smaller than the angle of reflection

(b) is greater than the angle of reflection

(c) is equal to the angle of reflection

(d) is always parallel to the normal **[1]**

5 State three features of light.

....

....

.... **[3]**

6 Draw a diagram to show how an image is formed in a plane mirror.

[4]

Name: ....

7

(a) Explain the phenomenon of apparent depth.

....

....

.... **[3]**

(b) The refractive index of water is 1.33. If light travels through air at a speed of 300 000 km/s what is the speed of light in water?

....

.... **[2]**

(c) Explain how the refractive index of a medium is related to apparent depth.

....

.... **[2]**

8 The focal length of a convex lens is 5 cm. Determine the height, position, and type of image formed when an object 4 m tall is placed at a distance twice the focal length from the convex lens.

[3]

9

(a) State the reasons for short sight and long sight.

....

.... **[2]**

(b) Suggest how short sight and long sight can be corrected.

....

.... **[2]**

[Total: 25]

Name: ....

Electromagnetic waves

For questions 1 to 4, choose the correct answer by circling the letter.

1 Which of these are not radio waves?

(a) gamma rays (b) microwaves (c) UHF (d) VHF **[1]**

2 Which of these have the highest frequency?

(a) X-rays (b) ultraviolet rays (c) gamma rays (d) radio waves **[1]**

3 Which of these can be used to sound security alarms?

(a) X-rays (b) radio waves

(c) infrared radiation (d) ultraviolet radiation **[1]**

4 Which of these cause cancer?

(a) X-rays and ultraviolet radiation

(b) radio waves and gamma rays

(c) gamma rays and infrared radiation

(d) gamma rays and X-rays **[1]**

5 State four properties of electromagnetic waves.

....

....

....

.... **[4]**

6 State the wavelength range of visible light.

.... **[1]**

7

(a) Name the type of radiation that:

(i) causes suntan

.... **[1]**

(ii) is used for satellite communication

.... **[1]**

Name: ....

(iii) passes through a thin sheet of lead

.... **[1]**

(iv) is used to take photographs at night

.... **[1]**

(v) can pass through flesh but is only partially stopped by bones

.... **[1]**

(b) Which parts of the electromagnetic spectrum can be harmful to life? State how they are dangerous in each case.

....

....

.... **[3]**

(c) How would you show that there was an invisible radiation beyond the red end of the visible spectrum?

....

.... **[2]**

(d) Name one region of the electromagnetic spectrum that has a frequency greater than visible light.

.... **[1]**

State briefly:

(i) how the radiation may be produced

.... **[1]**

Name: ....

(ii) how the radiation may be detected

.... **[1]**

(iii) one practical application of the radiation

.... **[1]**

8 How do microwaves cook food? How is this different from cooking with infrared waves?

....

.... **[2]**

[Total: 25]

Name: ....

Sound

For questions 1 to 4, choose the correct answer by circling the letter.

1 Sound waves are …

(a) longitudinal waves

(b) transverse waves

(c) electromagnetic waves

(d) radio waves [1]

2 Sound waves cannot travel through …

(a) iron (b) water (c) vacuum (d) gas [1]

3 Sound waves travel faster through …

(a) cold air (b) warm air (c) pressurized air (d) vacuum [1]

4 Distant trains sound louder at night because sound waves get …

(a) reflected (b) absorbed (c) diffracted (d) refracted [1]

5 State two properties of sound waves.

....

.... [2]

6 What is the approximate range of audible frequencies?

.... [1]

7 Describe how sound waves are produced by a loudspeaker.

....

....

.... [3]

8

(a) State the formula for calculating the speed of sound.

.... [1]

Name: ....

(b) State three factors affecting the speed of sound.

....

.... **[3]**

9

(a) A train blows its whistle as it enters a 50-metre long tunnel. What is the time delay at the other end of the tunnel between hearing the sound of the train's whistle through the rails and through the air? Assume that the speed of sound in air and through steel is 342 m/s and 1560 m/s respectively.

....

.... **[3]**

(b) Whale-watchers use the reflection of ultrasound waves to identify the presence of whales in the vicinity of their boats. If the safe distance from a whale is 100 m, what is the measured time delay between the emitted and reflected signal from the whale at a depth of 100 m? Assume that the speed of sound in water is 1560 m/s.

....

.... **[2]**

(c) Orchestras tune to concert pitch, A, at 440 Hz. What is the wavelength of the instruments playing at this frequency if the speed of sound is 330 m/s?

....

.... **[2]**

(d) Calculate the time taken by an echo to be heard off a wall at a distance of 2 m from the source. Take the speed of sound in air to be 330 m/s.

....

.... **[2]**

(e) Suggest two applications of the echo-sounding principle.

....

.... **[2]**

[Total: 25]

Name: ....

Magnets and electricity

For questions 1 to 4, choose the correct answer by circling the letter.

1 Which of the following is non-magnetic?

(a) iron **(b)** steel **(c)** copper **(d)** nickel **[1]**

2 The magnetic field is strongest …

(a) at the poles **(b)** at the centre

(c) at the N-pole only **(d)** at the S-pole only **[1]**

3 Which of the following poles of two bar magnets would attract?

(a) N and N **(b)** S and S **(c)** N and S **(d)** a–c **[1]**

4 A piece of steel can be magnetized by …

(a) stroking it with a bar magnet

(b) rubbing it with copper

(c) placing it in a coil of wire

(d) dropping it to the ground **[1]**

5

(a) Draw the magnetic lines of force between

(i) two like poles

[2]

(ii) two unlike poles

[2]

Name: ....

6 Name one hard and one soft magnetic material.

....

.... **[1]**

7 State three features of a magnetic field produced by an electric current passing through a wire.

....

....

.... **[3]**

8 Explain how a magnetic field is produced around a solenoid.

....

....

.... **[3]**

[Total: 15]

Name: ....

Static electricity

For questions 1 to 4, choose the correct answer by circling the letter.

1 Which of these subatomic particles has a negative charge?

(a) neutron **(b)** proton **(c)** electron **(d)** a & b **[1]**

2 Which of these is a conductor?

(a) plastic **(b)** silver **(c)** paper **(d)** glass **[1]**

3 Earthing helps to prevent …

(a) sparks

(b) electric shocks

(c) charge building up

(d) all of the above **[1]**

4 The SI unit of charge is …

(a) coulomb **(b)** ampere **(c)** volt **(d)** watt **[1]**

5

(a) Why do most non-metals conduct charge poorly?

....

.... **[2]**

(b) State one non-metal that is a conductor.

.... **[1]**

6

(a) Explain the following in terms of electric charge:

(i) a plastic comb attracts bits of paper

.... **[1]**

(ii) a TV screen attracts dust

.... **[1]**

(iii) two charged rods repel each other

.... **[1]**

Name: ....

(b) Explain how the properties of electric charge can be used to reduce air pollution by a power plant.

....

....

.... **[3]**

6

(a) Draw diagrams to show the distribution of charge on a metal sphere after being induced by

(i) a positively-charged rod

[1]

(ii) a negatively-charged rod

[1]

[Total: 15]

Name: ....

Current electricity

For questions 1 to 4, choose the correct answer by circling the letter.

1 An ammeter is used to measure …

(a) current

(b) potential difference

(c) power

(d) resistance [1]

2 Which of the following increases when cells are connected in series in a circuit?

(a) total resistance

(b) total current

(c) total potential difference

(d) overall energy loss [1]

3 The resistance of a wire can be increased by …

(a) reducing the current

(b) increasing the current

(c) reducing its length

(d) increasing its length [1]

4 A thermistor conducts more current when …

(a) the temperature falls

(b) the temperature increases

(c) the length increases

(d) the length is reduced [1]

5

(a) Draw the symbols for the following:

(i) ammeter

[1]

(ii) cell

[1]

Name: ....

(iii) switch

[1]

(b) State the formula for calculating charge.

.... [1]

6

(a) Explain why a car battery of 12 V might deliver less potential difference after being installed.

....

....

.... [2]

(b) What happens to the potential difference when two or more components are connected in series in a circuit?

....

.... [1]

7

(a) State three factors affecting the resistance of a wire.

....

....

.... [3]

(b) Draw symbols for the following:

(i) resistor

[1]

Name: ....

(ii) thermistor

[1]

(c)

(i) A resistor has a resistance of 5 Ω. What is the current passing through it if a potential difference of 15 V is applied?

....

.... **[2]**

(ii) State how the current passing would change if the potential difference were doubled.

.... **[1]**

8

(a) Draw a circuit showing two bulbs connected in parallel to a power source.

[2]

(b) State what happens when one of the bulbs is removed. Give reasons.

....

.... **[2]**

(c) Explain what would happen if one of the bulbs in a series circuit were removed.

....

.... **[2]**

[Total: 25]

Name: ....

Using electricity

For questions 1 to 4, choose the correct answer by circling the letter.

1 Alternating current flows …

(a) forwards

(b) backwards

(c) backwards and forwards

(d) opposite to the direct current **[1]**

2 Double insulation substitutes for the …

(a) fuse **(b)** earth wire **(c)** live wire **(d)** circuit breaker **[1]**

3 One kilowatt hour is equal to …

(a) 360 000 J **(b)** 3 600 000 J **(c)** 3600 J **(d)** 360 J **[1]**

4 A plug does not include …

(a) an earth wire **(b)** a neutral wire

(c) a live wire **(d)** none of the above **[1]**

5

(a) State the equation for calculating the power of a component in a circuit.

.... **[1]**

(b) Calculate the power of a component when a current of 5 A passes through it and a potential difference of 12 V is applied across its ends.

....

.... **[2]**

(c) How would the power of the component be affected if a similar bulb were connected in series?

....

.... **[2]**

6

(a) State the function of a fuse in a circuit.

.... **[1]**

Name: ....

(b) An electric iron has a power rating of 1100 W. Suggest an appropriate fuse for the iron if the voltage is 230 V.

....

.... **[2]**

(c) A circuit breaker performs the same function as a fuse. State one advantage over a circuit breaker over a fuse.

....

.... **[1]**

(d) Some appliances may not contain an earth wire. Are they necessarily dangerous?

....

.... **[1]**

7

(a) Identify four hazards associated with mains electricity.

....

....

....

.... **[4]**

(b) Suggest two ways in which these hazards can be avoided.

....

.... **[2]**

8

(a) If the potential difference is 12 V, how much energy is produced by an electric kettle when a current of 4 A is passed through it for 3 minutes to boil water for a cup of tea?

....

.... **[2]**

Name: ....

(b) Calculate the cost of running the kettle to have a cup of tea every day for two weeks if energy costs 12cu per unit and the kettle has a power of 1.1 kW.

....

.... **[3]**

[Total: 25]

Name: ....

Electromagnetism

For questions 1 to 4, choose the correct answer by circling the letter.

1 The force on a current-carrying wire in a magnetic field can be increased by …

(a) increasing the current

(b) decreasing the current

(c) reducing the length of the wire

(d) using a thicker wire **[1]**

2 According to Fleming's left-hand rule, the force acts …

(a) perpendicular to the current and the field

(b) parallel to the current and the field

(c) perpendicular to the voltage and the field

(d) parallel to the voltage and the field **[1]**

3 In a simple DC motor, the turning effect is maximum when the coil is …

(a) vertical (b) diagonal (c) horizontal (d) moving clockwise **[1]**

4 Increasing the number of turns on the coil …

(a) decreases the turning effect

(b) increases the turning effect

(c) has no effect on the turning effect

(d) causes it to turn in the opposite direction **[1]**

5

(a) State the function of the commutator and carbon brushes in a simple DC motor.

....

.... **[2]**

(b) How can the direction of a force on a current-carrying wire in a magnetic field be determined?

....

.... **[2]**

Name: ....

(c) How would you cause the coil to rotate in the opposite direction?

....

.... **[2]**

(d) State two ways in which the turning effect on the coil can be increased.

....

.... **[2]**

(e) Why is the performance of the motor enhanced when several coils are substituted for the copper wire?

....

.... **[2]**

(f) How does using an iron armature instead of a copper coil affect the performance of the motor?

....

.... **[1]**

[Total: 15]

Name: ....

Electromagnetic induction

For questions 1 to 4, choose the correct answer by circling the letter.

1 An induced EMF will be greater when …

(a) a shorter length of wire is used

(b) a stronger magnet is used

(c) moving the wire slower

(d) using a thicker wire **[1]**

2 An induced current flows in a direction …

(a) to oppose the change producing it

(b) perpendicular to the change producing it

(c) diagonal to the change producing it

(d) the same as the change producing it **[1]**

3 When the coil on an AC generator rotates faster …

(a) the frequency of the AC is increased

(b) the frequency of the AC is decreased

(c) the frequency is unaffected

(d) fewer magnetic lines are cut **[1]**

4 A transformer works on the principle of …

(a) AC voltage

(b) induced magnetism

(c) mutual induction

(d) rectification **[1]**

5

(a) State Faraday's law of electromagnetic induction.

....

.... **[2]**

(b) How would you reverse the direction of the induced EMF?

....

.... **[2]**

Name: ....

6 Draw a graph to show how the current produced by an AC generator changes with the position of the coil.

[4]

7

(a) What is meant by mutual induction?

....

.... **[2]**

(b) Describe how a transformer operates.

....

....

....

.... **[4]**

(c) Suggest one application each of a step-up and a step-down transformer.

....

.... **[2]**

(d) Why is AC preferred over DC for mains electricity?

....

.... **[1]**

Name: ....

(e) What role do transformers play in electricity transmission?

....

.... **[2]**

(f) State two causes of energy wastage in transformers.

....

.... **[2]**

[Total: 25]

Name: ....

Introduction to electronics

For questions 1 to 4, choose the correct answer by circling the letter.

1 A microphone is an example of …

(a) an output device (b) an input device (c) a processor (d) a source of noise **[1]**

2 A transistor acts as a …

(a) resistor (b) microphone (c) switch (d) relay **[1]**

3 A diode allows current to flow …

(a) forwards only

(b) backwards only

(c) forwards and backwards at the same time

(d) forwards or backwards depending on the type of diode **[1]**

4 A thermistor can be used to create …

(a) a temperature-sensitive switch

(b) a light-sensitive switch

(c) a time-delay switch

(d) a sound-sensitive switch **[1]**

5 Differentiate between analogue and digital signals.

....

....

.... **[2]**

6

(a) State the function of the following components:

(i) resistor

.... **[1]**

(ii) capacitor

.... **[1]**

(iii) integrated circuit

.... **[1]**

Name: ....

(b) Describe how a reed switch operates.

....

....

.... **[3]**

(c) Suggest two applications of a reed switch.

....

.... **[2]**

7

(a) Describe, with the help of a circuit diagram, how a light-sensitive switch might be created.

....

....

.... **[5]**

(b) Suggest two applications for a light-sensitive switch.

....

.... **[2]**

8

(a) State the function of the tungsten filament in the thermionic emission experiment.

....

.... **[1]**

Name: ....

(b) Why is a vacuum created in the tube used for the experiment?

....

.... **[1]**

(c) State two properties of electron rays.

....

.... **[2]**

[Total: 25]

Name: ....

Electronic systems

For questions 1 to 4, choose the correct answer by circling the letter.

1 In a logic table, the input and output states are interpreted as …

(a) high or low

(b) near or far

(c) logical or illogical

(d) static or dynamic **[1]**

2 If the value of two input values for an OR gate is 0 and 1, the output is …

(a) 0 **(b)** 1 **(c)** 0 or 1 **(d)** both 0 and 1 **[1]**

3 Which of the following is also called an inverter?

(a) OR gate **(b)** NAND gate **(c)** NOT gate **(d)** AND gate **[1]**

4 The clock in a computer is worked by a/an …

(a) bistable **(b)** astable **(c)** OR gate **(d)** AND gate **[1]**

5

(a) State two uses of logic gates in computers.

....

....

.... **[2]**

(b) Explain why semiconductors are widely used in computers.

....

....

.... **[2]**

Name: ....

6

(a) Draw a circuit diagram for a security system that grants access only when both the fingerprint and retina scan match with those in the database.

[2]

(b) Draw the logic table for the circuit in part (a).

[2]

7 Describe how an astable is used as a pulse generator.

....

....

.... **[3]**

[Total: 15]

Name: ....

Radioactivity

For questions 1 to 4, choose the correct answer by circling the letter.

1 Which of these types of radiation is the most penetrating?

(a) alpha **(b)** beta **(c)** gamma **(d)** X-ray **[1]**

2 Gamma rays are deflected by …

(a) magnetic fields

(b) electric fields

(c) both magnetic and electric fields

(d) neither magnetic nor electric fields **[1]**

3 Background radiation comes from …

(a) rocks

(b) food

(c) air

(d) all of the above **[1]**

4 Which of the following is a product of alpha decay?

(a) antineutrino **(b)** helium-4 nucleus **(c)** electron **(d)** X-ray **[1]**

5

(a) Explain why alpha particles are more ionizing than beta or gamma particles.

....

.... **[1]**

(b) Describe the deflection of alpha and beta particles in a magnetic field.

....

....

.... **[2]**

(c) Suggest three safety precautions to be observed when using radioactive sources.

....

....

.... **[3]**

Name: ....

6

(a) How is the daughter nucleus different from the parent nucleus in:

(i) alpha decay

....

.... **[2]**

(ii) beta decay

....

.... **[2]**

(b) Strontium-90 has a half-life of 28 years. If a sample of the isotope has an activity of 500 Bq what would the approximate activity be after 50 years?

....

.... **[2]**

7

(a) Explain how nuclear fission is carried out in a nuclear reactor.

....

....

....

....

.... **[4]**

(b) How does the Sun produce an enormous amount of energy?

....

....

.... **[2]**

Name: ....

8 Suggest three practical applications of radioactivity.

....

....

.... **[3]**

[Total: 25]

Name: ....

The atom

For questions 1 to 4, choose the correct answer by circling the letter.

1 The nucleus of an atom contains …

(a) electrons and protons

(b) protons

(c) protons and neutrons

(d) electrons **[1]**

2 A beta particle has mass and charge similar to a/an …

(a) proton (b) electron (c) neutron (d) atom **[1]**

3 The activity of a radioactive sample is …

(a) the number of disintegrations per second

(b) the number of alpha particles per second

(c) the number of bonds per second

(d) the increase in mass per second **[1]**

4 Rutherford discovered that …

(a) most of the mass of an atom exists in the centre

(b) most of the atom consists of empty space

(c) electrons orbit the nuclues

(d) all of the above **[1]**

5 What are the particles you would expect to find in an atom? Give some idea of their relative masses and state what charge, if any, each kind has.

....

....

.... **[3]**

6

(a) electron proton neutron nucleus nucleon

Which of these

(i) orbits the nucleus?

.... **[1]**

Name: ....

(ii) is uncharged?

.... **[1]**

(iii) is a name for two types of particles?

.... **[1]**

(b) Complete the table below:

	Electrons	Protons	Neutrons	Nucleon number	Symbol
Sodium-23	11				
Aluminium-27	13				
Strontium-90	38				

[2]

7

(a) In an experiment to find the half-life of radioactive iodine, the rate of emission falls from 200 counts per second to 25 counts per second in 75 minutes. What is its half-life?

....

.... **[2]**

(b) If the half-life of a radioactive gas is 2 minutes, to what fraction of its initial value would the rate of emission have fallen after 8 minutes?

....

.... **[2]**

Name: ....

8 Plot the data in the table on a graph and determine the half-life of the radioactive isotope (polonium-218):

Time / min	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Count rate / (counts/sec)	260	205	160	129	104	82	64	51

.... **[4]**

9 A sample of a radioactive substance was emitting 4000 alpha particles a second at the start of an experiment. Ten minutes later it was emitting 2000 particles per second.

(a) What is the half-life of the substance?

....

.... **[1]**

(b) How long after the start would you expect to measure a count of 500 particles a second?

....

.... **[1]**

(c) How much activity (in counts per second) would you expect after 10 half-lives?

....

.... **[1]**

Name: ....

(d) The natural 'background' count of radiation is about 2 counts per second in most places. How long would it take for radiation from the radioactive waste to be just less than this background radiation?

....

.... **[2]**

[Total: 25]

Physical quantities and measurement

(1) direction; scalar **(2)** 80 N **(3) (a)** m/s **(b)** kg **(c)** m **(4)** 60 **(5)** A micrometer can measure distances as small as 0.001 cm so it is appropriate for measuring the thickness of a copper wire. A pair of vernier calipers is appropriate for measuring the thickness of a metal chip since they can be used to measure distances as small as 0.01 cm.

Speed and linear motion

(1) 80 x 1000/60 x 60 = 80000 m/3600 s = 22.22 m/s; d = 22.22 m/s x 2 x 60 s x 60 s = approximately 160 km **(2)** Uniform acceleration means that the acceleration is constant and does not change. In other words, the change in velocity over time does not change. **(3) (a)** B: 10 m/s; D: 40 m/s. **(b)** The upward sloping curve indicates that the car is accelerating over time. **(4)** 12.5 m **(5)** 15, 300, 30, 675

Circular motion and friction

(1) (a) friction between the saw and the wood **(b)** the upward force provided by the inflated castle **(c)** air resistance **(2)** 3 N; 4 m/s^2 **(3)** A space rocket burns fuel to produce a huge mass of gas which is pushed out through a nozzle at the base. The thrust produced helps it to overcome the force of gravity and escape the gravitational field of the Earth. **(4)** changes in mass of the object, speed of the object, and radius of the circular path **(5)** Friction between the surfaces of moving parts generates heat.

Mass, weight, and density

(1) density of block = 5 kg x 1000/(3.0 cm x 2.0 cm x 2.0 cm) = 5000 g/12 cm^3 = 41.67 g/cm^3 density of liquid = 50 kg x 1000/0.1 dm^3 x 1000 = 50000 g/100 cm^3 = 500 g/cm^3. Since the density of the block is less than the density of the liquid the block will float. **(2)** mass is a scalar quantity whereas weight is a vector quantity; mass remains constant whereas weight differs with gravitational field; because weight is a force **(3)** 450 N; 225 N **(4)** because the ball resists a change in its motion; a force greater than 150 N to overcome the inertia of the ball **(5)** The water splashed out could be collected and the volume measured using a measuring cylinder. This would be the volume of the alien object.

Turning forces

(1) Beam B should not be in equilibrium because the sum of clockwise moments (30 N) is greater than the sum of anticlockwise moments (20 N) about point O. **(2)** Centre of mass of a body is the point at which the turning effects of all gravitational forces cancel out. It is crucial for a tightrope walker to be aware of his centre of mass to maintain equilibrium by keeping the centre of mass over the rope. **(3)** limit of proportionality is at (x,y) = (45,6). **(4)** spring constant k = 2/15 = 0.13; For F = 5 N, x = F/k = 5 N/0.13 = 38.46 mm **(5) (a)** Steel is flexible. This causes the skyscraper to return to its original shape upon being stretched by high winds and earthquakes. **(b)** Pushing at the farther end increases the perpendicular distance from the centre of rotation. This results in greater moment of the force applied making it easier to open the door.

Pressure

(1) p = F/A = 100 N /8 m x 5 m = 100 N/40 m = 2.5 Pa; by applying greater force on the block or by reducing the area **(2)** B, because the thick base would be able to withstand the greater pressure at the bottom of the water. **(3)** pressure = ρgh = 1000 x 10 m/s^2 x 0.5 m = 5000 Pa; he should use fibreglass because it can withstand the pressure **(4)** The barometer should show a lower reading at high altitude because of lower atmospheric pressure. Since the barometer shows a higher reading it is probably defective. **(5)** See page 69 of *Fundamental Physics*. **(6)** because temperature changes can affect the volume of the gas according to the kinetic theory of matter **(7)** $p_1V_1 = p_2V_2$ => 2 x 10 = p_2 x 8 => 20 = 8 x p_2 => p_2 = 20/8 = 2.5; to be increased by 0.5 atm

Energy I

(1) (a) chemical energy to kinetic energy **(b)** solar energy to thermal energy **(c)** wind energy to kinetic energy **(2)** The law of conservation of energy describes how energy can be converted from one form to another to perform work. **(3)** gravitational PE = mgh = 5 kg x 10 m/s^2 x 1 m = 50 J; KE gained or gravitational PE lost = mgh = 5 kg x 10 m/s^2 x 0.33 m = 16.67 J **(4) (a)** Efficiency helps to determine how much energy would be required for the machine to perform a certain amount of work; efficiency of machine A = 900/1000 = 90%; efficiency of machine B = 800/900 = 0.89%; machine B wastes less energy. **(b)** power output of machine A = 900/3600 = 0.25 W; power output of machine B = 800/2700 = 0.30 W; machine B gives greater power output. **(5)** cause pollution; non-renewable **(6)** See page 86 of *Fundamental Physics*.

Energy II

(1) conductors allow heat to travel across them but insulators do not; copper, silver, etc. **(2)** temperature difference across the ends; area of cross-section; length **(3)** See page 109 of *Fundamental Physics*. **(4)** Liquid A; a lot of heat energy would be required to overcome the density and cause the movement of molecules **(5) (a)** black is a good absorber and emitter of heat so the saucepan heats up and cools faster than a white one **(b)** They reflect heat within the flask and prevent thermal radiation. **(6)** using double-glazed windows; filling wall cavities with plastic foam **(7)** See page 110 of *Fundamental Physics*.

Temperature

(1) because it is a metal, it is a better conductor of heat than water **(2)** 0°C and 100°C; 273°C **(3)** 298, 37, 375 **(4)** A clinical thermometer uses one metal whereas a thermocouple thermometer uses two. A clinical thermometer uses the expansion of mercury to measure temperature whereas a thermocouple thermometer uses voltage difference. **(5)** See page 101 of *Fundamental Physics*. **(6)** The mercury rises higher in a narrower tube which makes it appropriate for measuring small temperature changes. **(7)** It has a lower range than would be useful in science experiments.

Matter and heat

(1) The molecules of evaporating liquids carry away thermal energy from the molecules of the evaporating surface. **(2)** Boiling takes place when the vapour pressure in the liquid overcomes the atmospheric pressure to escape into the air. Heat is necessary to provide the molecules with the required energy. In evaporation, only the surface molecules possess enough energy to escape into the air. **(3) (a)** See page 115 of *Fundamental Physics*. **(b)** See page 116 of *Fundamental Physics*. **(c)** See page 118 of *Fundamental Physics*. **(4)** 840,000 J **(5)** the temperature at which the solid melts to a liquid; the temperature at which the first bubbles rise from the bottom of the vessel to the surface and escape **(6)** how much energy needs to be transferred to convert the water into steam **(7)** The gas would expand and the piston would rise. The pressure on the walls of the container would increase because the gas molecules would hit it with greater energy.

Kinetic model of matter

(1) The molecules of a solid are held in a fixed shape by strong forces of attraction between them. Molecules of a gas possess very weak forces of attraction. **(2)** definite volume but no fixed shape; no fixed shape or volume; strong bonds between molecules; very weak bonds between molecules; very little space between molecules; some space between molecules; particles vibrate about fixed positions; particles move at high speed and collide with one another; molecules possess moderate potential energy; molecules possess the greatest potential energy **(3)** The molecules gain thermal energy and vibrate with greater energy to overcome the forces of attraction that hold them in a definite shape **(4)** by increasing the temperature, surface area, air flow over the surface; reducing humidity **(5)** See page 99 of *Fundamental Physics*. **(6)** See page 115 of *Fundamental Physics*. **(7)** The bubbles need less vapour pressure to overcome atmospheric pressure. **(8)** See page 115 of *Fundamental Physics*.

Waves

(1) (a) wavelength **(b)** amplitude **(2)** In transverse waves, the oscillations occur at right angles to the direction of wave travel. In longitudinal waves the oscillations occur backwards and forwards along the direction of wave travel. They are called compressions and rarefactions. **(3)** the number of waves passing a point per second measured in hertz (Hz); $f = v/\lambda = 12/3 = 4$ Hz **(4)** light, sound, radio; light waves reflect and refract; sound waves undergo diffraction **(5)** See page 126 of *Fundamental Physics*. **(6)** A wavefront is a diagrammatic representation of a wave.

Light

(1) (a) normal **(b)** incident ray **(c)** reflected ray **(2)** See page 142 of *Fundamental Physics*. **(3)** See page 142 of *Fundamental Physics*. **(4)** See page 146 of *Fundamental Physics*. **(5)** See page 147 of *Fundamental Physics*; speed of light in diamond = speed of light in vacuum /refractive index = 300 000 km/s/2.42 = 123 967 km/s. **(6)** See page 153 and 159 of *Fundamental Physics*.

Electromagnetic waves

(1) gamma rays, ultraviolet radiation, radio waves (other responses possible) **(2)** See page 160 of *Fundamental Physics*. **(3)** See page 160 of *Fundamental Physics*. **(4) (a)** mobile phones, microwave ovens, etc. **(b)** security alarms, optical fibres, etc. **(c)** tanning lamps, sterilization, etc. **(d)** cancer treatment, food sterilization **(e)** X-ray photography, cancer treatment, etc. **(5)** See page 147 of *Fundamental Physics*.

Sound waves

(1) See page 128 of *Fundamental Physics*. **(2)** Electromagnetic waves can travel in a vacuum but sound waves need a medium to travel. **(3) (a)** 330 m/s; distance = 330 m/s x 3 s/2 = 495 m **(b)** Sound waves are refracted through the layers of cooler air close to the ground. This causes the waves to bend towards the ground and the sounds seem to be coming from a closer source. **(4)** timbre **(5) (a)** 20–20 000 Hz **(b)** ultrasound; cleaning, breaking, echo-sounding, metal testing, etc. **(6) (a)** The wavefront of a high pitched sound would show a larger number of waves **(b)** The wavefront of a louder sound would show a larger amplitude. **(7)** 25 m

Magnets and electricity

(1) causing a material to become magnetized by placing them within the magnetic field of a magnet; steel; iron **(2)** the atomic magnets become disorganized; by stroking with a magnet **(3) (b)** The poles will be reversed. **(c)** See page 207 of *Fundamental Physics*. **(4)** magnetic relay, circuit breaker, magnetic storage **(5)** increasing the current; using a stronger magnet; increasing wire length

Static electricity

(1) The plastic comb became charged when rubbed by the hair. This created electrostatic charge and the comb was able to attract the bits of paper by inducing charges in them. **(2)** Atoms of metals contain electrons that can break away and flow around carrying a charge. This is why metals are called conductors. Rubber is an insulator because it does not contain such free electrons. Metals can be used to make the conducting part of electrical wiring while rubber can be used cover it to provide protection. **(3) (a)** positive **(b)** negative **(c)** no charge **(4) (a)** Negative charges will collect in the upper part of the sphere and positive charges in the lower part because the positive charges in the rod will cause atoms in the upper part to become negatively charged. This is called induction. **(b)** a spark might occur when charges escape from the end and ionize the air; earthing **(5)** when the molecules in air are not ionized; when the molecules become ionized due to radiation and other forces and do not find any free electrons to recombine with

Current electricity

(1) the flow of electrons in a circuit; by connecting a component (bulb) or ammeter in the circuit **(2)** 20 A **(3) (a)** switch **(b)** bulb **(c)** cell **(4)** See pages 178-9 of *Fundamental Physics*. **(5) (a)** R = V/I; increasing wire length, reducing cross-sectional area of the wire, using a wire of a different material, increasing the temperature **(b)** R = V/I = 9 V/3 A = 3 Ω **(c)** The current would be doubled according to Ohm's law.

Using electricity

(2) (a) 3 A; by adding up the potential difference across each bulb **(b)** 4 A **(3) (a)** See page 191 of *Fundamental Physics*. **(b)** 5 A **(4) (a)** to prevent electric shocks; because the plastic casing of these appliances provides the necessary insulation **(b)** 9.6cu

Electromagnetism

(1) (b) by the magnetic field produced by the current in the wire acting on the poles of the magnet **(c)** by increasing the current, using a stronger magnet, and increasing the length of wire in the field **(d)** There would be no force. **(e)** See pages 210-211 of *Fundamental Physics*. **(2) (a)** See page 212 of *Fundamental Physics*. **(b)** by increasing the current, using a stronger magnet, increasing the number of turns on the coil, and increasing the area of the coil **(c)** Steel would become permanently magnetized by the current.

Electromagnetic induction

(1) (a) See page 214 of *Fundamental Physics*. **(b)** It would increase. **(c)** using a stronger magnet, increasing the length of the wire in the magnetic field **(2) (a)** flows in the reverse direction **(b)** The current would flow in the direction opposite to that when the bar magnet was first pushed into the coil. **(3)** when the coil is horizontal; maximum magnetic field lines are being cut at this position **(4)** $n_2/n_1 = 3 \Rightarrow n_2/200 = 3 \Rightarrow n_2 = 200 \times 3 = 600$; $V_2/V_1 = n_2/n_1 \Rightarrow 30/V_1 = 3$ V $\Rightarrow V_1 = 30/3$ V = 10 V; $V_1I_1 = V_2I_2 \Rightarrow 10$ V x $I_1 = 60$ W (since $V_2I_2 = 60$ W) $\Rightarrow I_1 = 60$ W/10 V = 60 A **(5) (a)** cheaper to produce on a large scale; can be adjusted using transformers **(b)** the air provides natural insulation; they are visually unappealing

Introduction to electronics

(1) (a) Electrons are emitted under very low gas pressure. **(b)** They are emitted from the filament connected to the negative terminal of the power supply and are attracted towards the anode connected to the positive terminal. **(c)** charge (c) = current (A) x time (s) **(2) (a)** Y-plates deflect the electron beam to move it vertically. X-plates deflect the beam to move it horizontally. **(b)** The timebase applies a voltage across the X-plates to cause the beam to move from left to right. The fluorescent screen helps to produce the waveform for the electron beam. **(c)** The peak voltage is a measure of the vertical deflection of the electron beam. The peak-to-peak time is the period of the spot produced by the electron beam and can be used to determine the frequency. **(d)** peak voltage = 4.0 cm x 20 V/cm = 100.0 V **(e)** peak-to-peak time = 3.0 cm x 10 ms/cm = 30.0 ms = 0.03 s **(3) (b)** It acts as a switch that completes the circuit for the bell when a current is passed through a coil wound round it. **(c)** The thermistor acts as part of the potential divider by allowing the current to pass through the circuit when it is sufficiently heated.

Electronic systems

(1) (b) It helps to connect smaller circuits into integrated circuits by acting as a switch. **(c)** See page 236 of *Fundamental Physics*. **(4) (a)** Yes. The cross-coupling of the NOR gates and the flipping feature allow the bistable to remember its new output states. **(b)** It is used to give off pulses at regular rates which can be used in the clock of a computer control system.

Radioactivity

(1) (a) Some materials exist as isotopes and have unstable nuclei because of a different number of neutrons in the nucleus while most materials possess stable nuclei in their atoms. Therefore, radioactive decay is the result of the disintegration of the unstable nuclei of isotopes. **(b)** alpha particles, beta particles, gamma rays **(c)** ionizing effect: gamma rays, beta particles, alpha particles; penetrating effect: alpha particles, beta particles, gamma rays **(2) (a)** Nuclear fission involves the breaking up of a nucleus to release energy whereas fusion involves the joining of smaller nuclei to make heavier ones. Nuclear fusion results in the release of a much greater amount of energy than nuclear fission. **(b)** A moderator such as graphite or water is used to slow down the reaction. Control rods containing boron or cadmium are lowered and raised to adjust the rate of the reaction. **(c)** a large amount of energy can be produced; helium is produced as a waste product and is not radioactive; extremely high levels of pressure and temperature need to be maintained **(3) (a)** 125 Bq **(b)** See page 265 of *Fundamental Physics*. **(4) (a)** background radiation; exposure to nuclear dust **(b)** wearing protective clothing; using radiation detectors

The atom

(1) (b) Atomic number (A) refers to the number of protons in the nucleus. Mass number (Z) refers to the number of neutrons and protons in the nucleus. It is also called the nucleon number. Atomic number of helium = 2; mass number of helium = 4 **(c)** The difference exists because lithium has two isotopes named lithium-6 and lithium-7. These isotopes have the same number of protons in the nucleus but lithium-7 has one additional neutron and occurs more commonly. **(2) (a)** The nucleon number and charge are conserved. The products are a new element with an atomic number 2 less and mass number 4 less than the parent nucleus, and an alpha particle. **(b)** The nucleon number and charge are conserved. The products are a new element with an atomic number 1 more than and mass number the same as the parent nucleus, a beta particle, and an antineutrino. **(c)** ${}^{226}_{88}\mathrm{Ra} \rightarrow {}^{222}_{86}\mathrm{Rn} + {}^{4}_{2}\alpha$ **(d)** ${}^{131}_{53}\mathrm{I} \rightarrow {}^{131}_{54}\mathrm{Xe} + {}^{0}_{-1}\beta + {}^{0}_{0}\bar{\nu}$ **(3) (a)** Most alpha particles passed undeflected. A few alpha particles were deflected slightly. A few alpha particles bounced back after being repelled. **(b)** The ‘plum pudding’ model of the atom was rejected and the positive charge was thought to be concentrated in the centre with the negative charges orbiting it.

Physical quantities and measurement

(1) a **(2)** d **(3)** c **(4)** b **(5)** **(a)** 10^6 **(b)** 5×10^{-4} **(c)** 2.65×10^3 **(6)** 1.2×10^{-2} **(7)** **(a)** Zero error is a defect in the measuring instrument that causes it to give a reading other than zero when it should not. In a pair of vernier calipers zero error might arise due to incorrect calibration of the instrument or due to environmental conditions. **(b)** See page 15 of *Fundamental Physics*. **(8)** **(a)** 5.56 m/s **(b)** scalar; scalar quantities are expressed in terms of magnitude only whereas vector quantities are expressed in terms of both magnitude and direction **(c)** average acceleration = change in velocity/time; when the change in velocity is constant over time; when the change in velocity is smaller than in the previous time interval **(9)** 47 N, 15° to the 30 N force

Kinematics

(1) c **(2)** d **(3)** b **(4)** a **(5)** **(b)** The rising slope and curved shape indicate that the car covers a greater distance during each time interval. In other words, it accelerates. **(c)** straight and upward-sloping **(6)** See page 30 of *Fundamental Physics*. **(7)** **(a)** **(i)** 20 m/s; it is the velocity with which the object is thrown upwards against the downward force of gravity **(ii)** 0 m/s **(iii)** 20 m/s; the object falls with the same velocity because the force of gravity and air resistance does not change **(8)** **(a)** A moving object is in uniform acceleration when its velocity change is constant during each time interval. See page 35 of *Fundamental Physics* for graph. **(b)** A moving object is in non-uniform acceleration when its velocity change over time is not consistent. A car might cover larger distances over time when it is started but cover smaller distances over time while coming to a stop. See page 35 of *Fundamental Physics* for graph. **(9)** **(a)** If no external force is acting on an object, it will, if stationary, remain stationary; if moving, keep moving at a steady speed in a straight line. **(b)** Answers may vary.

Dynamics

(1) d **(2)** a **(3)** d **(4)** b **(5)** **(a)** See page 37 of *Fundamental Physics*. **(b)** **(i)** It acts on a smaller surface area and does not reduce the speed of the skydiver. **(ii)** It acts on a larger surface area and slows down the speed. **(6)** **(a)** Force = mass x acceleration **(b)** Resultant force = 150 N – 30 N = 120 N; F = ma => a = F/m => a = 120/100 => 1.2 m/s^2 **(c)** the force of friction that needs to be overcome to get a stationary object into motion; it is greater than dynamic friction which is the force that needs to be applied to keep an object in motion against friction between the sliding surfaces **(d)** It produces heat. **(7)** **(a)** To every action there is an equal but opposite reaction. **(b)** See page 45 of *Fundamental Physics*. **(8)** **(a)** See page 48 of *Fundamental Physics*. **(b)** See page 48 of *Fundamental Physics*. **(c)** It would have to be increased to keep the object in circular motion.

Mass, weight, and density

(1) a **(2)** c **(3)** a **(4)** b **(5)** A large iceberg is less dense than water and so floats. A steel pin has a greater density than water and so it sinks. **(6)** all masses attract each other; the larger the mass, the greater the force; the closer the masses, the stronger the force **(7)** **(a)** 104.17 g **(b)** **(i)** 1 litre **(ii)** 1.0×10^{-3} m^3 **(c)** **(i)** 20 N **(ii)** 6.67 N **(8)** 500 N

Turning forces

(1) a **(2)** c **(3)** b **(4)** b **(5)** **(a)** If an object is in equilibrium, the sum of the clockwise moments about any point is equal to the sum of the anticlockwise moments about that point. **(b)** The sum of the forces in one direction must equal the sum of the forces in the opposite direction. The principle of moments must apply. **(6)** **(a)** by keeping his centre of mass over the tightrope at all times **(b)** A metal beam is wider than a tightrope making it easier to keep one's centre of mass over it. **(7)** **(a)** 20 N x 0.4 m = W x 0.1 m => W = 80 N **(b)** Stable equilibrium exists when the centre of mass remains over the base after it is tilted. Unstable equilibrium exists when the centre of mass is just about balanced over the base. Neutral equilibrium exists when the centre of mass always remains over the base. **(8)** See page 59 of *Fundamental Physics*.

Pressure

(1) c **(2)** b **(3)** a **(4)** b **(5)** **(a)** 32 Pa **(b)** 0.5 kg **(c)** Mass would remain unchanged. Pressure exerted by the cube would be 0.83 N **(6)** **(a)** to withstand the greater pressure exerted by water at greater depths **(b)** See page 67 of *Fundamental Physics*. **(7)** **(a)** The air pressure inside the vacuum cleaner is lowered with the help of a fan. Air from the outside rushes into the cleaner carrying with it dirt and dust. **(b)** See page 70 of *Fundamental Physics*. **(c)** Breathing becomes difficult because of low oxygen levels. Food takes longer to cook because of the lowered boiling point of water. **(d)** by carrying oxygen cylinders; by using a pressure cooker

Energy I

(1) b **(2)** d **(3)** d **(4)** b **(5)** **(a)** Joule (J); $W = F \text{ x } d \Rightarrow W = 5 \text{ N x } 4 \text{ m} \Rightarrow W = 20 \text{ J}$ **(b)** An object possesses potential energy when there is a change in its position, shape, or state. Elastic potential energy is the potential energy possessed by a body when it is stretched or compressed. **(6)** **(a)** Energy cannot be made or destroyed, but it can change from one form to another **(b)** See page 81 of *Fundamental Physics*. **(c)** thermal energy, sound energy **(d)** $PE = m \text{ x } g \text{ x } h \Rightarrow PE = 20 \text{ kg x } 15 \text{ m x } 10 \text{ m/s}^2 \Rightarrow PE = 3000 \text{ J}$; KE gained = PE lost => KE gained = 1/3 x 3000 J => KE gained = 1000 J **(7)** **(a)** $P = W/t \Rightarrow P = (2000 \text{ kg x } 10 \text{ m/s}^2 \text{ x } 5 \text{ m})/300 \text{ s} \Rightarrow P = 333.33 \text{ W}$ **(b)** efficiency = useful power output/total power input => efficiency = 333.33 W/1000 W => efficiency = 33.33%

Energy II

(1) c **(2)** d **(3)** b **(4)** b **(5)** **(a)** spins the generator **(b)** converts mechanical energy from the turbine into electrical energy **(6)** **(a)** greenhouse effect; acid rain **(b)** by installing flue gas desulfurization units in power stations to absorb sulfur dioxide from the exhaust gases **(c)** nuclear energy; wind energy **(d)** cost; environmental impact; efficiency; etc. **(7)** **(a)** Nuclear fission involves the disintegration of nuclei to release energy. Nuclear fusion involves the combining of nuclei to release energy. **(b)** Advantage: releases much greater amounts of energy; Disadvantage: requires much more challenging pressure and temperature conditions **(c)** **(i)** Large solar panels need to be installed. **(ii)** Huge areas of land are needed. **(iii)** Suitable sites are limited. **(d)** Tidal energy is obtained when tidal water flows into and out of a lake created by building a dam on an estuary. Wave energy is the energy produced by the motion of waves in the sea. **(8)** See page 261 of *Fundamental Physics*.

Temperature

(1) a **(2)** c **(3)** b **(4)** c **(5)** It is a liquid and a good conductor of heat so expands on heating. **(6)** **(a)** See page 100 of *Fundamental Physics*. **(b)** Mercury can be harmful on contact with the skin or if swallowed. **(7)** See page 101 of *Fundamental Physics*. **(8)** **(a)** -223°C **(b)** 473 K **(c)** 546°C **(9)** **(a)** a scale with equal divisions between the fixed points **(b)** See page 102 of *Fundamental Physics*. **(c)** **(i)** Mercury thermometers are less sensitive than coloured alcohol thermometers because mercury expands less than alcohol upon heating. **(ii)** Mercury thermometers can be used to measure much higher temperatures than alcohol thermometers whereas alcohol thermometers can be used to measure much lower temperatures than mercury thermometers before the alcohol freezes.

Heat and its effects

(1) a **(2)** c **(3)** d **(4)** c **(5)** **(a)** When water freezes to form ice the molecules become aligned in a special structure in which the intermolecular spaces are larger than in water. The same number of molecules take up a larger volume in the form of ice. As a result ice is less dense than water. See page 105 of *Fundamental Physics* for diagram. **(b)** When a gas is heated at constant pressure the molecules absorb energy and their kinetic energy increases. They move more rapidly and collide more frequently with one another and with the walls of the container. This creates pressure on the walls and the volume of the gas in increased. **(c)** Molecules in solids possess stronger forces of attraction between them than molecules in liquids. They need more energy to overcome the strong intermolecular forces and expand. **(7)** **(a)** Metal bar A probably has a greater area of cross-section, is shorter, and the temperature difference across its ends is greater. **(b)** Insulators do not possess free electrons. **(c)** wrapping the hot water tank with plastic foam lagging; insulating the loft with mineral wool; filling wall cavities with plastic foam; double-glazing windows **(8)** See page 110 of *Fundamental Physics*. **(9)** **(a)** the amount of energy required to be transferred to one kilogram of a substance to raise its temperature by 1°C **(b)** energy transferred = $m \text{ x } c \text{ x } \Delta T \Rightarrow E = 4 \text{ kg x } 4200 \text{ J/(kg-°C) x } 80\text{°C} \Rightarrow E = 1344 \text{ x } 10^3 \text{ J}$

Kinetic model of matter

(1) d **(2)** b **(3)** b **(4)** c **(5)** **(a)** **(i)** Solids have a fixed shape; liquids and gases do not. **(ii)** Solids and liquids possess definite volume; gases do not. **(iii)** Solids possess strong intermolecular forces of attraction; liquids possess weaker intermolecular forces of attraction; gases possess the weakest intermolecular forces of attraction. **(iv)** Molecules of solids vibrate about their positions; molecules of liquids move greater distances; molecules of gases move across the largest distances between them **(b)** **(i)** Molecules gain potential energy when they move away from one another by opposing the intermolecular forces of attraction. **(ii)** Molecules gain kinetic energy by virtue of their motion within the intermolecular spaces. **(6)** **(a)** Evaporation is the process by which molecules on the surface of a liquid gain sufficient energy to overcome the air pressure and escape into the atmosphere in the form of a gas. **(b)** humidity, wind, temperature, surface area **(c)** Evaporation takes place at a temperature lower than the boiling point of a liquid whereas boiling takes place at specific temperatures. Evaporation is much slower than boiling. In boiling bubbles form at the bottom of the liquid whereas in evaporation molecules leave from the surface without forming bubbles. Water boils faster at high altitudes because the molecules have to overcome lower levels of atmospheric pressure **(7)** See page 115 of *Fundamental Physics*. **(8)** When sweat evaporates from the skin surface, it carries thermal energy away from the body.

Waves

(1) b **(2)** c **(3)** a **(4)** d **(5)** **(a)** by moving it from side to side **(b)** by holding one end and moving it forwards and backwards **(c)** In a longitudinal wave the direction of the oscillations is along the line of travel of the wave whereas in a transverse wave the direction of oscillations is at right angles to the line of travel of the wave. **(6)** **(a)** A wavefront is a diagrammatic representation of the points reached by a wave during its motion. A wavefront represents the peaks and troughs of a wave. **(b)** **(i)** by measuring the distance between two consecutive peaks or troughs **(ii)** by counting the number of waves per second **(iii)** by measuring the distance between the peak or trough of a wave and its mean position **(7)** **(a)** speed (v) = frequency (f) x wavelength (λ). The equation represents the relationship between the speed, frequency, and wavelength of a wave.
(b) $v = f \times \lambda \Rightarrow v = 25 \text{ Hz} \times 0.5 \text{ m} \Rightarrow v = 12.5 \text{ m/s}$ **(c)** $v = f \times \lambda \Rightarrow f = v/\lambda \Rightarrow f = 200/1 \Rightarrow f = 200 \text{ Hz}$
(8) **(b)** Sound waves can turn around corners. Radio waves can travel large distances and bend around obstacles. Waves diffract when they spread out after passing through a small hole or slit.

Light

(1) b **(2)** d **(3)** a **(4)** c **(5)** Light travels in straight lines. Light is a type of electromagnetic radiation. Light transfers energy. **(7)** **(a)** See page 146 of *Fundamental Physics*. **(b)** refractive index = speed of light in air/speed of light in water => speed of light in water = speed of light in air/refractive index => v = 300 000/1.33 => v = 225 564 km/s **(c)** Light is refracted to a greater extent when passing through a medium with a higher refractive index. The greater degree of refraction causes the medium to appear less deep than it really is.
(9) **(a)** In short sight the lens of the eye cannot be stretched thin enough to converge light rays from distant objects on the retina. The rays converge before reaching the retina. In long sight the lens of the eye cannot be made thick enough to converge light rays from near objects on the retina. The rays do not converge even when they have arrived at the retina. **(b)** Short sight can be corrected by placing a diverging lens before the eye. Long sight can be corrected by placing a converging lens before the eye.

Electromagnetic waves

(1) a **(2)** a **(3)** c **(4)** a **(5)** They all reflect, refract, and diffract; they are non-mechanical waves so do not need a medium through which to travel; they are transverse waves; they travel at high speeds **(6)** 400 nm to 750 nm **(7)** **(a)** **(i)** ultraviolet **(ii)** microwave **(iii)** gamma radiation **(iv)** infrared **(v)** X-rays **(b)** UV radiation, X-rays and gamma radiation cause skin cancer by ionizing cells **(c)** placing a thermometer just beyond the red end of the visible spectrum would indicate a temperature rise compared with the electromagnetic source switched off or blocked. **(d)** ultraviolet radiation **(i)** very hot objects or gas discharges **(ii)** photographic paper; fluorescence **(iii)** killing bacteria **(8)** Microwaves produced in a microwave oven penetrate deep into the food and excite the water molecules in the food, causing a heating effect. Infrared radiation is absorbed by the food in close proximity of the infrared source, creating a heating effect. The food is then cooked by conduction from the outside inwards.

Sound

(1) a **(2)** c **(3)** b **(4)** d **(5)** Sound waves are longitudinal waves. They cannot travel through a vacuum. **(6)** between 20 and 20 000 Hz **(7)** See page 128 of *Fundamental Physics*. **(8) (a)** speed of sound = distance travelled/time taken **(b)** temperature, medium, frequency **(9) (a)** delay = time taken by sound to travel through air – time taken by sound to travel through rails => (50 m/330 m/s) – (50 m/1560 m/s) => t = 0.12 s **(b)** 128 ms **(c)** $\lambda = v/f$ => λ = 330 m/s / 440 Hz => λ = 0.75 m **(d)** time = 2 x distance/speed of sound => t = 2 x 2 m/330 m/s => t = 4/330 => t = 0.012 s **(e)** radar; electronic tape-measure

Magnets and electricity

(1) c **(2)** a **(3)** c **(4)** a **(5) (a) (i)** See page 205 of *Fundamental Physics*. **(ii)** See page 205 of *Fundamental Physics*. **(6)** hard magnetic material: steel; soft magnetic material: iron **(7)** The magnetic field lines are circles. The field is strongest closer to the wire. Increasing the current increases the strength of the field. **(8)** See page 206 of *Fundamental Physics*.

Static electricity

(1) c **(2)** b **(3)** d **(4)** a **(5) (a)** They do not possess free electrons that can carry charge. **(b)** carbon **(6) (a) (i)** Running the comb through hair causes the plastic to become charged with static electricity, which causes the bits of paper to be attracted. **(ii)** Leaving the TV on for some time charges the screen so that dust particles in the air become attracted to it. **(iii)** The rods possess opposite charges causing them to be repelled by one another. **(b)** See page 173 of *Fundamental Physics*.

Current electricity

(1) a **(2)** a **(3)** d **(4)** b **(5) (a) (i)** See page 176 of *Fundamental Physics*. **(ii)** See page 176 of *Fundamental Physics*. **(iii)** See page 176 of *Fundamental Physics*. **(b)** charge (c) = current (A) x time (s) **(6) (a)** The potential difference of a battery falls to less than its EMF when connected in a circuit. This happens because some of the energy is wasted within the battery leaving less potential difference to drive current through the circuit. **(b)** The potential difference becomes divided among the components in a series circuit. **(7) (a)** length; material; temperature **(c) (i)** $V = IR$ => $I = V/R$ => I = 15 V/5 Ω => I = 3 A **(ii)** The current passing though would also be doubled. **(8) (b)** The other bulb remains lit because the circuit connecting it to the power source has not been broken. **(c)** The second bulb would no longer remain lit because removing one of a bulb in a series circuit also breaks the circuit connecting the other bulbs to the power source.

Using electricity

(1) c **(2)** b **(3)** b **(4)** d **(5) (a)** power (W) = PD (V) x current (A) **(b)** power (W) = PD (V) x current (A) => P = 12 V x 5 A => P = 60 W **(c)** The power of the battery would be shared by the two components leaving the first component with less power than previously. **(6) (a)** It breaks the circuit before it overheats and catches fire. **(b)** current = power/voltage = 1100 W/230 V = 4.8 A; a 5 A fuse would be appropriate **(c)** A circuit breaker does not need to be replaced every time it trips. **(d)** No, provided they have double insulation. **(7) (a)** frayed wiring; overheated extension leads; electrocution; cutting cables accidentally **(b)** replacing old wiring; using a plug-in RCD **(8) (a)** energy transformed (J) = PD (V) x current (A) x time (s) => E = 12 V x 4 A x (3 x 60 s) => E = 8640 J **(b)** energy supplied = power (W) x time (t) => E = 2 kW x (3 / 60 x 14 h) => E = 1.4 kWh => E = 1.4 Units; total cost = 1.4 x 12cu = 16.8cu

Electromagnetism

(1) a **(2)** a **(3)** c **(4)** b **(5) (a)** The commutator helps to keep the coil turning by changing the direction of the current through it when it is in a vertical position and the turning effect becomes weaker. The carbon brushes keep the coil connected to the battery. **(b)** See page 210 of *Fundamental Physics*. **(c)** by positioning the battery or the poles of the magnet the other way round **(d)** using a stronger magnet; increasing the number of turns on the coil **(e)** The motor runs more smoothly and has a greater turning effect because of the turning effect produced by individual coils set at various angles. **(f)** The iron armature becomes magnetized because it is a soft magnetic material and helps to increase the strength of the magnetic field.

Electromagnetic induction

(1) b **(2)** a **(3)** a **(4)** c **(5)** **(a)** The EMF induced in a conductor is proportional to the rate at which magnetic field lines are cut by the conductor. **(b)** moving the wire in the opposite direction; reversing the field direction by turning the magnet around **(6)** See page 218 of *Fundamental Physics*. **(7)** **(a)** See page 220 of *Fundamental Physics*. **(b)** See page 221 of *Fundamental Physics*. **(c)** Step-up transformers are used in electricity transmission. Step-down transformers are used in electronic equipment such as microphones to bring down the supply voltage to a level that is safe for the circuitry of the appliance. **(d)** AC is generated more efficiently. It can be stepped up or down using transformers whereas DC cannot. **(e)** Step-up transformers increase the voltage before electricity can be distributed from the generator to consumers over thin long-distance cables. Step-down transformers bring down the voltage to safe levels for consumers. **(f)** resistance in the wire; eddy currents because of induced current in the transformer core

Introduction to electronics

(1) b **(2)** c **(3)** d **(4)** a **(5)** Analogue signals show continuous variation while digital signals show variation between two states only. **(6)** **(a)** **(i)** maintains current and voltage levels for other components to work properly **(ii)** stores small amounts of electric charge **(iii)** store entire circuits on a small chip **(b)** See page 233 of *Fundamental Physics*. **(c)** sensors on automatic sliding doors; burglar alarms **(7)** **(a)** See page 263 of *Fundamental Physics*. **(b)** night lighting in homes; outdoor floodlights **(8)** **(a)** It serves as the cathode from where electrons are discharged. **(b)** A vacuum allows electrons to travel freely without colliding with gas molecules and prevents the tungsten filament from getting burned as a result of a reaction between oxygen and the heated filament. **(c)** Electron rays are negatively charged and are attracted towards the anode. They are deflected by a magnetic field.

Electronic systems

(1) a **(2)** b **(3)** c **(4)** b **(5)** **(a)** controlling automated systems; storing data; etc. **(b)** Semiconductors conduct electricity when warm and do not conduct when cold. This feature makes them suitable for use in logical circuits and for alternating between two states, processing instructions, and storing data in computers. **(7)** See page 241 of *Fundamental Physics*.

Radioactivity

(1) c **(2)** d **(3)** d **(4)** b **(5)** **(a)** Alpha particles have the greatest charge and so possess the strongest ionizing capability. They are also bigger, hence slower, which gives them a greater time to ionize any atoms they pass by. **(b)** Alpha and beta particles deflect in opposite directions in a magnetic field because they are oppositely charged. Beta particles deflect by a greater degree because they are lighter than alpha particles. **(c)** wearing protective clothing to avoid exposure to skin; keeping the radioactive material covered when not in use; disposing of nuclear waste safely **(6)** **(a)** **(i)** The daughter nucleus has an atomic number 2 less and mass number 4 less than the parent nucleus. **(ii)** The daughter nucleus has an atomic number 1 more than the parent nucleus and the same mass number as it. **(b)** approximately 145 Bq **(7)** **(a)** See page 260 of *Fundamental Physics*. **(b)** by the fusion of hydrogen atoms to form helium atoms under enormous levels of temperature and pressure **(8)** medical tracers; monitoring the thickness of industrial products; estimating the age of fossils

The atom

(1) c **(2)** b **(3)** a **(4)** d **(5)** proton: relative mass 1, charge +1; neutron: relative mass 1, charge 0; electron: relative mass almost negligible, charge -1 **(6)** **(a)** **(i)** electron **(ii)** neutron **(iii)** nucleon **(b)** Sodium-23: 11, 12, 23, ${}^{23}_{11}\text{Na}$; Aluminium-27: 13, 14, 27, ${}^{27}_{13}\text{Al}$; Strontium-90: 38, 52, 90, ${}^{90}_{38}\text{Sr}$ **(7)** **(a)** 25 mins **(b)** 1/32 **(8)** Half-life is approximately 3 minutes. **(9)** **(a)** 10 minutes **(b)** 30 minutes **(c)** 4 counts per second **(d)** 110 minutes

Notes