MEADOW PARK SCHOOL

Physics Paper 2 Knowledge and Exam Practice

Friday 16th June 2022

Higher Tier

Topics – Forces, Waves and Electromagnetism

How to use this booklet

MEADOW PARK SCHOOL

Rehearse the content using to knowledge organiser pages.

You can look-cover-say-check.

Make flash cards for content you find more difficult.

Watch ‘free science lesson’ or ‘snap revision’ youtube videos and anything you don’t get.

Then complete the exam practice questions.

Required Practical

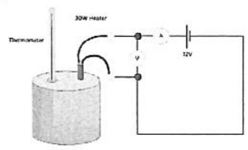
Investigating Specific Heat Capacity

independent variable – material

dependent variable – specific heat capacity

control variables – insulating layer, initial temperature, time taken

$\Delta E = m \times c \times \Delta\theta$



Method:

1. Using the balance, measure and record the mass of the copper block in kg.
2. Wrap the insulation around the block.
3. Put the heater into the large hole in the block and the block onto the heatproof mat.
4. Connect the power pack and ammeter in series and the voltmeter across the power pack.
5. Using the pipette, put a drop of water into the small hole.
6. Put the thermometer into the small hole and measure the temperature.
7. Switch the power pack to 12V and turn it on.
8. Read and record the voltmeter and ammeter readings – during the experiment, they shouldn't change.
9. Turn on the stop clock and record the temperature every minute for 10 minutes.
10. Record the results in the table.
11. Calculate work done and plot a line graph of work done against temperature.

Equations

$E = \frac{1}{2}mv^2$

$E_p = mgh$

$E_e = \frac{1}{2}ke^2$

$\Delta E = m \times c \times \Delta\theta$

$P = \frac{E}{t}$

$P = \frac{W}{t}$

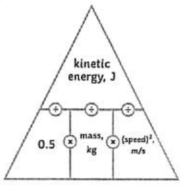
Kinetic and Potential Energy Stores

Movement Energy

kinetic energy = $\frac{1}{2}$ x mass × speed^2

$$E_k = \frac{1}{2}mv^2$$

(J) (kg)(m/s)

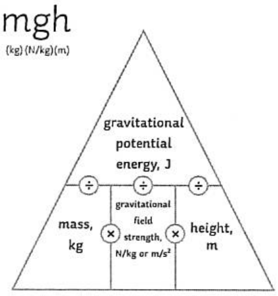


When something is off the ground, it has gravitational potential energy

gravitational potential energy = mass x gravitational field strength x height

$$E_p = mgh$$

(J) (kg) (N/kg)(m)



When an object falls, it loses gravitational potential energy and gains kinetic energy.

Stretching an object will give it elastic potential energy.

elastic potential energy = $\frac{1}{2}$ × spring constant × extension^2

$$E_e = \frac{1}{2}ke^2$$

(J) (N)(m)

Transferring Energy by Heating

Heating a material transfers the energy to its thermal energy store - the temperature increases.

E.g. a kettle: energy is transferred to the thermal energy store of the kettle. Energy is then transferred by heating to the waters thermal energy store. The temperature of the water will then increase.

Some materials need more energy to increase their temperature than others.

change in thermal energy = mass × specific heat capacity × temperature change

$$\Delta E = m \times c \times \Delta\theta$$

(J) (kg) (J/kg°C) (°C)

Specific heat capacity is the amount of energy needed to raise the temperature of 1kg of a material by 1°C.

Energy Stores and Systems

Energy Stores	
kinetic	Moving objects have kinetic energy.
thermal	All objects have thermal energy.
chemical	Anything that can release energy during a chemical reaction.
elastic potential	Things that are stretched.
gravitational potential	Anything that is raised.
electrostatic	Charges that attract or repel.
magnetic	Magnets that attract or repel.
nuclear	The nucleus of an atom releases energy.

Energy can be transferred in the following ways:

mechanically – when work is done;

electrically – when moving charge does work;

heating – when energy is transferred from a hotter object to a colder object.

Conservation of Energy

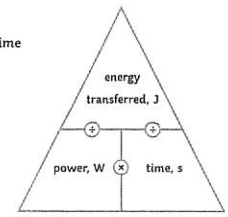
Energy can never be created or destroyed, just transferred from one form to another. Some energy is transferred usefully and some energy gets transferred into the environment. This is mostly wasted energy.

Power

Power is the rate of transfer of energy – the amount of work done in a given time.

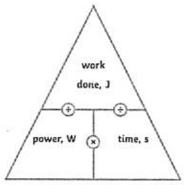
power = energy transferred ÷ time

P (W) = E (J) ÷ t (s)



power = work done ÷ time

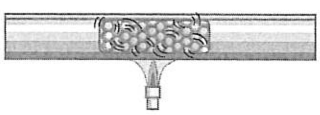
P (W) = W (J) ÷ t (s)



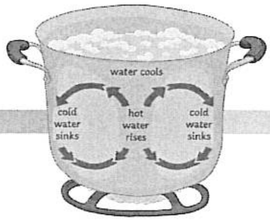
Energy Transfer

Lubrication reduces the amount of friction. When an object moves, there are frictional forces acting. Some energy is lost into the environment. Lubricants, such as oil, can be used to reduce the friction between the surfaces.

Conduction – when a solid is heated, the particles vibrate and collide more, and the energy is transferred.

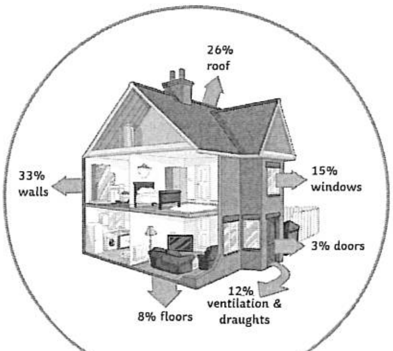


Convection – when a liquid or a gas is heated, the particles move faster. This means the liquid or gas becomes less dense. The denser region will rise above the cooler region. This is a convection current.



Insulation – reduces the amount of heat lost. In your home, you can prevent heat loss in a number of ways:

- thick walls;
- thermal insulation, such as:
- loft insulation (reducing convection);
- cavity walls (reduces conduction and convection);
- double glazing (reduces conduction).

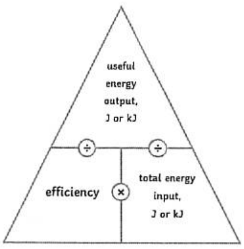


Efficiency

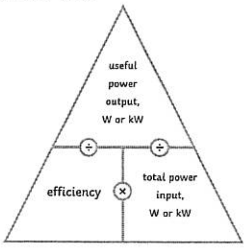
When energy is transferred, some energy is wasted. The less energy that is wasted during the transfer, the more efficient the transfer.

There are two equations to calculate efficiency:

$$\text{efficiency} = \frac{\text{useful output energy transfer}}{\text{total input energy transfer}}$$



$$\text{efficiency} = \frac{\text{useful power output}}{\text{total power input}}$$



Some energy is always wasted. Nothing is 100% efficient.

Efficiency

Non-renewable – coal, oil, gas - they will all run out, they damage the environment, but provide most of the energy.

Renewable – they will never run out, can be unreliable and do not provide as much energy.

Energy Resource	Advantages	Disadvantages
solar – using sunlight	Renewable, no pollution, in sunny countries it is very reliable.	Lots of energy needed to build, only works during the day, cannot increase power if needed.
geothermal – using the energy of hot rocks	Renewable and reliable as the rocks are always hot. Power stations have a small impact on environment.	May release some greenhouse gases and only found in specific places.
wind – using turbines	Renewable, no pollution, no lasting damage to the environment, minimal running cost.	Not as reliable, do not work when there is no wind, cannot increase supply if needed.
hydroelectric – uses a dam	Renewable, no pollution, can increase supply if needed.	A big impact on the environment. Animals and plants may lose their habitats.
wave power – wave powered turbines	Renewable, no pollution.	Disturbs the seabed and habitats of animals. Unreliable.
tidal barrages – big dams across rivers	Renewable, very reliable, no pollution.	Changes the habitats of wildlife, fish can be killed in the turbines.
biofuels	Renewable, reliable, carbon neutral.	High costs, growing biofuels may cause a problem with regards to space, clearance of natural forests.
non-renewable – fossil fuels	Reliable, enough to meet current demand, can produce more energy when there is more demand.	Running out, release CO_2, leading to global warming, and also release SO_2 which causes acid rain.

Trends in energy resources – most of our electricity is generated by burning fossil fuels and nuclear. The UK is trying to increase the amount of renewable energy resources. The governments are aware that non-renewable energy resources are running out; targets of renewable resources have been set. Electric and hybrid cars are also now on the market.

However, changing the fuels we use and building renewable power plants cost money. Many people are against the building of the plants near them and do not want to pay the extra in their energy bills. Hybrid and electric cars are also quite expensive.

AQA Combined Science: **Physics Topic 5 Forces**

Scalar and Vector Quantities

A scalar quantity has **magnitude** only. Examples include temperature or mass.

A vector quantity has both **magnitude** and **direction**. Examples include velocity.

Speed is the scalar magnitude of **velocity**.

A vector quantity can be shown using an **arrow**. The size of the arrow is relative to the magnitude of the quantity and the direction shows the associated direction.

Contact and Non-Contact Forces

Forces either **push** or **pull** on an object. This is as a result of its interaction with another object.

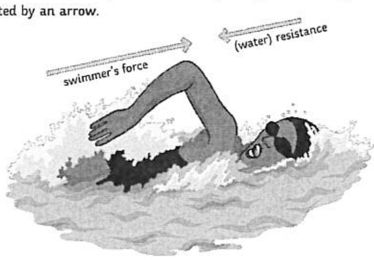
Forces are categorised into two groups:

Contact forces – the objects are touching e.g. friction, air resistance, tension and contact force.

Non-contact forces – the objects are not touching e.g. gravitational, electrostatic and magnetic forces.

Forces are calculated by the equation: **force (N) = mass (kg) × acceleration (m/s²)**

Forces are another example of a **vector quantity** and so they can also be represented by an **arrow**.



Gravity

Gravity is the natural phenomenon by which any object with mass or energy is drawn together.

- The **mass** of an object is a **scalar** measure of how much matter the object is made up of. Mass is measured in **kilograms (kg)**.
- The **weight** of an object is a **vector** measure of how gravity is acting on the mass. Weight is measured in **newtons (N)**.

weight (N) = mass (kg) × gravitational field strength (N/kg)

(The gravitational field strength will be given for any calculations. On earth, it is approximately 9.8N/kg).

An object's **centre of mass** is the point at which the weight of the object is considered to be acting. It does not necessarily occur at the centre of the object.

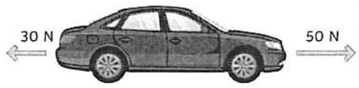
The mass of an object and its weight are **directly proportional**. As the mass is increased, so is the weight. Weight is measured using a **spring-balance (or newton metre)** and is measured in **newtons (N)**.

Resultant Forces

A **resultant force** is a single force which replaces several other forces. It has the same effect acting on the object as the combination of the other forces it has replaced.

The forces acting on this object are represented in a **free body diagram**.
The arrows are relative to the magnitude and direction of the force.

The car is being pushed to the left by a force of 30N. It is also being pushed to the right by a force of 50N.



The resultant force is 50N – 30N = 20N

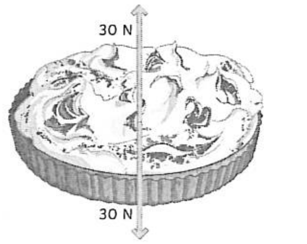
The 20N resultant force is pushing to the right, **so the car will move right**.

When a resultant force is not zero, an object will **change speed (accelerate or decelerate)** or **change direction (or both)**.

When an object is stationary, there are still forces acting upon it.

In this case, **the resultant force is 30N – 30N = 0N**.

The forces are in **equilibrium** and are **balanced**.



When forces are balanced, an object will either **remain stationary** or if it is moving, it will **continue to move at a constant speed**.

When resultant forces act along the same line, you calculate the resultant force as shown below.

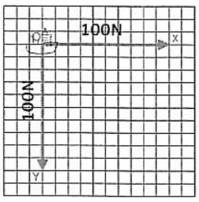
AQA GCSE Physics (Separate Science) Unit 5: Forces

Resultant Forces

A **vector diagram** can be used to determine the resultant of two forces that are not acting in a straight line.

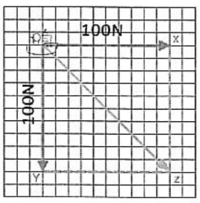
Worked example 1:

A boat is being pulled toward the harbour by two winch motors. Each motor is pulling with a force of 100N and they are working at right angles to each other. These forces are represented by lines OX and OY.



Construction lines can be added to the diagram to form rectangle OXZY. The line OZ is the diagonal of this rectangle.

OZ is the resultant force. It is the hypotenuse of the right-angle triangles OYZ and OXZ.



We can use the Pythagoras' theorem to calculate its length.

$$a^2 + b^2 = c^2$$

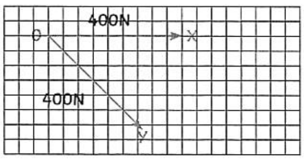
$100^2 + 100^2 = OZ^2$
$100^2 + 100^2 = 20\,000$
$\sqrt{20\,000} = 141.42$

The resultant force is 141.42N.

Alternatively, you can measure line OX and work out how many newtons are represented by each cm. Then measure the length of OZ and use your scale to calculate how many newtons the length represents.

Worked example 2:

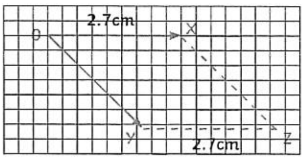
A horse drawn carriage is pulled by two horses with a force of 400N each. The horses are pulling in different directions and are not acting at an angle of 90°. OX and OY represent the force from each horse respectively, they represent the same magnitude of force so they will be the same length.



To calculate the resultant force in this situation we must use a **parallelogram of forces**.

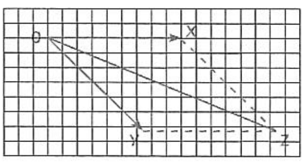
First, measure the length of OX. In this example it is 2.7cm.

Draw a line 2.7cm long from Y, parallel to OX. Connect the end of this line to X to form a parallelogram.



The line OZ is the diagonal of this parallelogram. OZ is the resultant force.

The length of OX is 2.7cm and the force is 400N.



We can work out how many newtons are represented by each cm by doing the calculation:
400 ÷ 2.7 = 148.15
1cm = 148.15N

Measure OZ. In this example it is 5cm.
5 × 148.15 = 740.74
The resultant force is 740.74N.

Work Done and Energy Transfer

When an object is moved by a force, the force transfers energy to the object. The amount of energy transferred to the object is the work done.

The work done on an object depends on the size of the force and the distance moved. It can be calculated using the equation:

work done = force × distance
W = F s

One joule of work is done when a force of one newton causes a displacement of one metre.

1 joule = 1 newton metre

Worked example

A man's car has broken down and he is pushing it to the side of the road. He pushes the car with a force of 160N and the car is moved a total of 8m.

Calculate the work done.

work done = force × distance
= 160 × 8
= 1280J

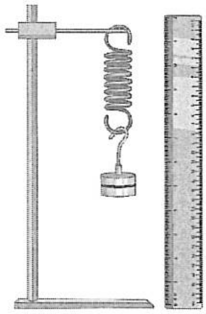
Not all of the energy transferred when work is done on an object is useful. For example, work done against the frictional forces of an object causes a rise in temperature of the object.

Required Practical Investigation Activity 6: Investigate the Relationship Between Force and Extension for a Spring

F = k × e

force applied (N) = spring constant (N/m) × extension (m)

You should be familiar with the equation above and the required practical shown to the right.

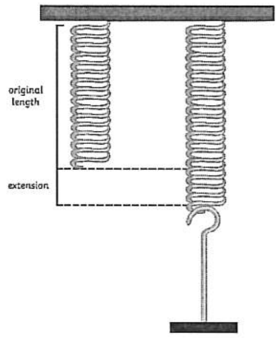


The spring constant is a value which describes the elasticity of a material. It is specific to each material. You can carry out a practical investigation and use your results to find the spring constant of a material.

1. Set up the equipment as shown.
2. Measure the original length of the elastic object, e.g. a spring, and record this.
3. Attach a mass hanger (remember the hanger itself has a weight). Record the new length of the spring.
4. Continue to add masses to the hanger in regular intervals and record the length each time.

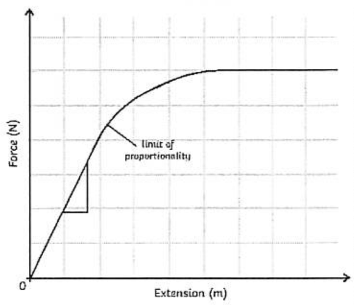
Once you have your results, you can find the extension for each mass using this formula: **spring length – original length**

The data collected is continuous so you would plot a line graph using the x-axis for extension (m) and the y-axis for force (N). As a result of Hooke's Law, you should have a linear graph. **The gradient of the graph is equal to the spring constant.** You can calculate it by rearranging the formula above or by calculating the gradient from your graph.



Spring Constant and Hooke's Law

Hooke's Law describes that the extension of an elastic object is proportional to the force applied to the object. However, there is a maximum applied force for which the extension will still increase proportionally. If **the limit of proportionality** is exceeded, then the object becomes **permanently deformed** and can no longer return to its original shape. This can be identified on a graph of extension against force when the gradient stops being linear (a straight line) and begins to plateau. The limit is shown on the graph above and this is the specific object's **elastic limit.**



Forces and Elasticity

When work is done on an elastic object, such as a spring, the energy is stored as elastic potential energy.

When the force is applied, the object changes shape and stretches. The energy is stored as elastic potential and when the force is no longer applied, the object returns to its original shape. The stored elastic potential energy is transferred as kinetic energy and the object recoils and goes back to its original shape.

Work Done: Elastic Objects

Work is done on elastic objects to stretch or compress them.

To calculate the work done (elastic potential energy transferred), use this equation:

$E (J) = 0.5 \times k \times e^2$

(elastic potential energy = 0.5 × spring constant × extension^2)

You might need to use this equation also: F = k × e

Worked example:

A bungee jumper jumps from a bridge with a weight of 800N. The elastic cord is stretched by 25m. Calculate the work done.

Step 1: find the spring constant using F = k × e

Rearrange to k = F ÷ e

800 ÷ 25 = 32N/m

Step 2: use the value for k to find the elastic potential energy (work done) using $E (J) = 0.5 \times k \times e^2$

$0.5 \times 32 \times 25^2$

E = 10 000J

Velocity

Velocity is a vector quantity. It is the speed of an object in a given direction.

Circular Motion (Higher tier only)

Objects moving in a circular path don't go off in a straight line because of a **centripetal force** caused by another force acting on the object.

For example, a car driving around a corner has a centripetal force caused by friction acting between the surface of the road and the tyres. When the Earth orbits around the Sun, it is held in orbit by gravity which causes the centripetal force.

When an object is moving in a circular motion, its speed is constant. Its direction changes constantly and because direction is related to velocity, this means that the velocity of the object is constantly changing too. The changes in velocity mean that the object is **accelerating**, even though it travels at a constant speed.

The acceleration occurs because there is a **resultant force** acting on the object. In this case, the resultant force is the velocity, which is greater than the centripetal force acting.

Forces and Motion: Distance vs Displacement

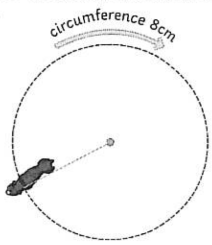
Distance is a scalar quantity. It measures how far something has moved and does not have any associated direction.

Displacement is a vector quantity. It measures how far something has moved and is measured in relation to the direction of a straight line between the starting and end points.

E.g. A dog is tethered to a post. It runs 360° around the post three times. Each 360° lap is 8m

distance = 8 × 3 = 24m

displacement = 0m (The dog is in the same position as when it started.)



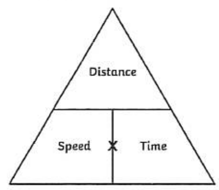
Speed

You should be able to recall the typical speed of different transportation methods.

Activity	Typical Value
walking	1.5m/s
running	3m/s
cycling	6m/s
driving a car	25mph (40km/h)
train travel	60mph (95km/h)
aeroplane travel	550mph (885km/h)
speed of sound	*330m/s*

These values are average only. The speed of a moving object is rarely constant and always fluctuating.

speed = distance ÷ time



You should be able to use this equation and rearrange it to find the distance or time.

Worked example:

John runs 5km. It takes him 25 minutes. Find his average speed in metres per second.

Step 1: convert the units

km → m (×1000) = 5000m

min → s (×60) = 1500s

Step 2: calculate s = d ÷ t

s = 5000 ÷ 1500

s = 3.33m/s

Worked example 2:

Zi Xin has driven along the motorway. Her average speed is 65mph. She has travelled 15 miles. How long has her journey taken? Give your answer in minutes.

Step 1: calculate t = d ÷ s

t = 15 ÷ 65

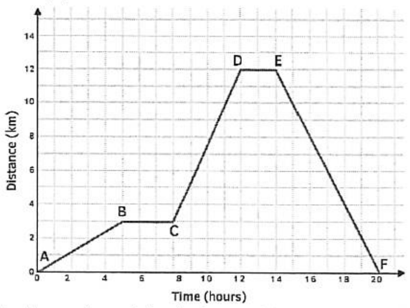
t = 0.23 (hours)

Step 2: convert units

hr → min (×60) = 13.8 minutes

Distance-Time and Velocity-Time Graphs

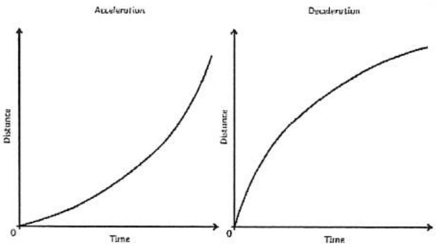
When an object travels in a straight line, we can show the distance which has been covered in a distance-time graph.



You should be able to understand what the features of the two types of graph can tell you about the motion of an object.

Graph Feature	Distance-Time Graph	Velocity-Time Graph
x-axis	time	time
y-axis	distance	velocity
gradient	speed	acceleration (or deceleration)
plateau	stationary (stopped)	constant speed
uphill straight line	steady speed moving away from start point	acceleration
downhill straight line	steady speed returning to the start point	deceleration
uphill curve	acceleration	increasing acceleration
downhill curve	deceleration	increasing deceleration
area below graph		distance travelled

Changing Speed on a D-T graph



When the graph is a **straight line**, it is representing a **constant speed**. A **curve** represents a changing speed, either **acceleration** or **deceleration**. The speed at any given point can be calculated by drawing a **tangent** from the curve and finding the **gradient** of the tangent.

Terminal Velocity

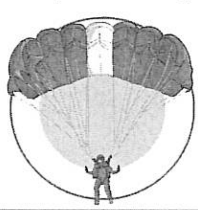
When an object begins moving, the force **accelerating** the object is much greater than the force resisting the movement. A resistant force might be air resistance or friction, for example.

As the **velocity** of the object increases, the force **resisting** the movement also increases. This causes the acceleration of the object to be reduced gradually until the forces become equal and are **balanced**. This doesn't cause the object to stop moving. As the object is already in motion, balanced forces mean it will continue to move at a steady speed. This steady speed is the maximum that the object can achieve and is called the **terminal velocity**.

The terminal velocity of an object depends on its shape and weight. The shape of the object determines the amount of resistant force which can act on it. For example, an object with a large surface area will have a greater amount of resistance acting on it.

Consider a skydiver and his parachute. When the skydiver first jumps from the aeroplane, he has a small area where the air resistance can act. He will fall until he reaches a terminal velocity of approximately 120mph.

After the skydiver releases his parachute, the shape and area has been changed and so the amount of air resistance acting is increased. This causes him to decelerate and his terminal velocity is reduced to about 15mph. This makes it a much safer speed to land on the ground.



Acceleration

Acceleration can be calculated using the equation:

acceleration (m/s²) = change in velocity (m/s) / time taken (s)

$$\text{acceleration } (m/s^2) = \frac{\text{change in velocity } (m/s)}{\text{time taken } (s)}$$

Worked example:

A dog is sitting, waiting for a stick to be thrown. After the stick is thrown, the dog is running at a speed of 4m/s. It has taken the dog 16s to reach this velocity. Calculate the acceleration of the dog.

$a = \Delta v \div t$

$a = (4-0) \div 16$

$A = 0.25 m/s^2$

Changes in **velocity** due to acceleration can be calculated using the equation below. This equation of motion can be applied to any moving object which is travelling in a **straight line** with a **uniform acceleration**.

Final velocity² (m/s) – initial velocity² (m/s) = 2 × acceleration (m/s²) × displacement (m)

or

$v^2 - u^2 = 2as$

Worked example:

A bus has an initial velocity of 2m/s and accelerates at $1.5 m/s^2$ over a distance of 50m. Calculate the final velocity of the bus.

Step 1: rearrange the equation: $v^2 - u^2 = 2as$

$v^2 = 2as + u^2$

Step 2: insert known values and solve

$v^2 = (2 \times 1.5 \times 50) + 2^2$

$v^2 = (150) + 4$

$v^2 = 154$

$v = \sqrt{154}$

$v = 12.41 m/s$

Braking Distance

The **braking distance** is the distance travelled by a vehicle once the brakes are applied and until it reaches a full stop.

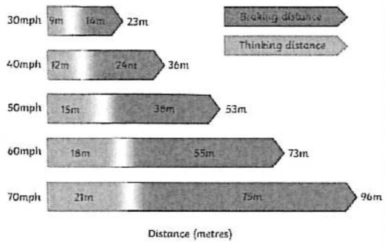
Braking distance is affected by:

- adverse weather conditions (wet or icy)
- poor vehicle condition (brakes or tyres)

When **force** is applied to the brakes, **work** is done by the **friction** between the car wheels and the brakes.

The work done reduces the kinetic energy and it is transferred as heat energy, increasing the temperature of the brakes.

increased speed = increased force required to stop the vehicle
increased braking force = increased deceleration



Large decelerations can cause a huge increase in **temperature** and may lead to the brakes **overheating** and the driver **losing control** over the vehicle

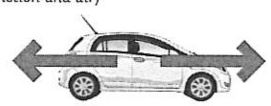
Newton's Laws of Motion: Newton's First Law

If the resultant force acting on an object is zero...

- **a stationary object will remain stationary.**
- **a moving object will continue at a steady speed and in the same direction.**

100N resistance (friction and air)

100N



Inertia – the tendency of an object to continue in a state of rest or uniform motion (same speed and direction).

Newton's Laws of Motion: Newton's Second Law

The acceleration of an object is proportional to the resultant force acting on it and inversely proportional to the mass of the object

resultant force (N) = mass (kg) × acceleration (m/s^2)

Inertial mass – how difficult it is to change an objects velocity. It is defined as the ratio of force over acceleration.

Newton's Laws of Motion: Newton's Third Law

When two objects interact, the forces acting on one another are always equal and opposite.

For example, when a book is laid on the table, it experiences a reaction force from the table. The table pushes up on the book. The book also pushes down on the table. These two forces are equal and opposite.

Stopping Distance

The stopping distance of a vehicle is calculated by:

stopping distance = thinking distance + braking distance

Reaction time is the time taken for the driver to respond to a hazard. It varies from 0.2s to 0.9s between most people.

Reaction time is affected by:

- **tiredness**
- **drugs**
- **alcohol**
- **distractions**

You can measure human reaction time in the lab using simple equipment: a metre ruler and stopwatch can be used to see how quickly a person reacts and catches the metre ruler. The data collected is quantitative and you should collect repeat readings and calculate an average result.

Momentum

momentum (N) = mass (kg) × velocity (m/s)

The law of conservation of mass (in a closed system) states that the total momentum before an event is equal to the total momentum after an event.

Worked example:

Calculate the momentum of a 85kg cyclist travelling at 7m/s.

p = m × v

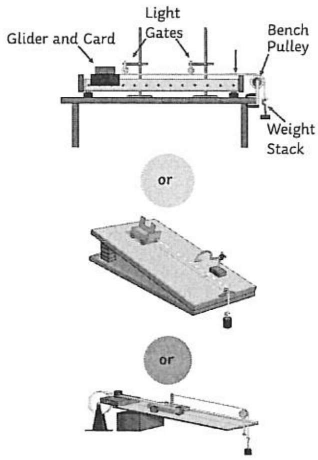
p = 85kg × 7m/s

p = 595kg m/s

Required Practical Investigation 7

Aim: investigate the effect of varying the force on the acceleration of an object of constant mass, and the effect of varying the mass of an object on the acceleration produced by a constant force.

You may be given any of the following apparatus set-ups to conduct these investigations:



Something is a **fair test** when only the independent variable has been allowed to affect the dependent variable.

The independent variable was **force**.

The dependent variable was **acceleration**.

The control variables were:

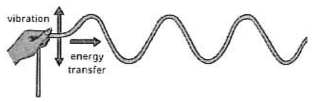
- **same total mass**
- **same surface/glider/string/pulley (friction)**
- **same gradient if you used a ramp**

AQA GCSE Combined Science Waves **Knowledge Organiser**

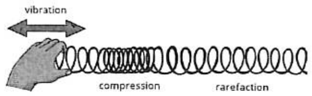
Transverse and Longitudinal Waves

Waves can be either **transverse** or **longitudinal**.

In a **transverse** wave, the vibrations of the particles are **perpendicular** (at right angles) to the direction of energy transfer. The wave has **peaks** (or crests) and **troughs**. Examples of transverse waves include **water waves** and **electromagnetic waves**.

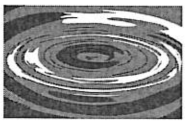


In a **longitudinal** wave, the vibrations of the particles are **parallel** to (in the same direction as) the direction of energy transfer. A longitudinal wave has areas of **compression** and **rarefaction**. **Sound waves** travelling through air are an example of this type of wave.



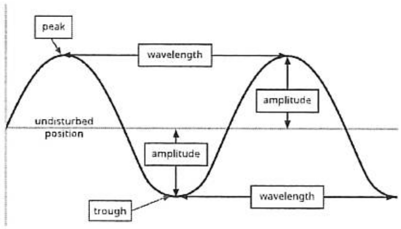
When a wave travels through a medium, energy is transferred by the particles but the matter itself does not move.

This can be shown by placing a cork in a tank of water and generating ripples across the surface. The cork will move up and down on the oscillations of the wave, but it will not travel across the tank.



Similarly, when sound waves move from a speaker towards the ear, the air particles next to the speaker do not move towards the ear; they vibrate around their original position.

Wave Properties



The **amplitude** of a wave is the distance from the undisturbed position to the peak or trough of the wave.

The **wavelength** is the distance from a point on one wave to the same point on the next wave, measured in **metres** (m).

The **frequency** of a wave is the number of waves that pass a given point every second, measured in **hertz** (Hz).

The **period** of a wave is the time taken for a full wave to pass a given point, measured in **seconds** (s).

$$\textbf{period} = \frac{1}{\textbf{frequency}} \text{ or } T = \frac{1}{f}$$

Wave speed is how quickly energy is transferred through a medium (or how quickly the wave travels), measured in **metres per second** (m/s).

wave speed = frequency × wavelength or $v = f\lambda$

The speed of a **sound wave** travelling through the air can be measured using a simple method. A person stands a measured distance from a large flat wall, e.g. 100m. The person then claps their hands and the time taken to hear the echo is measured. The speed of sound can be calculated using the equation:

$$\textbf{speed} = \frac{\textbf{distance}}{\textbf{time}}$$

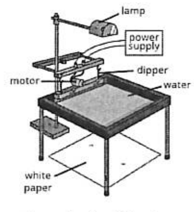
Remember, the distance that the sound wave has travelled will be double the distance between the person and the wall because the wave has travelled to the wall and back again. It is important to take several measurements and calculate the mean to reduce the effect of human error in your measurements.

Required Practical: Observing Waves

Make observations to identify the suitability of apparatus to measure the frequency, wavelength and speed of waves.

Waves in a Ripple Tank

The diagram shows the apparatus most commonly used for this investigation.



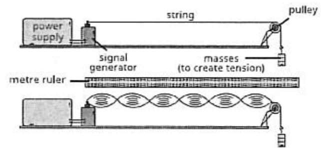
Method:

1. Set up the apparatus as shown in the diagram.
2. Turn on the power supply and observe the waves produced in the water. Make any necessary adjustments to the equipment, for example altering the potential difference of the power supply, so that the waves are clear to observe. **The lower the frequency of the waves, the easier it will be for measurements to be made.**
3. To measure the **wavelength**, use a metre ruler to measure the length of 10 waves and divide this value by 10 to find one wavelength. Repeat this several times and calculate the mean wavelength. A **stroboscope** can be used to freeze the wave pattern to make it easier to measure the waves.
4. To measure the **frequency**, mark a point on the white paper and count the number of waves that pass this point in 10 seconds. Divide the number of waves by 10 to find the number of waves that pass per second. Repeat this several times and calculate the mean frequency.
5. To calculate **wave speed**, use the equation:

wave speed = frequency × wavelength

Waves in a Solid

Waves in a solid can be observed using the apparatus shown in the diagram.



When the signal generator is switched on, the string begins to vibrate.

The frequency of the signal generator, the length of the string or the tension in the string is adjusted until a clear wave pattern can be seen. The wave should not look like it is moving.

To find the **wavelength**, count the number of half wavelengths (single loops) in 1 metre, then divide the length by the number of half wavelengths and multiply by two.

The **frequency** of the wave is the frequency of the signal generator.

Wave speed can be calculated using the equation:

wave speed = frequency × wavelength

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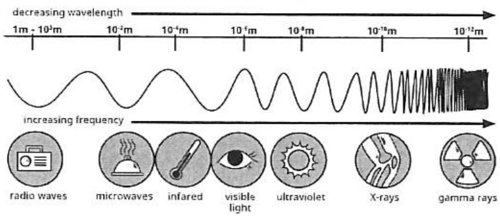
The Electromagnetic Spectrum

Electromagnetic waves are transverse waves. They transfer energy from a source to an absorber. All electromagnetic waves travel at the same speed through a vacuum or air. They are grouped by their wavelength and frequency to form a continuous spectrum.



Remember: **R**oman **M**en **I**nvented **V**ery **U**nusual **X**-ray **G**uns

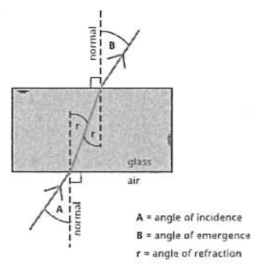
Properties of Electromagnetic Waves

When a wave moves into a medium with a different density (e.g. from air into glass), the wave changes direction. This is called **refraction**. This can be represented by a ray diagram.

When a wave enters the glass block at an angle to the normal, it bends towards the normal. The angle of refraction is smaller than the angle of incidence. The angle at which the wave leaves the glass block (angle of emergence) is equal to the angle at which it enters the glass block (angle of incidence).

If a wave enters a different medium at 90° (perpendicular) to the boundary, it will not change direction but instead carry on in a straight line.

(HT only) Refraction occurs due to the difference in density of the two materials. When a wave moves from a less dense medium to a more dense medium (e.g. from a gas to a solid), it slows down and bends towards the normal. When a wave moves from a more dense medium to a less dense medium (e.g. from a solid to a gas), it speeds up and bends away from the normal.



Electromagnetic Wave	Uses and Applications	Explanation (HT only)	Extra Information
radio waves	terrestrial television and radio communications	Radio waves can be transmitted over long distances by reflecting them off a layer of the Earth's atmosphere called the ionosphere.	**(HT Only)** Oscillations in electrical circuits can produce radio waves. **(HT Only)** An alternating current can be produced when radio waves are absorbed.
microwaves	satellite communication, satellite television, heating food	Microwaves can penetrate the Earth's atmosphere to communicate with satellites. When water molecules absorb microwaves, it causes their internal energy store, and therefore their temperature, to increase.	Microwaves are used in mobile phone communications as well as satellite television.
infrared	cooking, thermal imaging camera, electric heaters, short-range communications (remote controls)	Infrared waves cause heating as they are absorbed by matter. Infrared cameras can detect infrared radiation to produce thermal images.	Infrared radiation can cause burns to skin.
visible light	vision, fibre optic communication	In fibre-optic cables, pulses of visible light are used to send coded signals over large distances.	The human eye can only detect visible light waves.
ultraviolet	energy efficient lamps, sun tanning, detecting forged bank notes, sterilising water	Some chemicals absorb energy from ultraviolet waves and then emit this energy as visible light. This is known as fluorescence.	Absorption of ultraviolet waves by the skin can increase the risk of skin cancer and lead to premature ageing of the skin.
X-rays	medical imaging, airport security	X-rays can penetrate soft tissue, such as muscles and skin, but are absorbed by hard structures like bones.	X-ray absorption by human tissues can lead to gene mutation and cancer.
gamma rays	sterilising medical equipment, sterilising food, radiotherapy for cancer treatment	Gamma rays are highly penetrating and can easily pass through body tissues. The ionising ability of gamma rays means that they can damage cancerous cells (as well as healthy ones).	Gamma rays are produced by changes in the nucleus of an atom. Gamma ray absorption by human tissues can lead to gene mutation and cancer.

Hazards and Risks of Electromagnetic Waves

Ultraviolet waves, X-rays and gamma rays have some risks associated with them.

How dangerous electromagnetic radiation is depends on the type of wave and the dosage.

Radiation dosage is measured in sieverts (Sv) or millisieverts (mSv).

Safe limits of exposure of each type of radiation are known and can be referred to when assessing the risk of using electromagnetic radiation.

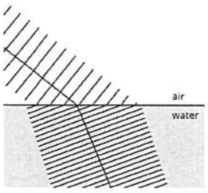
AQA GCSE Combined Science Waves **Knowledge Organiser**

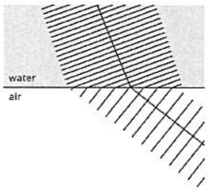
Properties of Electromagnetic Waves

(HT Only) Different substances absorb, reflect, refract or transmit electromagnetic waves in different ways. This may change depending on the wavelength of the electromagnetic wave.

A wave front diagram shows that as a wave moves from a less dense to a more dense medium (e.g. from air into water), at an angle to the normal, it slows down and its wavelength decreases. One side of the wave reaches the more dense medium first, causing the wave to change direction. Although the wavelength decreases, the frequency of the wave remains the same due to its change in speed.

When a wave moves from a more dense medium into a less dense medium, the reverse happens. The wave speeds up and its wavelength increases. The frequency of the wave remains the same.



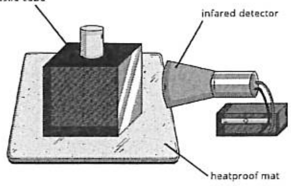


Required Practical: Radiation and Absorption

Investigate how the nature of a surface affects the amount of infrared radiation absorbed or radiated by that surface.

In this investigation, you are finding out which type of surface emits the most **infrared** radiation:

- **dark and matt**
- **dark and shiny**
- **light and matt**
- **light and shiny**



Method:

1. Place the **Leslie cube** on a heatproof mat.
2. Boil some water in a kettle, fill the Leslie cube with hot water and put the lid on.
3. Use a thermometer or an **infrared detector** to measure the amount of infrared radiation emitted from one of the surfaces of the Leslie cube.
4. Repeat the experiment for each surface of the Leslie cube, ensuring that the infrared detector is an equal distance from each surface.

You should find that a dark, matt surface emits much more infrared radiation than a light, shiny surface.

AQA Combined Science: **Physics Topic 7 Magnetism and Electromagnetism**

Poles of a Magnet

A magnet has two ends called **poles**: the **north pole** and the **south pole**. The magnetic forces of the magnet are strongest at the poles.

When two magnets are brought close together, they will **attract or repel**, depending on which poles are brought together:

- **Like poles** will **repel** one another e.g. N-N or S-S.
- **Opposite poles** will **attract** e.g. N-S.

The forces exerted between the poles of two magnets are a type of **non-contact force**: the magnets do not have to be touching for the effect to be observed.

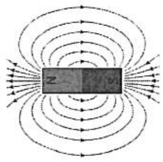
Remember that only **iron, cobalt and nickel** (or alloys containing these metals) are magnetic.

A **permanent magnet** is one with its own magnetic field. The magnetism cannot be turned on or off e.g. a bar magnet or a horseshoe magnet.

An **induced magnet** is a material which becomes magnetic only when placed within a magnetic field. Induced magnets only attract other materials and lose most (if not all) of their magnetism when removed from the magnetic field e.g. iron filings.

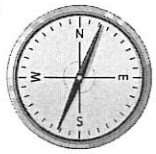
Magnetic Fields

The **magnetic field** is the area surrounding a magnet where the force is acting on another magnet or magnetic material. It can be observed using a compass placed at different points around a bar magnet. The field lines can be drawn by using the compass to mark the direction at a range of points.



A magnet always causes a magnetic material to be **attracted**. The strength of the magnetic field is determined by the proximity to the magnet.

When looking at a diagram of magnetic field lines, the force is strongest where the lines are closest together. The magnetic field of the magnet is strongest at the poles. The direction of the magnetic field shows the direction the force would act on another north pole. As a result, magnetic field lines always come away from the north pole (like poles repel) and towards the south pole (unlike poles attract).



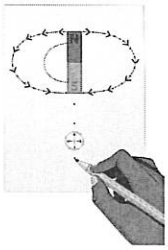
The earth produces a magnetic field and a magnetic compass uses this to help aid navigation. The core of the earth is made of iron (a magnetic material). A compass contains a small bar magnet shaped as a needle, which points in the direction of the earth's magnetic field.

Plotting Magnetic Field Lines

A magnetic compass can be used to plot and draw the magnetic field lines around a magnet.

You should be able to describe this method for a bar magnet.

1. Place the bar magnet in the centre of a sheet of plain paper.
2. Using a magnetic compass, position it on the paper somewhere around the magnet.
3. Observe the direction of the needle and carefully draw a dot at the circumference of the magnet, in line with each end of the needle. Make sure you include an arrow to indicate the direction of north.
4. Repeat steps 2 and 3 for several positions around the magnet.
5. Join the arrows to complete the magnetic field lines and whole pattern.



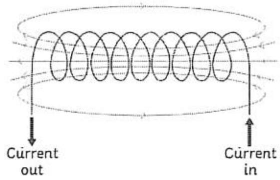
Electromagnetism

A circular **magnetic field** is produced when a current is passed through a conducting wire. This produces an **induced magnet**.

Switching off the current causes the magnetism to be lost.

The strength of the magnetic field can be increased by increasing the current flowing through the wire. The strength of the magnetic field is stronger closer to the wire.

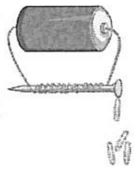
Coiling the wire to form a **solenoid** will also increase the strength of the magnetic field. The strength of the magnetic field created by a solenoid is strong and uniform throughout.



To increase the strength of the magnetic field around a solenoid you can...

- add an iron core;
- increase the number of turns in the coil;
- increase the current passing through the wire.

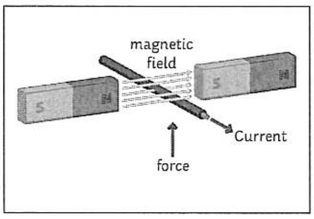
An **electromagnet** is a solenoid with an iron core. Electromagnets are **induced magnets** and can be turned on and off.



Electric motors, loudspeakers, electric bells and remotely controlled door locks all use **electromagnets**.

The Motor Effect and Flemings Left-Hand Rule

When a wire carrying a current is exposed to the magnetic field of another magnet, then a **force** is produced on the wire at a **right angle** to the direction of the magnetic field produced.



This is called the **motor effect.**

The force produced by the motor effect can be calculated using this equation:

force (N) = magnetic flux density (T) × current (A) × length (m)

For example:
A current of 8A is flowing through a wire that is 75cm long. The magnetic field acting at a right angle on the wire is 0.5T. Calculate the force.

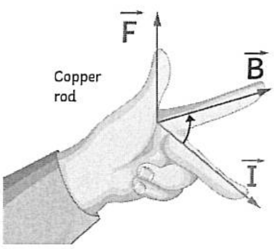
$F = B \times I \times l$

Remember: the equation uses length measured in m. The question gives you the length in cm so you need to convert it before you calculate your answer.

$F = 0.5 \times 8 \times 0.75$

$F = 3N$

From the equation we can see that the force acting on a given length of wire (e.g. 1m) will be increased if the current increases or the magnetic flux density increases. If the current flowing through a wire is **parallel** to the magnetic field, then **no force** is produced – there is no motor effect.



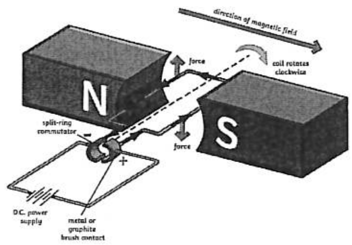
You might be shown a diagram and asked to indicate the direction of the force produced. **Fleming's left-hand rule** can help you do this because it represents the **relative orientation** of the force produced by the motor effect.

Remember:

- Use your **left hand!**
- The angle between your index finger and middle finger should be a **right angle** on the horizontal plane.
- The angle between your index finger and thumb should be a **right angle** on the vertical plane.
- Your **thumb** represents the direction of the **force**.
- Your **index finger** represents the direction of the **magnetic field.**
- Your **middle finger** represents the direction of the **current** flowing through the wire.

Electric Motors

When the wire carrying the current is **coiled**, the motor effect acting on it causes the wire to **rotate**. This is how an **electric motor** works.



As the **current** flows (from negative to positive), the force produced in each side of the coil acts in **opposite directions**, causing the coil to **rotate** overall.

When the coil reaches a **vertical position**, the force produced is now **parallel** to the magnetic field line and so would be **zero**. This would cause the motor to stop rotating.

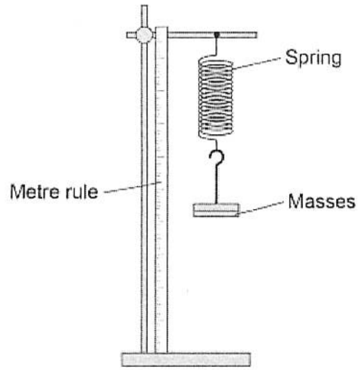
To maintain the rotation of the coiled wire, a **split ring commutator** is used to supply the current to the wire. The DC supply reaches the split ring via graphite or metal **brushes** which maintain the connection while allowing it to rotate freely on the **axle**.

The two halves of the split ring commutator ensure that the **current supplied** to the wire **changes direction** each half-turn (or that the current supplied is the same direction on each side of the motor) and as a result, the force produced maintains a **constant rotation** in one direction overall.

Q1.

The figure below shows a stretched spring.

The spring is elastically deformed.



(a) What is meant by 'elastically deformed'?

Tick (✓) **one** box.

As the force on the spring increases the length of the spring increases.	☐
Only a very small force is needed to stretch the spring.	☐
The force on the spring causes it to change shape.	☐
The spring will return to its original length when the force is removed.	☐

(1)

(b) Describe a method to determine the extension of the spring.

____

____

____

____

(2)

(c) The extension of the spring is 80 mm.

spring constant = 40 N/m

Calculate the elastic potential energy of the spring.

Use the Physics Equations Sheet.

____

____

____

____

____

Elastic potential energy = ____________ J

(3)

(d) Write down the equation which links extension (*e*), force (*F*) and spring constant (*k*).

____

(1)

(e) A force of 300 N acts on a different spring.

The force causes the spring to extend by 0.40 m.

Calculate the spring constant of the spring.

____

____

____

____

____

Spring constant = ____________ N/m

(3)

(Total 10 marks)

Q2.

Professional rugby players wear a tracking device that measures their velocity and acceleration.

Figure 1 shows a player wearing a tracking device.

The player is tackling another player who is running with the ball.

Figure 1

(a) Velocity and acceleration are both vector quantities.

What is a vector quantity?

Tick (✓) **one** box.

A quantity with both magnitude and direction	☐
A quantity with direction only	☐
A quantity with magnitude only	☐

(1)

(b) Which of the following is a vector quantity?

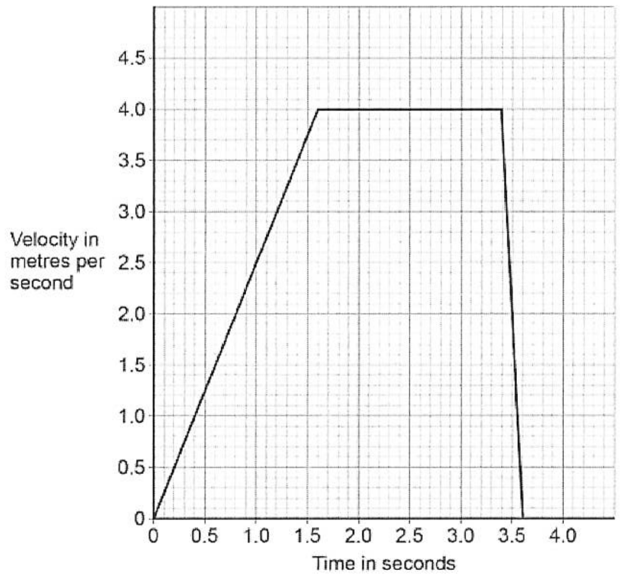
Tick (✓) **one** box.

Displacement	☐
Distance	☐
Time	☐
Work done	☐

(1)

Figure 2 shows a velocity–time graph for the player running with the ball.

Figure 2



(c) Determine the acceleration of the player between 0 and 1.6 s.

____

____

____

Acceleration = ______________ m/s^2

(2)

(d) Describe the motion of the player between 3.4 s and 3.6 s.

____

____

(1)

The force exerted on the player when she is tackled causes her to accelerate.

(e) Write down the equation which links acceleration (a), mass (m) and resultant force (F).

____

(1)

(f) The player accelerates at 25 m/s^2 when a resultant force of 1800 N acts on her.

Calculate the mass of the player.

Mass = ______________ kg

(3)

(g) The tracking device sends data to a computer during the game.

Suggest **one** advantage of the data being sent during the game.

(1)

(Total 10 marks)

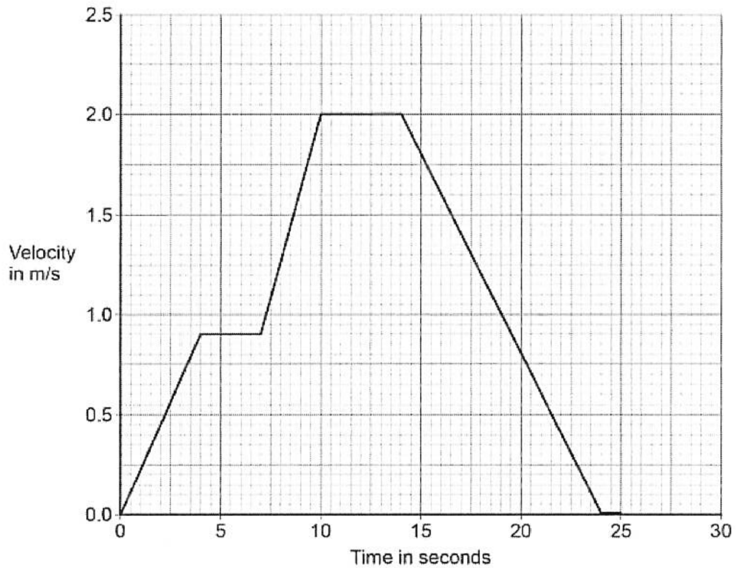
Q3.

Figure 1 shows a runner using a smart watch and a mobile phone to monitor her run.

Figure 1

Figure 2 is a velocity–time graph for part of the runner's warm-up.

Figure 2



(a) Determine the total time for which the velocity of the runner was increasing.

Time = ______________ s

(2)

(b) Determine the deceleration of the runner.

Deceleration = ______________ m/s²

(2)

The smart watch and mobile phone are connected to each other by a system called Bluetooth.

Bluetooth is wireless and uses electromagnetic waves for communication.

(c) Suggest why the phone and watch being connected by a wireless system is an advantage when running.

____ **(1)**

(d) Write down the equation that links frequency, wave speed and wavelength.

____ **(1)**

(e) The electromagnetic waves have a frequency of 2 400 000 000 Hz

The speed of electromagnetic waves is 300 000 000 m/s

Calculate the wavelength of the electromagnetic waves.

____

____

____

____

____

____

Wavelength = _______________ m

(3)

(f) The table shows some information about four types of Bluetooth.

Type	Power in milliwatts	Range in metres
1	100	100
2	2.50	10.0
3	1.00	1.00
4	0.50	0.50

Mobile phones use type **2** Bluetooth to communicate with other devices.

Suggest **two** reasons why.

1 ____

____

2 ____

____ **(2)**

(Total 11 marks)

Q4.

Figure 1 shows five different metal samples.

Figure 1

(a) A student placed a magnet close to each metal sample.

Describe what happened.

____

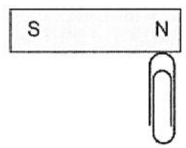
____

____

____ **(2)**

Figure 2 shows a paper clip being attracted to a permanent magnet.

Figure 2



(b) The paper clip in **Figure 2** is not a permanent magnet.

Explain what would happen if the paper clip was removed and brought close to the south pole of the permanent magnet.

____

____

____

____ **(2)**

(c) Write down the equation that links gravitational field strength (*g*), mass (*m*) and weight (*W*).

____ **(1)**

(d) The student added more paperclips to one end of the magnet.

The maximum number of paperclips the magnet could hold was 20

Each paper clip had a mass of 1.0 g

gravitational field strength = 9.8 N/kg

Calculate the maximum force the magnet can exert.

Force = ____________ N

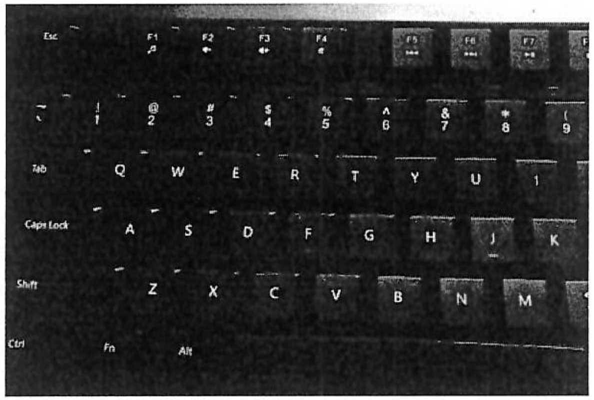
(3)

(Total 8 marks)

Q5.

The photograph below shows a computer keyboard.

There is a spring under each key.



(a) The springs behave elastically when a force is applied.

What is meant by elastic behaviour?

Tick (✓) **one** box.

The spring will be compressed when the force is applied to it.	☐
The spring will become deformed when the force is applied to it.	☐
The spring will become longer when the force is removed.	☐
The spring will return to its original length when the force is removed.	☐

(1)

(b) Suggest **two** properties that should be the same for each spring.

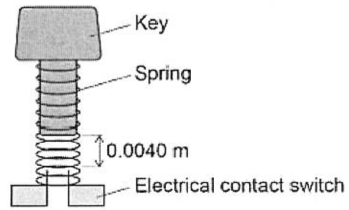
1. ____________

2. ____________

(2)

(c) **Figure 1** shows one of the keys and its spring.

Figure 1



The key must be pressed with a minimum force of 0.80 N before the key touches the switch.

Calculate the spring constant of the spring in **Figure 1**.

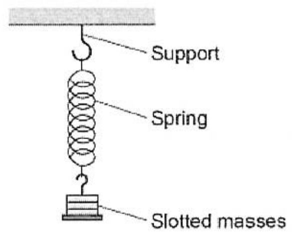
Spring constant = ____________ N/m

(3)

(d) **Figure 2** shows a spring that has been hung from a support.

The spring is stationary and has been stretched beyond its limit of proportionality.

Figure 2



Which **two** statements are true for the spring in **Figure 2**?

Tick (✓) **two** boxes.

The elastic potential energy of the spring is zero.	☐
The extension of the spring is directly proportional to the force applied.	☐
The upward force on the spring is equal to the downward force.	☐
The spring cannot be stretched any further.	☐
The spring is inelastically deformed.	☐

(2)
(Total 8 marks)

Q6.

Scientists are developing a hypersonic aeroplane that will travel much faster than normal aeroplanes.

(a) An aeroplane accelerates from a low speed to a high speed with the engines at maximum power.

Explain why the acceleration is **not** constant.

___

___

___

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(5)

(b) The hypersonic aeroplane will have jet engines and a rocket engine.

The speed of aeroplanes can be measured on a uniform scale called the Mach scale.

Mach 1 = 330 m/s

The jet engines will accelerate the aeroplane to Mach 5.5.

The rocket engine will accelerate the aeroplane from Mach 5.5 to Mach 25.5 in 300 s.

The average resultant force on the aeroplane when the rocket engine is used will be 630 000 N.

Calculate the mass of the hypersonic aeroplane.

Give your answer to 2 significant figures.

___

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Mass (2 significant figures) = ____________ kg

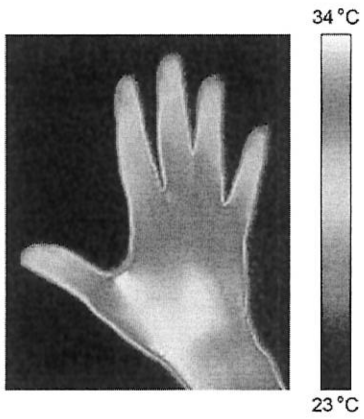
(6)
(Total 11 marks)

Q7.

Different parts of the electromagnetic spectrum are used in medical imaging.

Figure 1 shows an Figure of a person's hand taken with an infrared camera.

Figure 1



(a) Explain why the infrared camera is able to show that parts of the hand are at different temperatures.

____

____

____

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____

____

(2)

(b) Infrared has a range of wavelengths from 700 nm to 1 mm.

Which part of the electromagnetic spectrum would have waves with a wavelength of 6.5×10^{-7} m?

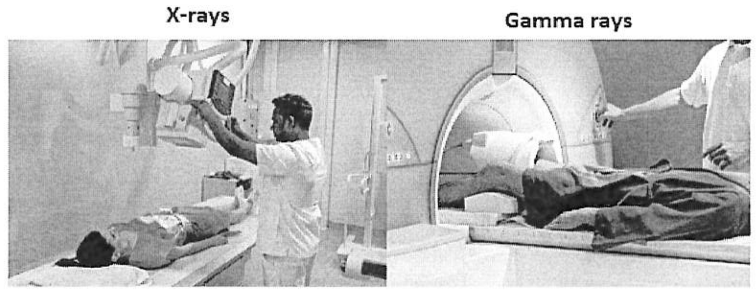
Tick (✓) **one** box.

- Infrared ☐
- Microwaves ☐
- Radio waves ☐
- Visible light ☐

(1)

(c) **Figure 2** shows X-rays and gamma rays being used for medical imaging.

Figure 2



To use X-rays for medical imaging, a machine produces a very brief burst of X-rays.

To use gamma rays for medical imaging, a radioactive isotope is injected into the patient's blood. The isotope is circulated around the body in the blood. The isotope emits gamma rays.

Compare the potential risks to a patient of using X-rays and gamma rays for medical imaging.

____

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(4)

X-rays are produced by colliding high-energy electrons into a metal target.

The electrons have high energy because they are accelerated to high speeds.

Only a small proportion of the kinetic energy of an electron is converted into an X-ray when it collides with the metal target.

(d) An electron is accelerated through a distance of 15 mm.

The work done on the electron is 1.2×10^{-13} J.

Calculate the force on the electron.

____

Force = ____________ N

(3)

(e) The metal target is made from tungsten.

Tungsten has the highest melting point of any metal.

Explain why using tungsten as the metal target enables the X-ray machine to be more powerful.

(3)

(Total 13 marks)

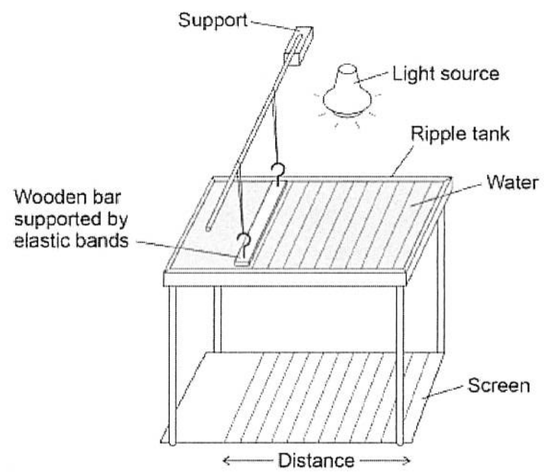
Q8.

Figure 1 below shows the equipment a teacher used to determine the speed of a water wave.

The equipment includes:

- a ripple tank filled with water
- a wooden bar that creates ripples on the surface of the water
- a light source which causes a shadow of the ripples on the screen.

Figure 1



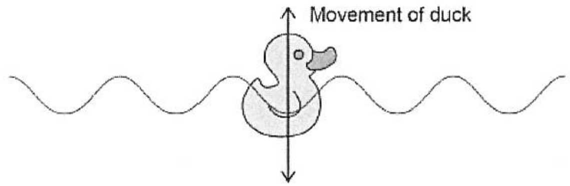
(a) Describe how equipment in **Figure 1** can be used to measure the wavelength, frequency and speed of a water wave.

(6)

The teacher put a plastic duck in the ripple tank as shown in **Figure 2**.

The plastic duck moved up and down as the waves in the water passed.

Figure 2



(b) How does the movement of the plastic duck in **Figure 2** demonstrate that water waves are transverse?

____

____

(1)

(c) The teacher measured the maximum height and the minimum height of the plastic duck above the screen as the wave passed.

The teacher repeated his measurements.

The table shows the teacher's measurements.

Maximum height in mm	509	513	511
Minimum height in mm	503	498	499

Calculate the mean amplitude of the water wave.

____

____

____

____

____

____

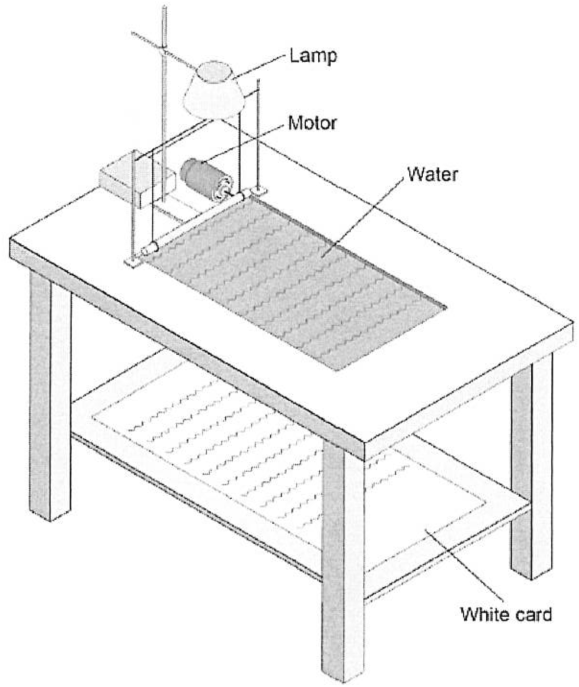
Mean amplitude = ____________ mm

(3)

(Total 10 marks)

Q9.

The diagram shows a ripple tank.



(a) The motor makes a noise when it is turned on.

Describe the differences between the properties of the sound waves produced by the motor and the water waves in the ripple tank.

____

____

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____

(4)

(b) The period of the sound waves produced by the motor is 8.3 milliseconds.

Calculate the frequency of the sound waves.

Use the Physics Equations Sheet.

Frequency = ____________ Hz

(3)

(c) Explain how a student could make appropriate measurements and use them to determine the wavelength of the waves in the ripple tank.

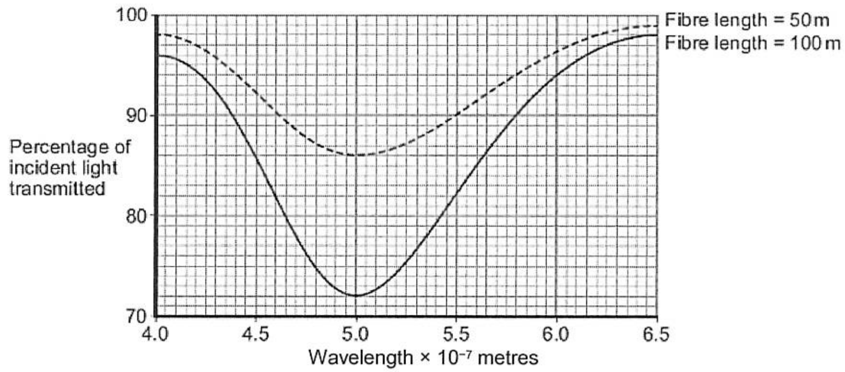
(6)

(Total 13 marks)

Q10.

Different wavelengths of light can be used to transmit information along optical fibres.

The graph below shows how the percentage of incident light transmitted through a fibre varies with the wavelength of light and the length of the fibre.



Compare the percentages of incident light transmitted through the two different fibres over the range of wavelengths shown.

(Total 3 marks)

Q11.

Different parts of the electromagnetic spectrum have different uses.

(a) The diagram shows the electromagnetic spectrum.

Radio waves	Microwaves	Infrared	Visible light	Ultraviolet	X-rays	Gamma rays

→

(i) Use the correct answers from the box to complete the sentence.

amplitude	frequency	speed	wavelength

The arrow in the diagram is in the direction of increasing ____________

and decreasing ____________ .

(2)

(ii) Draw a ring around the correct answer to complete the sentence.

The range of wavelengths for waves in the electromagnetic

spectrum is approximately [10^{-15} to 10^{4} / 10^{-4} to 10^{4} / 10^{4} to 10^{15}] metres.

(1)

(b) The wavelength of a radio wave is 1500 m.
The speed of radio waves is 3.0×10^{8} m / s.

Calculate the frequency of the radio wave.

Give the unit.

___

___

___

Frequency = ____________

(3)

(c) (i) State **one** hazard of exposure to infrared radiation.

___

(1)

(ii) State **one** hazard of exposure to ultraviolet radiation.

___

(1)

(d) X-rays are used in hospitals for computed tomography (CT) scans.

(i) State **one** other medical use for X-rays.

___

___

(1)

(ii) State a property of X-rays that makes them suitable for your answer in part **(d)(i)**.

___

___

(1)

(iii) The scientific unit of measurement used to measure the dose received from radiations, such as X-rays or background radiation, is the millisievert (mSv).

The table shows the X-ray dose resulting from CT scans of various parts of the body.

The table also shows the time it would take to get the same dose from background radiation.

Part of the body	X-ray dose in mSv	Time it would take to get the same dose from background radiation
Abdomen	9.0	3 years
Sinuses	0.5	2 months
Spine	4.0	16 months

A student suggests that the X-ray dose and the time it would take to get the same dose from background radiation are directly proportional.

Use calculations to test this suggestion and state your conclusion.

___

___

___

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___

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___

___

(3)

(Total 13 marks)

Q12.

A car aerial receives radio waves from a radio transmitter.

Radio waves are transverse waves.

Sound waves are longitudinal waves.

(a) Describe the difference between transverse waves and longitudinal waves.

___

___

___

___

(2)

(b) The radio waves have a frequency of 4.8×10^9 Hz

Wave speed of electromagnetic waves = 3.0×10^8 m/s

Calculate the wavelength of the radio waves.

Give your answer to 2 significant figures.

___

___

___

___

Wavelength = ___ m

(3)

(c) Describe how the radio waves reaching the car aerial produce signals in the electrical circuit of the car radio.

___

___

___

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___

___

___

___

(3)

(Total 8 marks)

Q13.

Many electrical appliances use the circular motion produced by their electric motor.

(a) Put ticks (✓) in the boxes next to **all** the appliances in the list which have an electric motor.

electric drill ☐

electric fan ☐

electric food mixer ☐

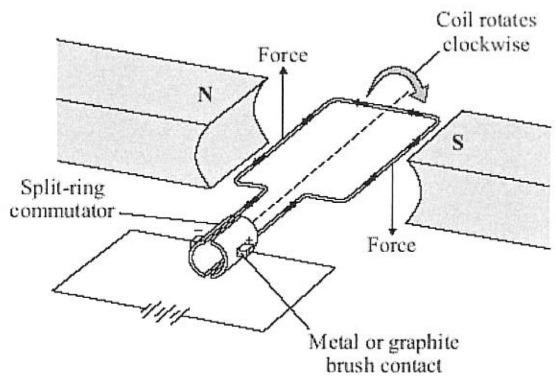
electric iron ☐

electric kettle ☐

electric screwdriver ☐

(2)

(b) One simple design of an electric motor is shown in the diagram. It has a coil which spins between the ends of a magnet.



(i) Give **two** ways of reversing the direction of the forces on the coil in the electric motor.

1. ___

___

2. ______________________________

______________________________ (2)

(ii) Give **two** ways of increasing the forces on the coil in the electric motor.

1. ______________________________

____

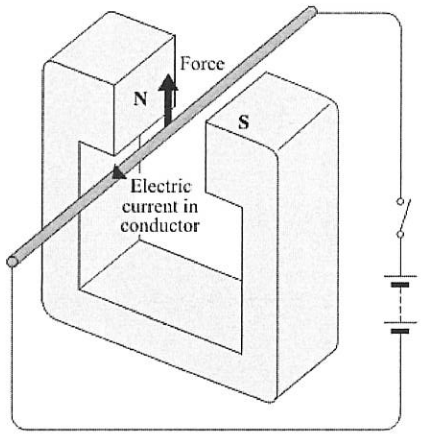
2. ______________________________

______________________________ (2)

(Total 6 marks)

Q14.

When a conductor carrying an electric current is placed in a magnetic field a force may act on it.



(a) State **two** ways in which this force can be increased.

1. ______________________________

2. ______________________________ (2)

(b) State **two** ways in which this force can be made to act in the opposite direction.

1. ______________________________

2. ______________________________ (2)

(c) In what circumstance will **no** force act on a conductor carrying an electric current

and in a magnetic field?

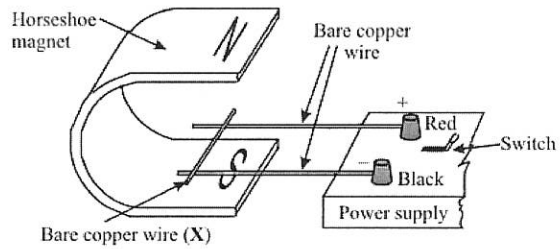
____

______________________________ (1)

(Total 5 marks)

Q15.

The diagram shows apparatus used to demonstrate the motor effect. **X** is a short length of bare copper wire resting on two other wires.



(a) (i) Describe what happens to wire **X** when the current is switched on.

____

____

____

(ii) What difference do you notice if the following changes are made?

A The magnetic field is reversed.

____

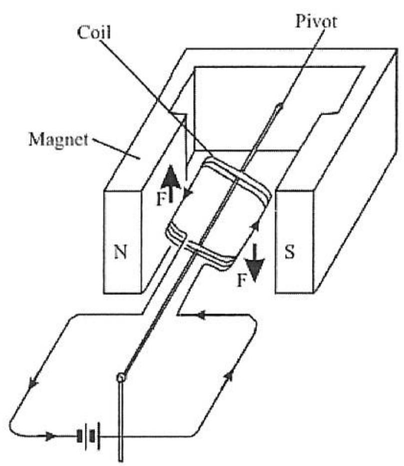
____

B The current is increased.

____

______________________________ (3)

(b) The diagram shows a coil placed between the poles of a magnet. The arrows on the sides of the coil itself show the direction of the conventional current.



The arrows labelled **F** show the direction of the forces acting on the sides of the coil. Describe the motion of the coil until it comes to rest.

____

____

____

____

____

(3)

(c) Most electric motors use electromagnets instead of permanent magnets. State three of the features of an electromagnet which control the strength of the magnetic field obtained.

1. ____

2. ____

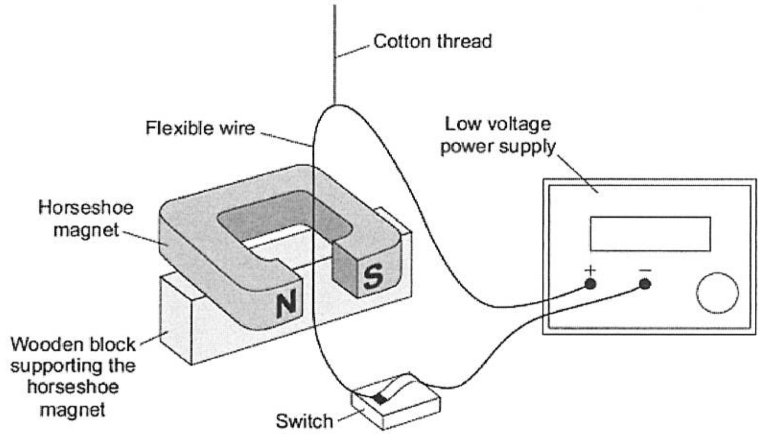
3. ____

(3)

(Total 9 marks)

Q16.

(a) A laboratory technician sets up a demonstration.



A flexible wire is suspended between the ends of a horseshoe magnet. The flexible wire hangs from a cotton thread. When the switch is closed, the wire kicks forward.

Identify the effect which is being demonstrated.

____

(1)

(b) A teacher makes some changes to the set-up of the demonstration.

What effect, if any, will each of the following changes have?

(i) more powerful horseshoe magnet is used.

____

____

(1)

(ii) The connections to the power supply are reversed.

____

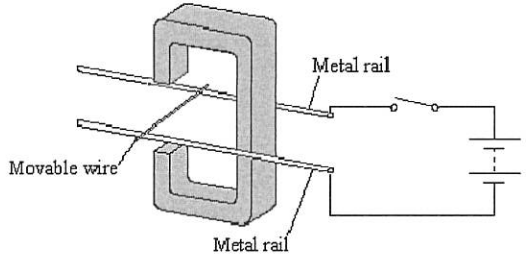
____

(1)

(Total 3 marks)

Q17.

The diagram shows apparatus used to demonstrate the electric motor effect. When he switch is closed the wire moves.



(i) Draw an arrow on the diagram to show the direction the wire moves.

(1)

(ii) Explain why the wire moves.

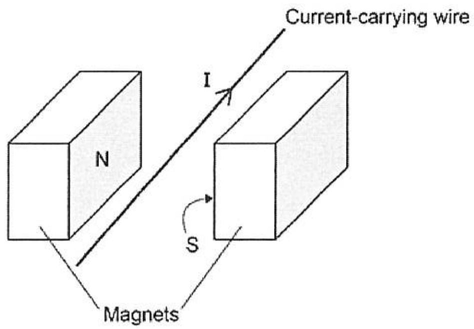
(2)
(Total 3 marks)

Q18.

A teacher demonstrated the motor effect.

Figure 1 shows the equipment used.

Figure 1



(a) Explain why there is a force on the wire when there is a current in the wire.

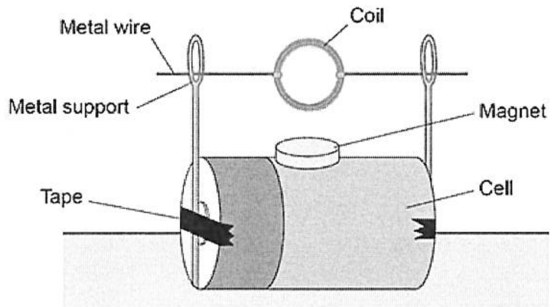
(2)

(b) Explain how the direction of the force on the wire can be predicted.

(3)

(c) **Figure 2** shows a simple electric motor.

Figure 2



Explain **one** way that the motor could be changed to increase the rate at which the coil rotates.

(2)
(Total 7 marks)