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EDEXCEL INTERNATIONAL GCSE PHYSICS: QUESTIONS BY TOPIC

Magnetism and Electromagnetism (6)

IGCSE Physics Topic 6

42 questions · 374 marks · Mark schemes included

Pearson Edexcel International GCSE (9-1) Physics 4PH1, Papers 1P/1PR & 2P/2PR, 2019-2025

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HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic and run from the lowest mark tariff to the highest within each one.

Click any row below to jump straight to that sub-topic or question.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

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QUESTIONS

42 questions · 374 marks · 4 sub-topics



SUB-TOPIC 6.1

MAGNETS AND MAGNETIC FIELDS

Sub-topic 6.1 · 10 questions · 75 marks · lowest tariff first



1 The passage describes some of the properties of magnets and magnetic fields.

Use words from the box to complete the passage.

aluminium	copper	hard	negative	
north	positive	soft	south	steel

Each word may be used once, more than once or not at all.

(5)

The north pole of one magnet will repel the pole of another magnet.

There is attraction between and magnets.

Materials that are difficult to magnetise are called magnetic materials.

The direction of the magnetic field lines for a magnet is from to south.

Iron is a magnetic material.

(Total for Question 1 = 5 marks)



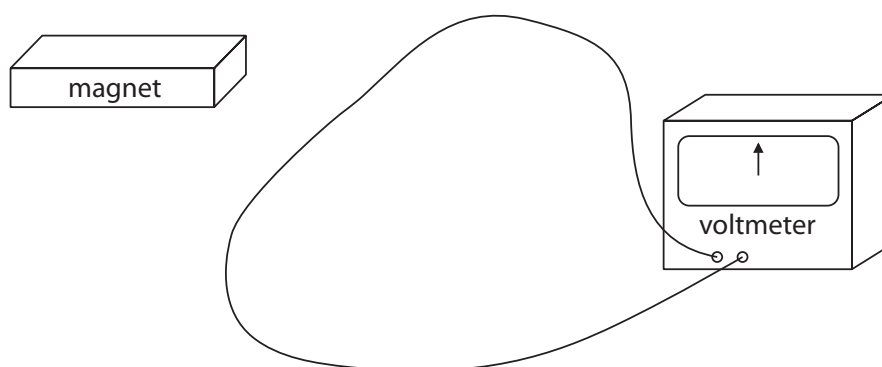
8 (a) The diagram shows a bar magnet.

Draw four magnetic field lines around the bar magnet.

(3)



(b) The diagram shows a loop of wire connected to the terminals of a voltmeter.



Explain why the voltmeter reading changes from zero when the magnet is moved near the loop of wire.

(2)

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(Total for Question 8 = 5 marks)

2 This question is about magnetic fields.

- (a) Describe an experiment to investigate the magnetic field pattern around a permanent bar magnet.

You may draw a diagram to help your answer.

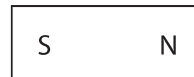
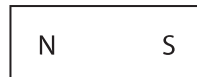
(3)



(b) The diagram shows two bar magnets.

Complete the diagram to show the magnetic field pattern.

(3)



(Total for Question 2 = 6 marks)



2 A student uses iron filings to investigate the magnetic field pattern around a bar magnet.

(a) Name the apparatus that the student could use to find the direction of the field lines.

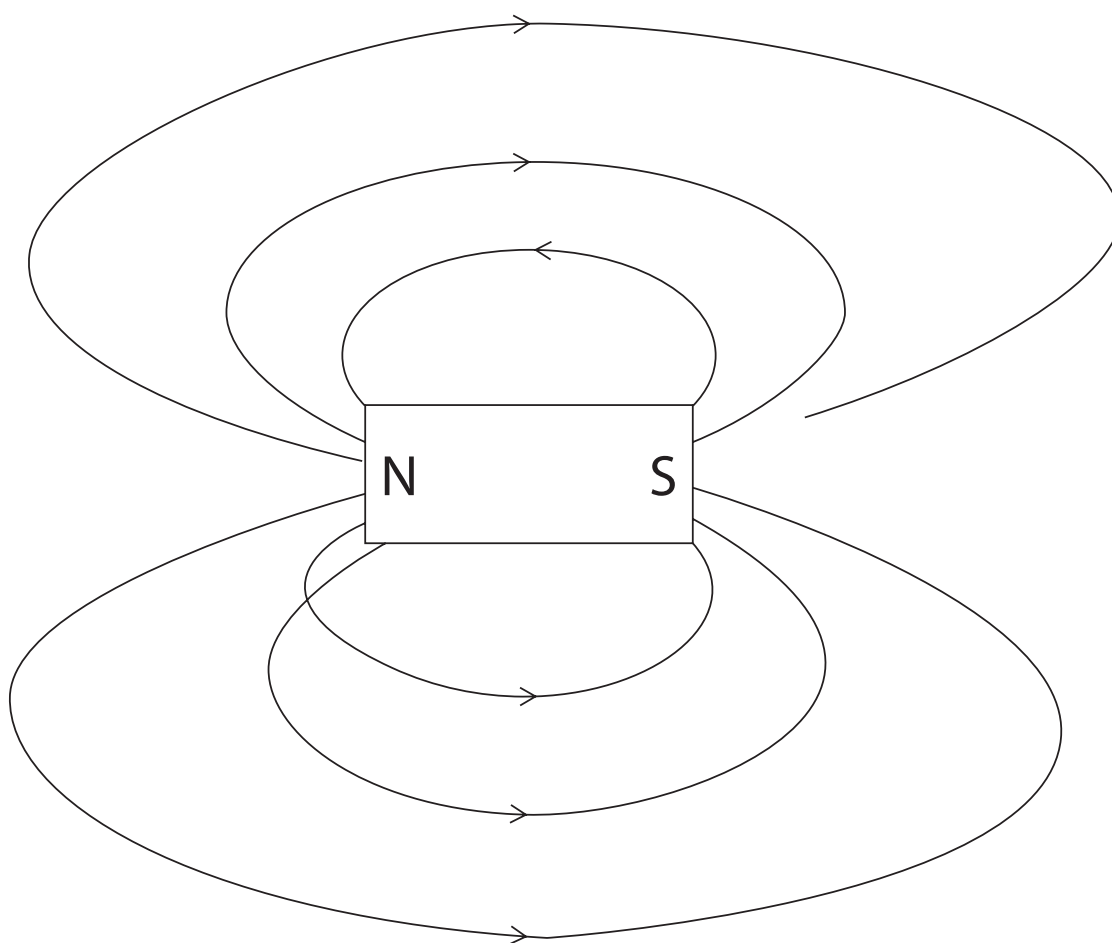
(1)

(b) The student draws a diagram of the magnetic field pattern of the magnet.

The student makes three mistakes.

Draw a circle around each mistake on the diagram.

(3)



(c) The magnet is made of a magnetically hard material.

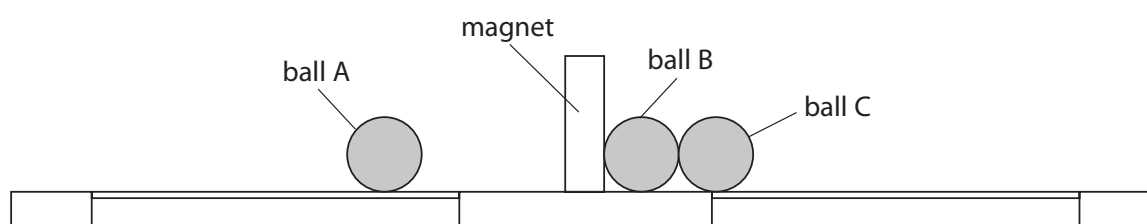
Describe what is meant by the term **magnetically hard**.

(2)

(Total for Question 2 = 6 marks)



7 The diagram shows a child's toy for accelerating steel balls.



This is how the toy works.

- the toy uses three identical steel balls, each with a mass of 4.1 g
- ball A moves towards the magnet
- ball B is in contact with the magnet
- balls B and C are initially at rest and are in contact with each other
- when ball A collides with the magnet, ball C moves away from the magnet

(a) Ball A moves towards the magnet with an initial velocity of 0.15 m/s.

Calculate the initial momentum of ball A.

(2)

initial momentum = ... kg m/s

(b) Ball A is attracted to the magnet.

Explain how this attraction affects the momentum of ball A as it approaches the magnet.

(2)

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- (c) When ball A collides with the magnet, a force of 1.3 N is exerted on ball C for a time of 0.0025 s.

This causes ball C to move away from the magnet.

Calculate the change in velocity of ball C due to this force.

(3)

change in velocity = ... m/s

(Total for Question 7 = 7 marks)

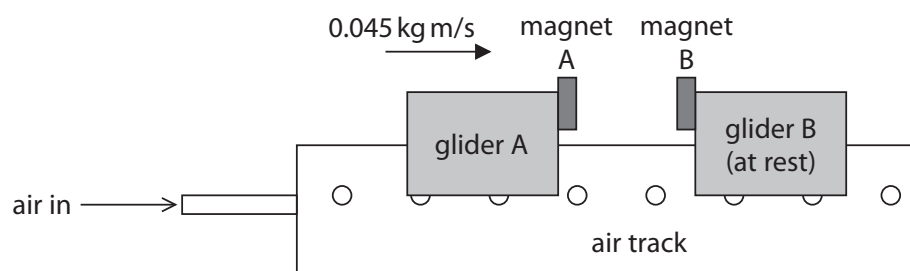


3 The diagram shows an air track that can be used to investigate motion without friction.

Air comes out through a series of small holes in the air track, which lifts the gliders slightly above the track.

There are two gliders on the track.

Each glider has a magnet.



The poles of the magnets nearest each other are alike.

(a) Explain the direction of the force acting on magnet A from magnet B.

(2)

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(b) The gliders collide and the magnets cause them to rebound.

Before the collision, the momentum of glider A is 0.045 kg m/s to the right and glider B is at rest.

(i) State the total momentum of glider A and glider B after the collision.

(1)

total momentum = ... kg m/s

(ii) After the collision, the momentum of glider A is 0.021 kg m/s to the left.

Calculate the momentum of glider B after the collision.

(2)

momentum of glider B = ... kg m/s

(iii) The time taken for glider B to change its momentum is 0.19 seconds .

Calculate the average force on glider B that causes this change in momentum.

(2)

average force = ... N

(iv) Give the direction of the force on glider B from glider A.

(1)

(Total for Question 3 = 8 marks)



6 Diagram 1 shows the magnetic field lines near the south pole of a bar magnet.

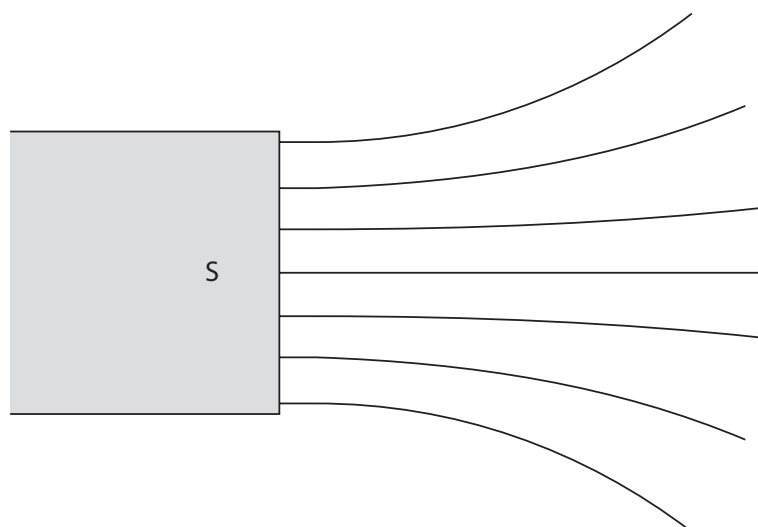


Diagram 1

(a) Draw two arrows on the field lines in diagram 1 to show the direction of the magnetic field lines.

(1)

(b) Which of these is attracted to the bar magnet if placed in the magnetic field?

(1)

- ☐ A copper
- ☐ B nickel
- ☐ C plastic
- ☐ D zinc

(c) The strength of the magnetic field changes as the distance from the south pole increases.

Explain how the magnetic field lines show this.

(2)

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(d) Diagram 2 shows a small piece of iron that has been placed in the magnetic field.

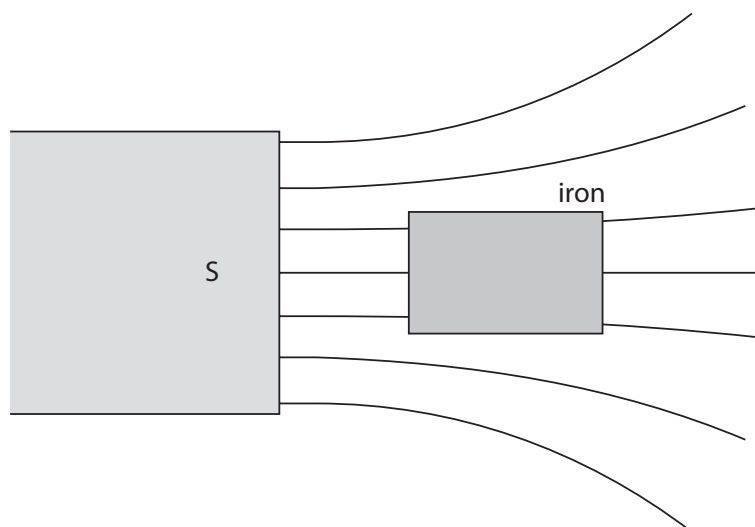


Diagram 2

The piece of iron becomes magnetised when placed in the magnetic field.

- (i) Explain why the piece of iron experiences a force towards the south pole of the bar magnet.

You may add to diagram 2 to help your answer.

(2)

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- (ii) A student suggests that the piece of iron is now a permanent magnet.

Explain why the student is incorrect.

(2)

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(Total for Question 6 = 8 marks)

11 A student investigates the magnetic fields produced by magnets.

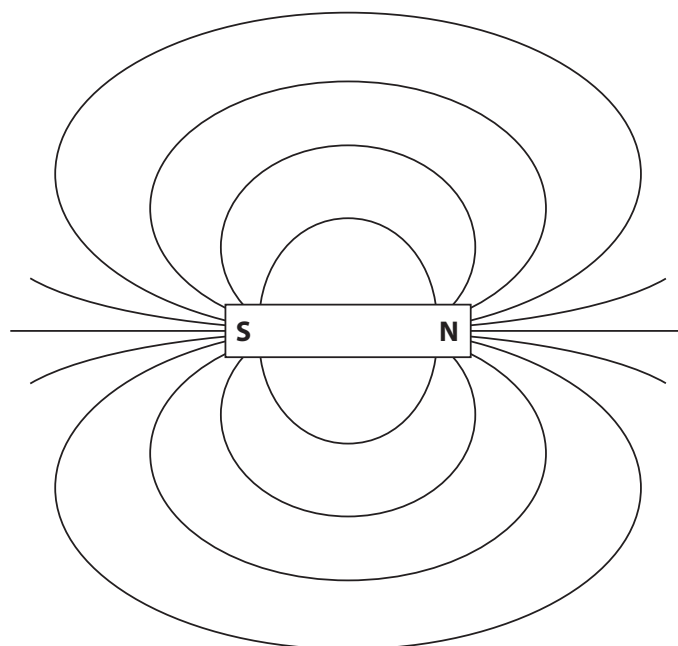
- (a) Describe a method he could use to determine the shape and direction of the magnetic field produced by a bar magnet.

You may use a diagram to help your answer.

(3)



(b) The diagram shows the shape of the magnetic field around the bar magnet.



(i) Add two arrows to the diagram to show the direction of the magnetic field.

(1)

(ii) Explain how the diagram shows that the strength of the magnetic field changes.

(2)

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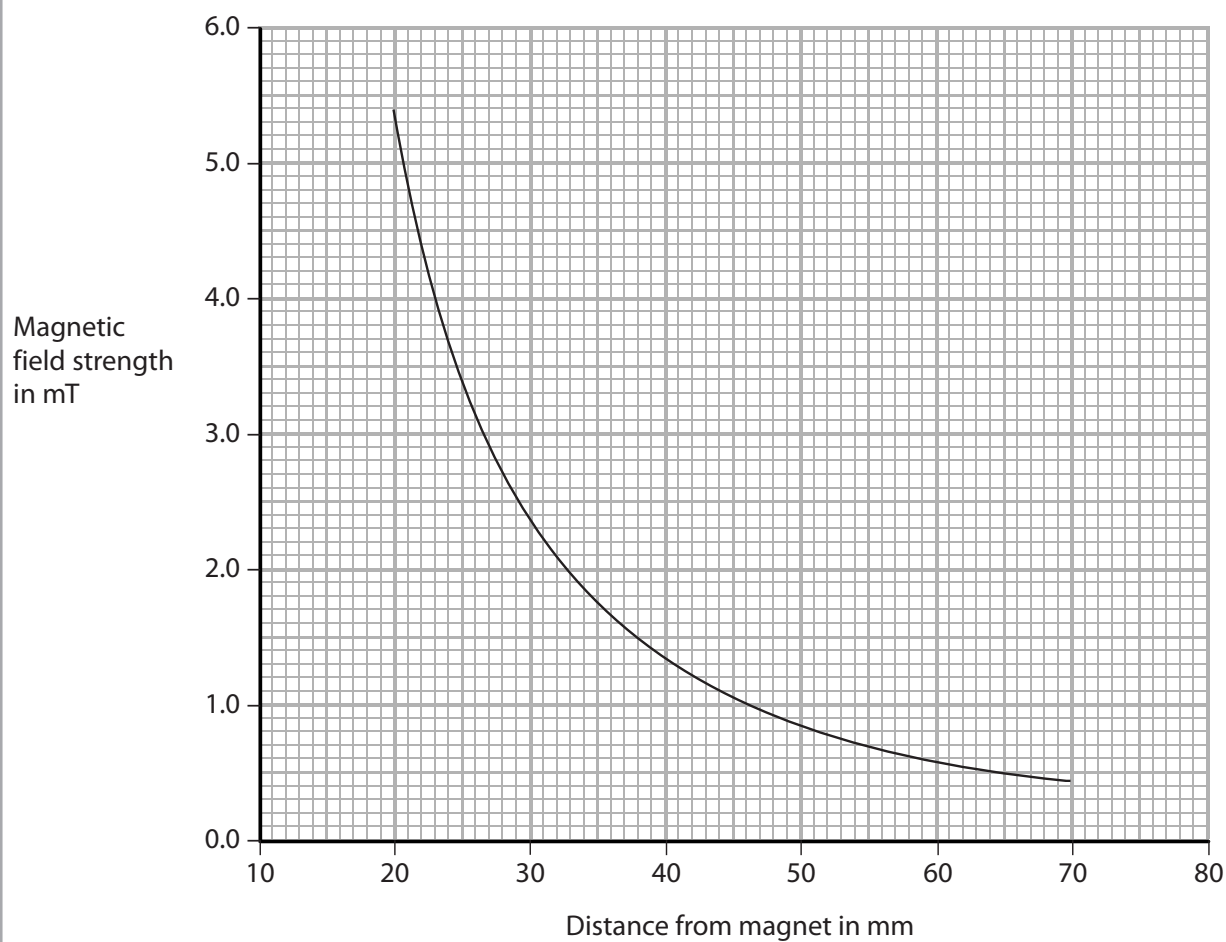
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(c) Magnetic field strength can be measured in units of milli-tesla (mT).

A student uses a different magnet.

The student measures the magnetic field strength at different distances from the north pole of this magnet.

The graph shows his results.



The student concludes that his results obey this relationship.

magnetic field strength $\times$ distance² = constant

Use data from the graph to deduce whether the student's results support this conclusion.

(4)

(Total for Question 11 = 10 marks)



7 Very strong magnets can be made using the element neodymium.

- (a) Diagram 1 shows parts of two neodymium magnets, X and Y, when they are held close together.

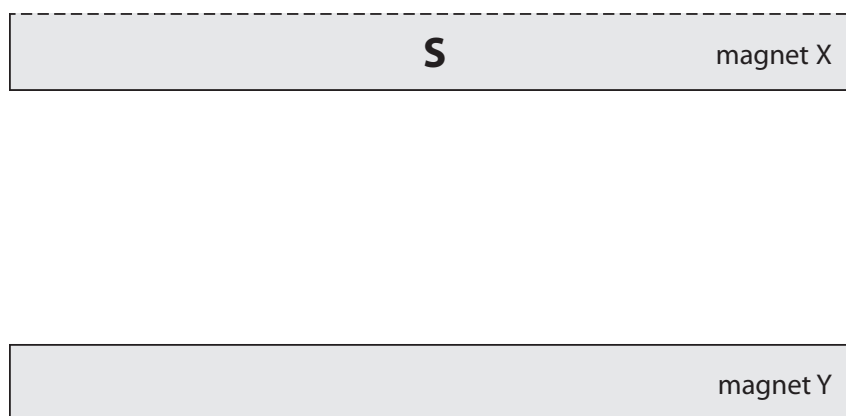


Diagram 1

A uniform magnetic field is produced in the space between the magnets.

Diagram 1 shows the south pole of magnet X.

Complete diagram 1 by drawing the uniform magnetic field and labelling the pole on magnet Y.

(3)

- (b) Diagram 2 shows another neodymium magnet being used to lift an iron ball from a table.

The iron ball is shown at the instant it leaves the surface of the table.

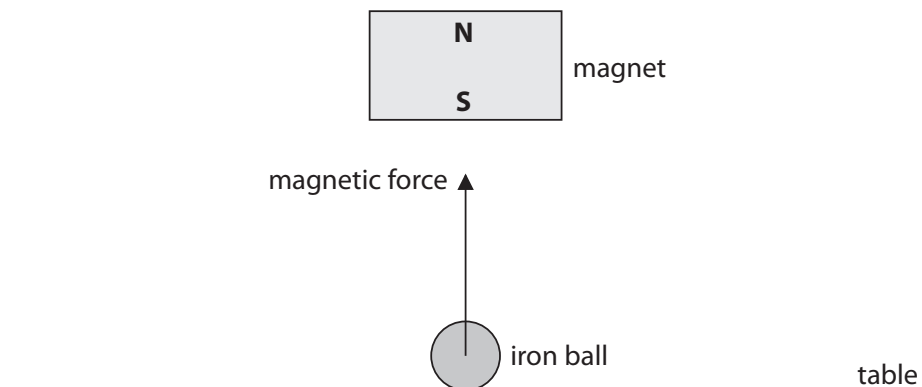


Diagram 2

- (i) Explain why the iron ball experiences an upward magnetic force.

(2)

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- (ii) The iron ball experiences an upward resultant force at the instant shown in diagram 2.

Draw a labelled arrow on diagram 2 to show the weight of the iron ball.

(1)

(iii) State the formula linking weight, mass and gravitational field strength.

(1)

(iv) At the instant shown in diagram 2, the resultant force acting on the iron ball is 124 mN and the magnetic force is 165 mN.

Calculate the mass of the iron ball.

(4)

mass of iron ball = ... kg

(v) Explain why the resultant force acting on the iron ball increases as the iron ball moves towards the magnet.

(2)

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(Total for Question 7 = 13 marks)



2 This question is about magnetic fields.

(a) Diagram 1 shows the poles of two strong bar magnets being held close together.

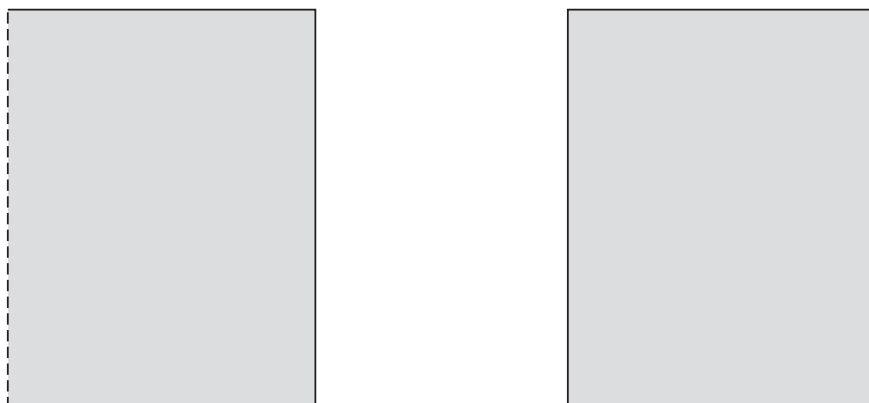


Diagram 1

There is a uniform magnetic field between the poles of the bar magnets.

Complete diagram 1 by drawing magnetic field lines to show the uniform magnetic field.

You should label the poles of the bar magnets.

(4)

(b) Diagram 2 shows a strong magnet attracting an iron block.

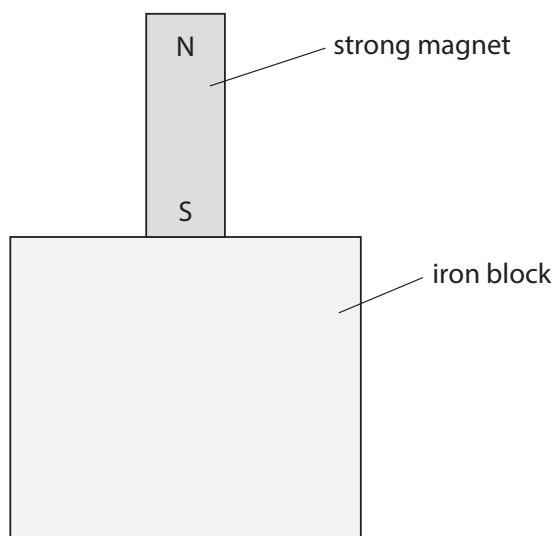


Diagram 2

- (i) The iron block becomes magnetised when it is in the magnetic field of the strong magnet.

Label the magnetic poles on the magnetised iron block in diagram 2.

(1)

- (ii) A student takes the strong magnet away from the iron block.

The student suggests they can permanently use the iron block to attract small pieces of iron.

Explain whether the student's suggestion is correct.

(2)

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(Total for Question 2 = 7 marks)

SUB-TOPIC 6.2

ELECTROMAGNETS AND THE MOTOR EFFECT

Sub-topic 6.2 · 14 questions · 130 marks · lowest tariff first



6 This question is about electromagnets.

- (a) Describe the construction of a simple electromagnet that is producing a magnetic field.

You may draw a diagram to help your answer.

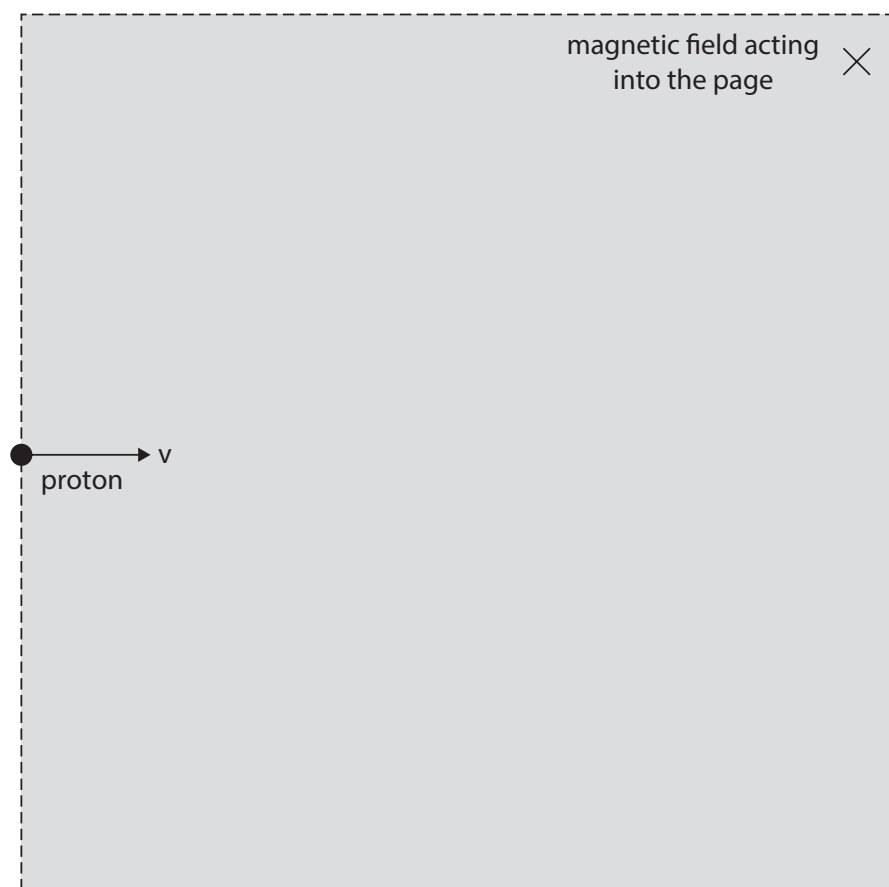
(3)



- (b) A proton moves through a uniform magnetic field produced by a strong electromagnet.

The shaded area in the diagram represents the magnetic field.

The initial velocity, v , of the proton is also shown.



- (i) Use the left-hand rule to determine the direction of the force acting on the proton.

(1)

- (ii) Explain how the force on the proton changes as the proton moves through the magnetic field.

You may add to the diagram to help your answer.

(2)

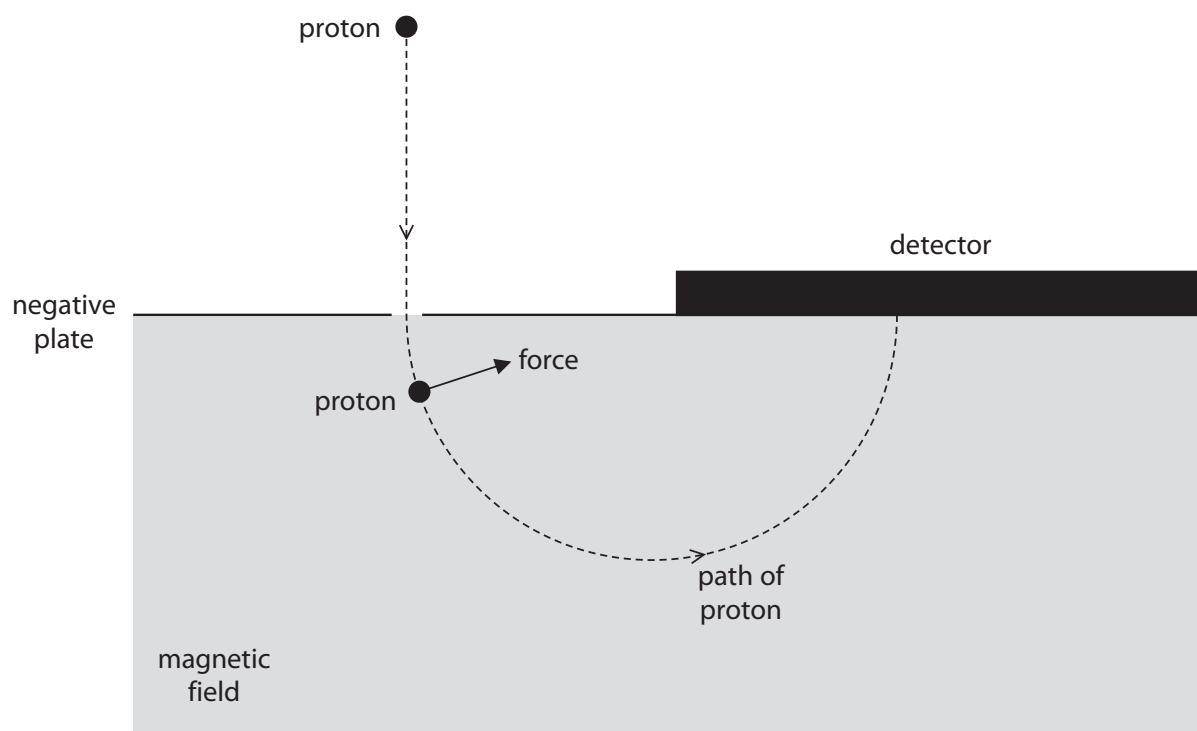
- (iii) Suggest why the velocity of the proton changes.

(1)

(Total for Question 6 = 7 marks)



- 8 The diagram shows a machine that can be used to measure the speed of fast-moving protons.



- (a) At the start, the proton is attracted towards a negatively charged plate.
(i) Give a reason why the proton is attracted to the negatively charged plate.

(1)

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- (ii) The proton accelerates at $1.90 \times 10^{11} \text{ m/s}^2$ from rest to a speed of $1.38 \times 10^5 \text{ m/s}$.

Show that the time taken for this acceleration is about $7 \times 10^{-7} \text{ s}$.

(3)

- (b) The proton passes through a hole in the negatively charged plate and enters an area where there is a magnetic field.

The magnetic field exerts a force on the proton, as shown in the diagram.

This force causes the proton to follow a circular path without changing speed.

- (i) Give the direction of the magnetic field.

(1)

- (ii) Suggest how increasing the strength of the magnetic field will affect the proton when it is moving in the magnetic field.

(2)

(Total for Question 8 = 7 marks)



7 This question is about a proton moving in a uniform magnetic field.

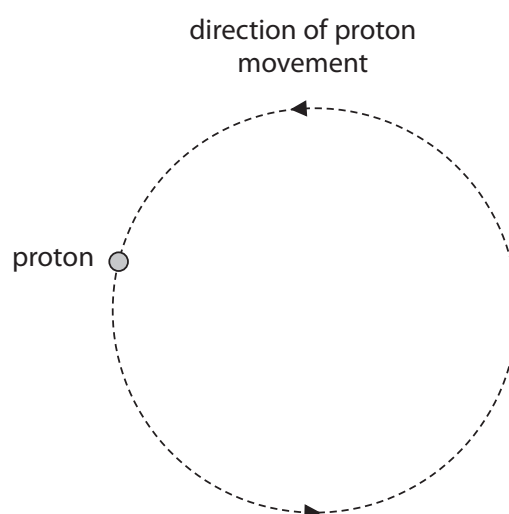
(a) Describe how to use two permanent magnets to produce a uniform magnetic field.

You may draw a diagram to support your answer.

(2)

(b) The diagram shows a proton moving in a circular path at constant speed in a uniform magnetic field.

This motion is similar to the movement of a planet in the Solar System.



(i) Draw an arrow to show the direction of the force on the proton.

(1)

(ii) Accurately measure the diameter of the proton's path.

(2)

diameter = ... cm



- (iii) The proton completes one orbit of its circular path in a time period of 8.7×10^{-6} seconds.

Calculate the orbital speed of the proton.

(3)

orbital speed = ... m/s

(Total for Question 7 = 8 marks)



- 7 A machine called the synchrocyclotron (SC) was designed to cause protons to move in a circular path using strong magnetic fields.

- (a) The SC used electromagnets to produce the strong magnetic fields.

Describe the construction of a simple electromagnet.

You may draw a diagram to support your answer.

(3)

- (b) The diagram shows a proton moving at velocity v in the magnetic field produced by the SC.



The direction of the magnetic field is into the page.

Using the left hand rule, determine the direction of the force acting on the proton due to the magnetic field.

(1)

- (c) The SC is surrounded by very thick concrete walls.

The radiation produced by the SC created atoms of radioactive barium-133 in the concrete walls.

Barium-133 has a half-life of 10.5 years.

- (i) State what is meant by the term **half-life**.

(2)

- (ii) In 1990, the SC stopped being used at CERN, a research centre.

In 1990, the largest number of barium-133 atoms were found 40 cm deep in the concrete walls.

Since 2014, members of the public have been allowed to visit the SC at CERN.

Explain why the radioactive barium-133 in the concrete walls is not a risk to people visiting the SC.

(2)

(Total for Question 7 = 8 marks)



8 This question is about magnetic fields.

(a) Diagram 1 shows a positively charged proton moving downwards in a uniform magnetic field.

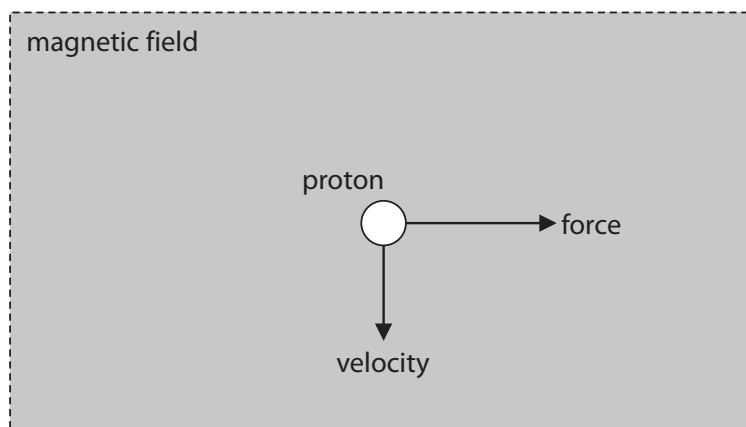


Diagram 1

The proton experiences a force to the right.

What is the direction of the magnetic field?

(1)

- ☐ A into the page
- ☐ B left
- ☐ C out of the page
- ☐ D upward

(b) When a current passes through a flat circular coil, a magnetic field is produced.

Complete diagram 2 by drawing the magnetic field of the flat circular coil.

(3)



Diagram 2

Turn over for the last part of the question



(c) A wireless charging base uses a magnetic field to charge the battery of a mobile phone.



© BeeBright/Shutterstock

There is an alternating current in a coil of wire in the charging base.

There is another coil of wire connected to the battery in the mobile phone.

(i) Explain how the wireless charging base charges the battery of the mobile phone.

(3)

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(ii) Discuss the advantages and disadvantages of using a high current in the wireless charging base.

(2)

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(Total for Question 8 = 9 marks)

7 Diagram 1 shows a loop of wire connected to a power supply.

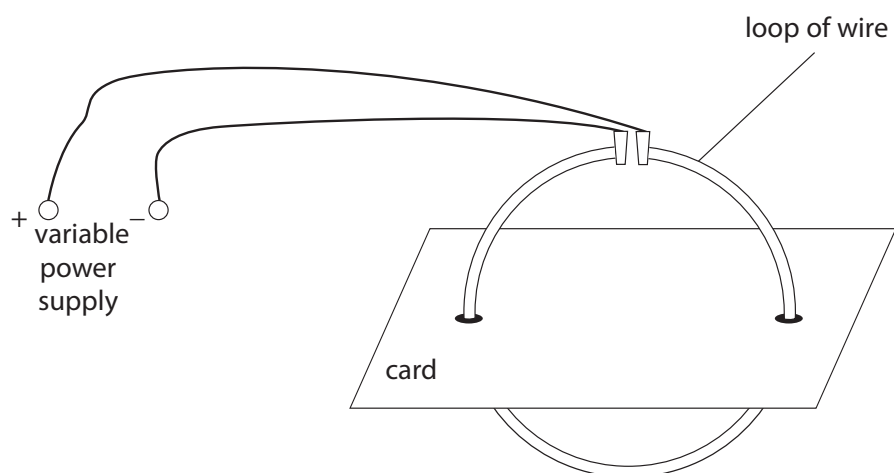


Diagram 1

(a) Describe how to find the shape of the magnetic field produced by the loop of wire. (3)

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(b) Diagram 2 shows the view from above the card with two cross-sections of the loop of wire.

Key

 current out of page

 current into page

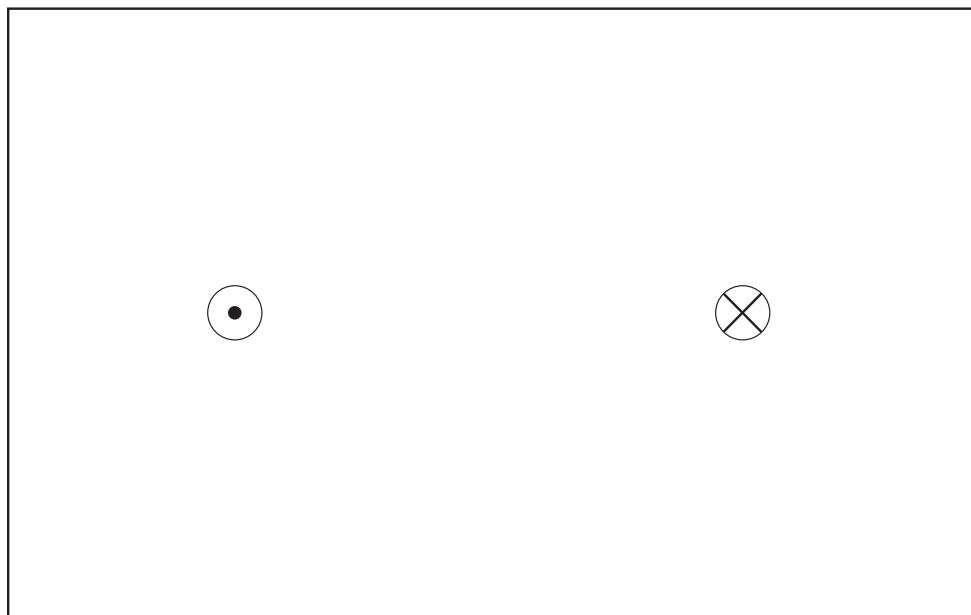
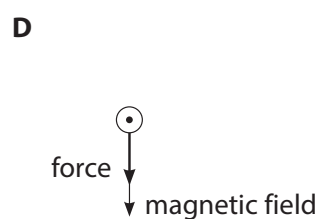
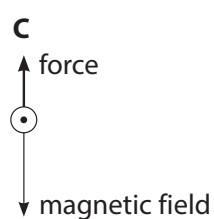
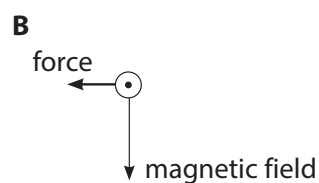
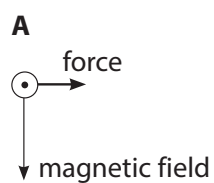


Diagram 2

On diagram 2, draw the magnetic field produced by the two cross-sections of the loop of wire.

(4)

- (c) (i) These diagrams show the magnetic field acting on a cross-section of wire when the current in the wire is out of the page.



Which diagram shows the correct direction of the force acting on the cross-section of wire due to the magnetic field?

(1)

- ☐ **A**
- ☐ **B**
- ☐ **C**
- ☐ **D**

- (ii) The magnetic field acting on the cross-section of wire is produced by the current in the other side of the loop of wire.

Explain why there is no effect on the direction of the force on the cross-section of wire when the direction of the current in the loop is reversed.

(2)

(Total for Question 7 = 10 marks)



4 This question is about magnets.

(a) Which of these substances is **not** attracted to a bar magnet?

(1)

- ☐ A cobalt
- ☐ B copper
- ☐ C iron
- ☐ D nickel

(b) Diagram 1 shows a bar magnet.



Diagram 1

Draw magnetic field lines on diagram 1 to show the shape and direction of the magnetic field around the bar magnet.

(3)

(c) Some bar magnets are made of steel.

Explain why steel is a good material for making bar magnets.

(2)

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- (d) Diagram 2 shows a cross-section through a wire placed between two magnetic poles.

The direction of the current in the wire is out of the page.

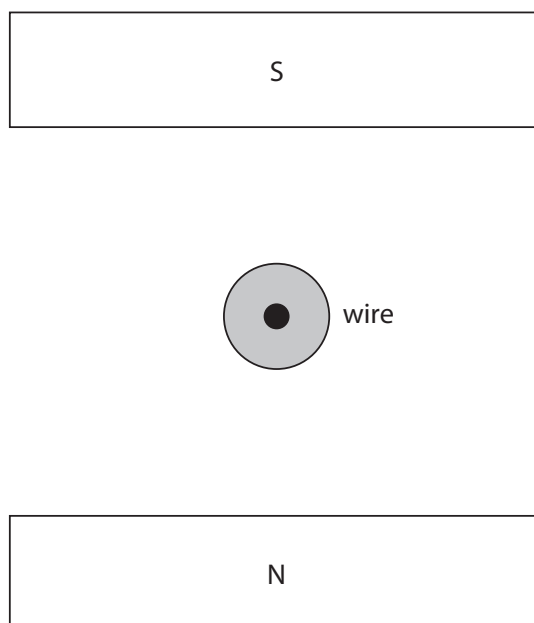


Diagram 2

- (i) Draw an arrow on diagram 2 to show the direction of the force on the wire due to the magnetic field.

Assume that the magnetic field is uniform.

(2)

- (ii) State two changes that could be made that would decrease the magnitude of the force on the wire in diagram 2.

(2)

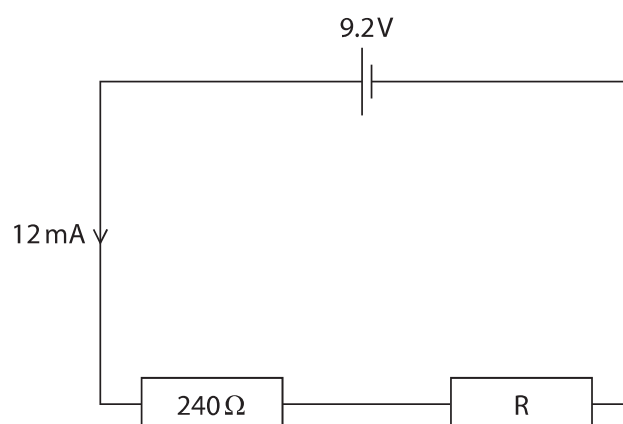
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(Total for Question 4 = 10 marks)

10 This question is about voltage and current.

(a) The diagram shows two resistors connected to a battery.

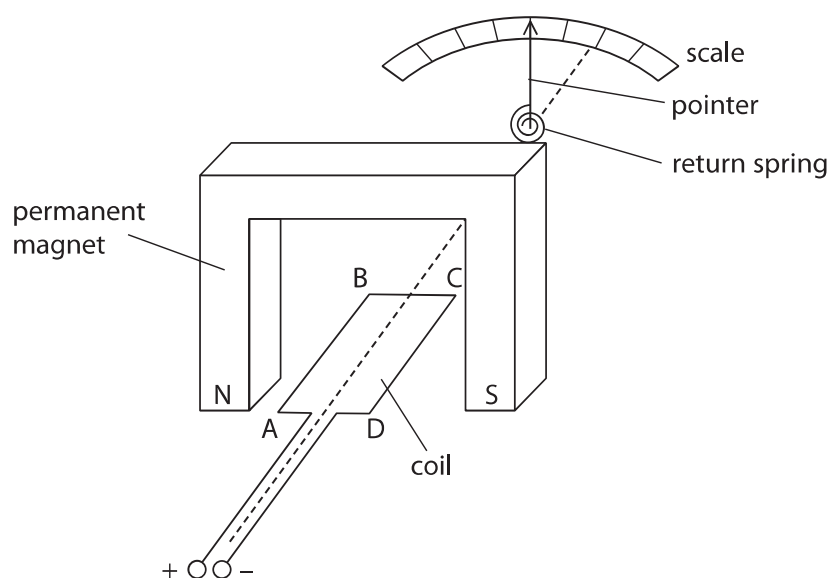


Calculate the voltage across resistor R.

(4)

voltage = ... V

- (b) The diagram shows the parts of an ammeter.
The pointer is connected to the coil so they can move together.



- (i) Explain what happens when there is a current in the coil.

(3)

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- (ii) Draw an arrow on the diagram to show the force acting on side CD of the coil when there is a current in the coil.

(1)

(iii) Explain how the ammeter could be changed so that it could measure smaller currents.
(3)

(Total for Question 10 = 11 marks)



- 12** Diagram 1 shows some apparatus used to demonstrate the magnetic force on a current-carrying wire in a magnetic field.

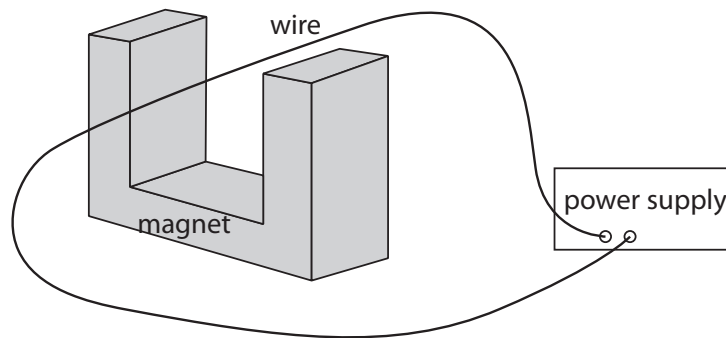


Diagram 1

- (a) Diagram 2 shows four different arrangements of the apparatus.

The symbol  shows that the current is directed out of the page.

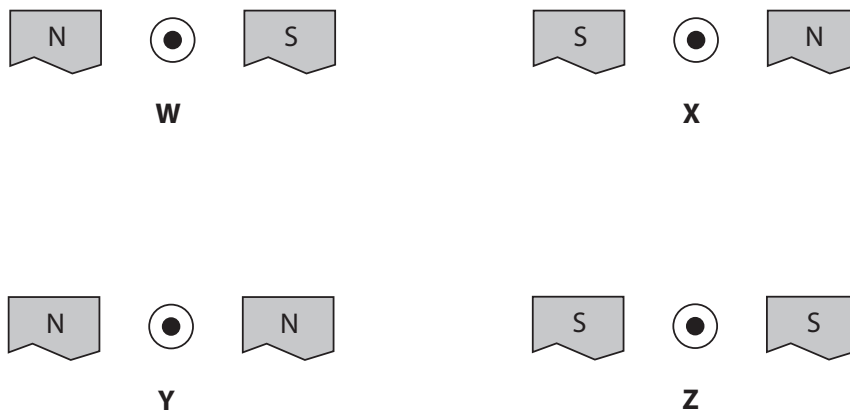


Diagram 2

Which arrangement of the apparatus will cause there to be an upwards magnetic force on the wire?

(1)

- ☐ **A** W
- ☐ **B** X
- ☐ **C** Y
- ☐ **D** Z

(b) The wire has a mass of 6.5 g.

(i) Calculate the weight of the wire.

Give your answer in mN.

(2)

weight = ... mN

(ii) There is an upwards magnetic force of 34 mN acting on the wire.

Calculate the acceleration of the wire.

(5)

acceleration = ... m/s^2

QUESTION 12 CONTINUES ON NEXT PAGE



(iii) Explain one method of increasing the magnitude of the magnetic force on the wire. (2)

(iv) Explain how the circuit could be changed to make the wire vibrate. (2)

(Total for Question 12 = 12 marks)



6 This question is about electromagnetism.

(a) Diagram 1 shows the magnetic field around a straight section of copper wire.

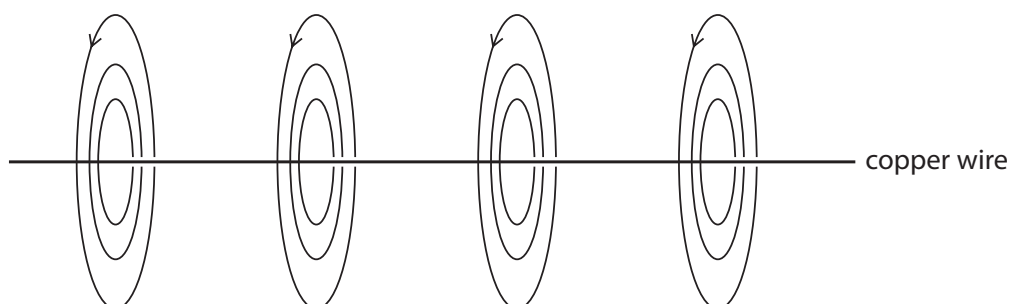


Diagram 1

Explain why the copper wire has the magnetic field shown in the diagram.

(2)

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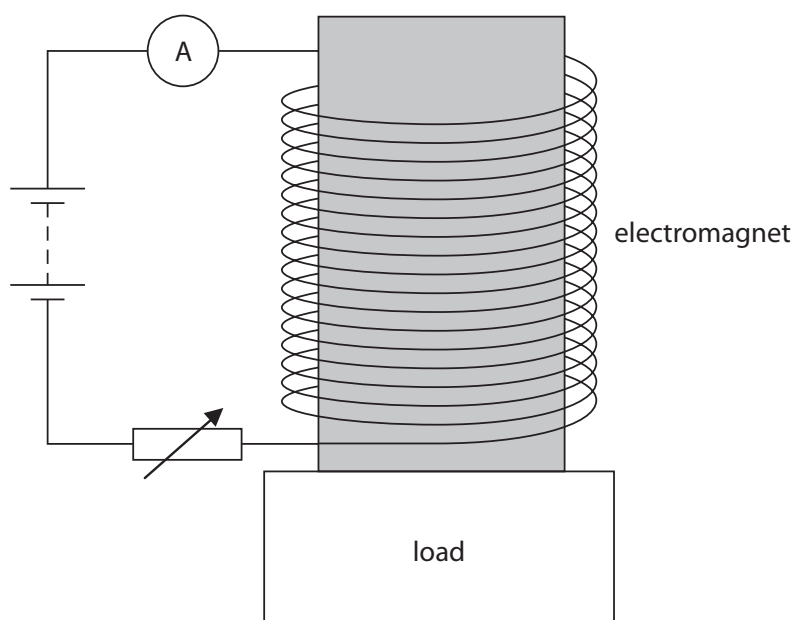
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(b) A student investigates how the strength of an electromagnet varies with the current in the electromagnet.

The diagram shows their apparatus.



This is the student's method.

- switch on the electromagnet at its maximum current
- place a load of 100 g so that it is held above the floor by the electromagnet
- slowly reduce the current in the electromagnet until the load falls from the electromagnet
- record the current at which the load falls
- record the current at which the same load falls two more times

Repeat the method for loads of different masses.

- (i) Suggest a suitable safety precaution for the student's investigation.

(1)

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- (ii) The table shows the student's results.

Mass of load in g	Current at which the load falls in A			
	1	2	3	Mean
100	0.28	0.31	0.31	0.30
200	0.60	0.57	0.57	0.58
300	0.91	0.90	0.86	0.89
400	1.19	1.23	1.27	1.23
500	1.45	1.57	1.48	1.50
600	1.79	1.84	1.87	

Calculate the mean current when the mass of the load was 600 g.

Give your answer to a suitable number of significant figures.

(2)

mean current = ... A



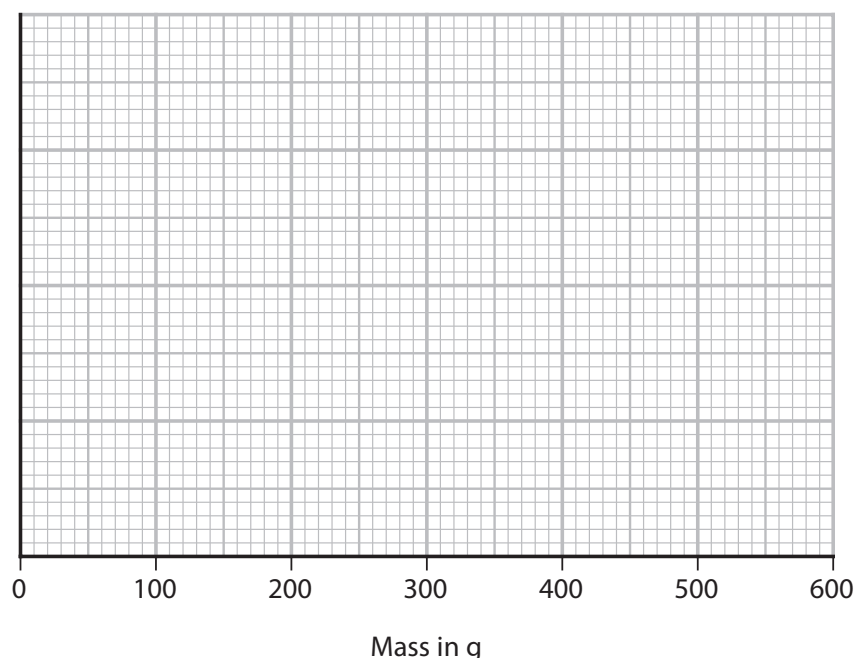
(iii) On the grid, plot a graph of the mean current against the mass of the load.

The scale for the mass axis has been done for you.

(3)

(iv) Draw the line of best fit.

(1)



(v) The student predicts that a load of 1.0 kg will fall when the current in the electromagnet is 3.0 A.

Comment on the student's prediction.

(3)

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(Total for Question 6 = 12 marks)



4 (a) A student investigates a sound wave with a frequency of 25 000 Hz.

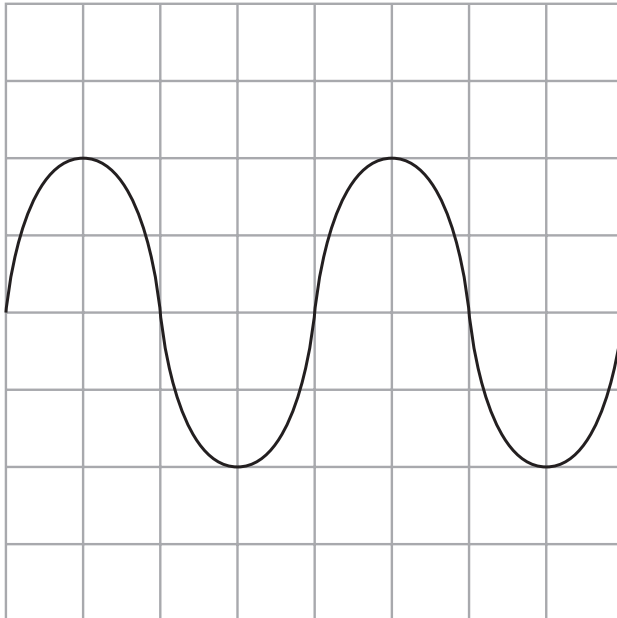
(i) Calculate the wavelength of this sound wave.

[speed of sound = 330 m/s]

(3)

wavelength = ... m

(ii) The oscilloscope trace represents the sound wave.



Oscilloscope settings

y direction: 1 square = 5V

x direction: 1 square = 0.01 ms

Determine the amplitude of the oscilloscope trace.

(2)

amplitude = ... V

(b) (i) Diagram 1 shows a coil of wire wrapped around a cardboard tube.

The coil is fixed to the cardboard tube.

On diagram 1, draw field lines to represent the magnetic field produced when the current is in the direction shown.

(3)

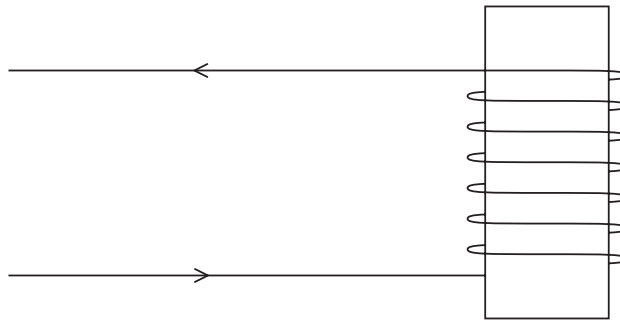


Diagram 1

(ii) Diagram 2 shows a model of a loudspeaker that uses the coil and the cardboard tube.

The cardboard tube is fixed to a thin piece of card, which is clamped at both ends.

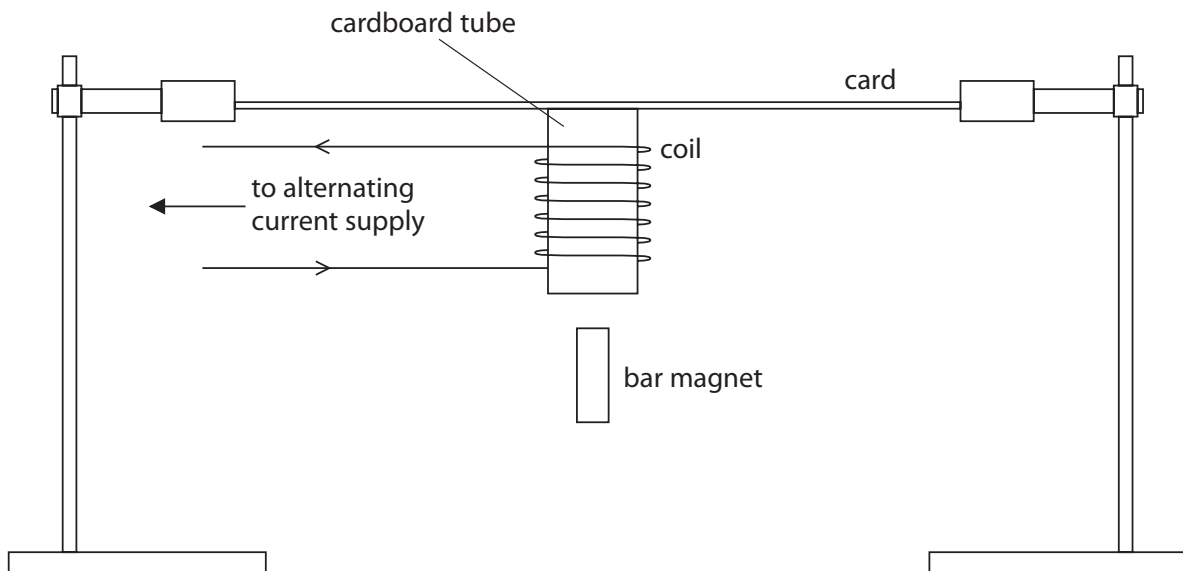


Diagram 2

The student holds a bar magnet near the bottom of the cardboard tube.

Explain why this causes the loudspeaker to produce a sound.

(3)

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(iii) When the frequency of the alternating current is 10 kHz, the student hears a sound.

The student increases the frequency of the alternating current to 25 kHz.

Explain why the student cannot hear a sound now, even though the card is still vibrating.

(2)

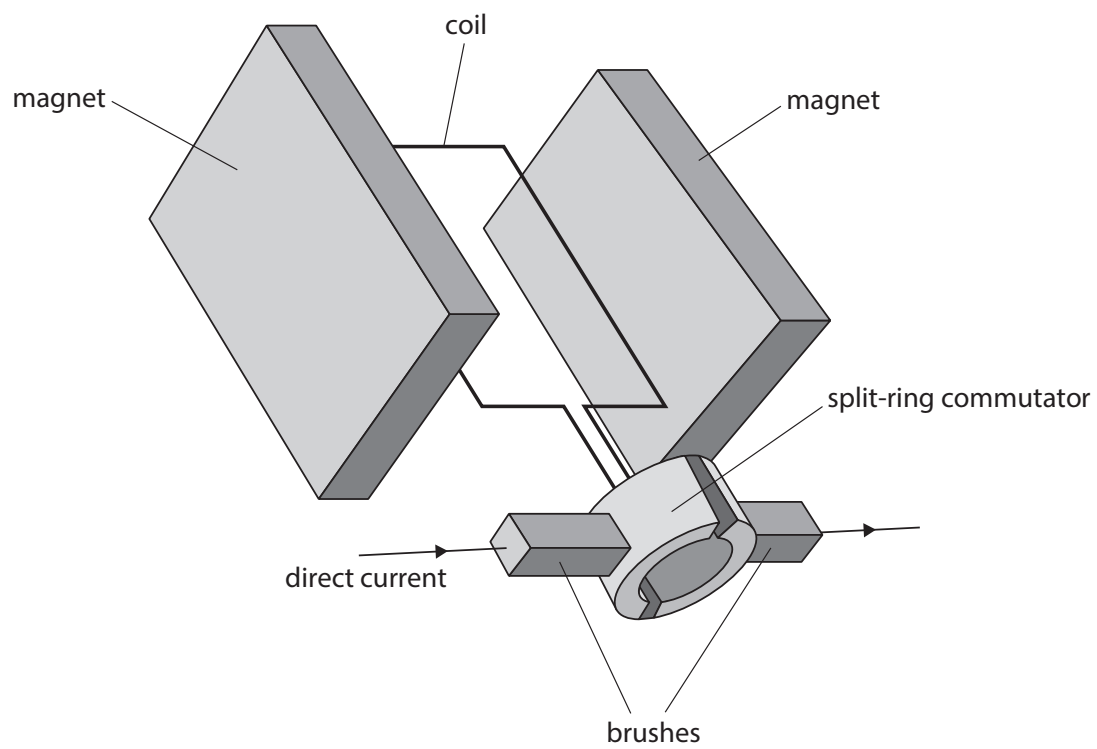
(iv) Suggest a change to the apparatus that would increase the loudness of the sound when the frequency of the alternating current is 10 kHz.

(1)

(Total for Question 4 = 14 marks)



5 The diagram shows a simple direct current (d.c.) electric motor.



Explain why the coil turns continuously when the motor is connected to a direct current supply.

You should refer to the brushes and the split-ring commutator in your answer.

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(Total for Question 5 = 6 marks)

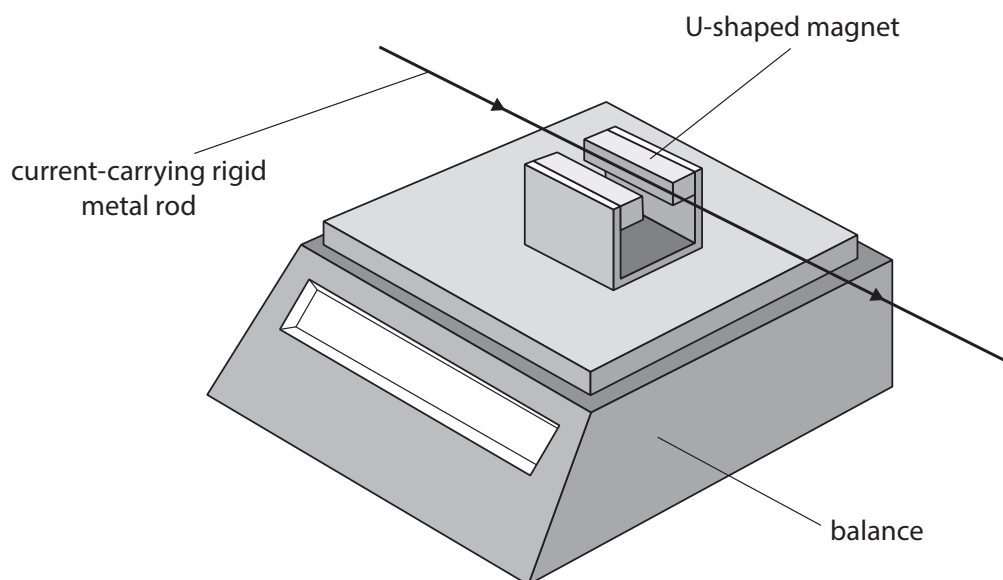


10 A student investigates the magnetic force on a current-carrying metal rod.

The student places a U-shaped magnet on a sensitive balance.

They connect a rigid metal rod to a low-voltage power supply, and then fix the rod in place so that it passes between the poles of the magnet.

The diagram shows part of the student's apparatus.



When there is a current in the metal rod, the rod experiences a force due to the magnetic field of the magnet.

The reading on the balance changes because the magnet experiences a force that is the same magnitude as the force on the rod, but in the opposite direction.

- (a) The student can increase the current in the metal rod up to a maximum of 5.0 A.

Suggest why the student should only have the power supply switched on for short periods of time.

(2)

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- (b) Before the power supply is switched on, the reading of the balance is 194.95 g.

After the power supply is switched on, the reading of the balance is 193.80 g.

Calculate the force exerted on the current-carrying rod by the magnet.

(4)

force = ... N



(c) The student investigates how the balance reading varies as they change the current in the metal rod.

The table shows the student’s results.

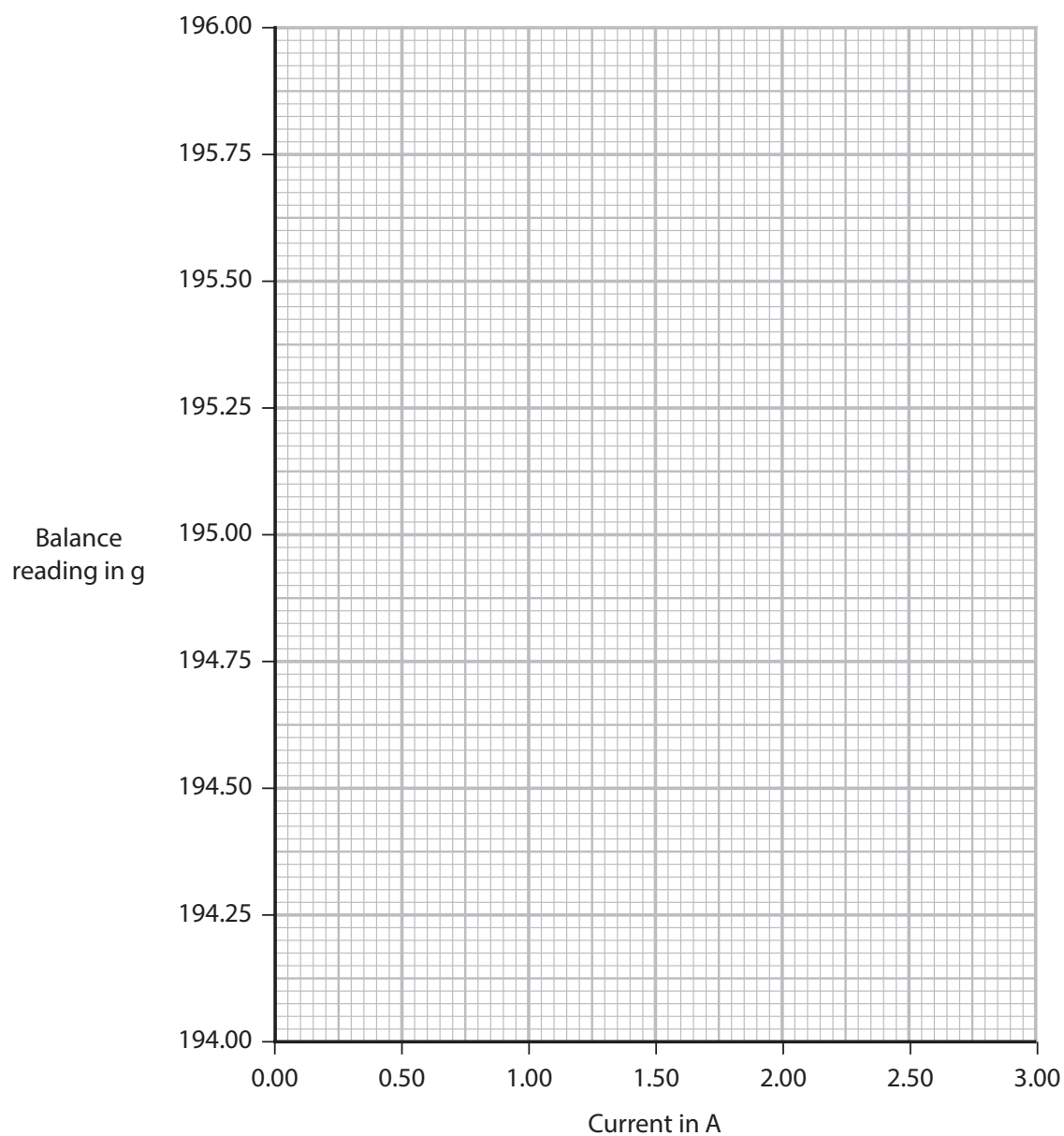
Current in A	Balance reading in g
0.00	194.95
0.50	194.80
1.00	194.65
1.50	194.50
2.00	194.35
2.50	194.20
3.00	194.05

- (i) Plot the student’s results on the grid.

(1)
- (ii) Draw the line of best fit.

(1)





- (iii) The student changes the connections between the metal rod and the power supply to reverse the direction of the current.

Draw another line on the graph to show how the balance reading will vary with current after this change has been made.

(3)

(Total for Question 10 = 11 marks)

SUB-TOPIC 6.3

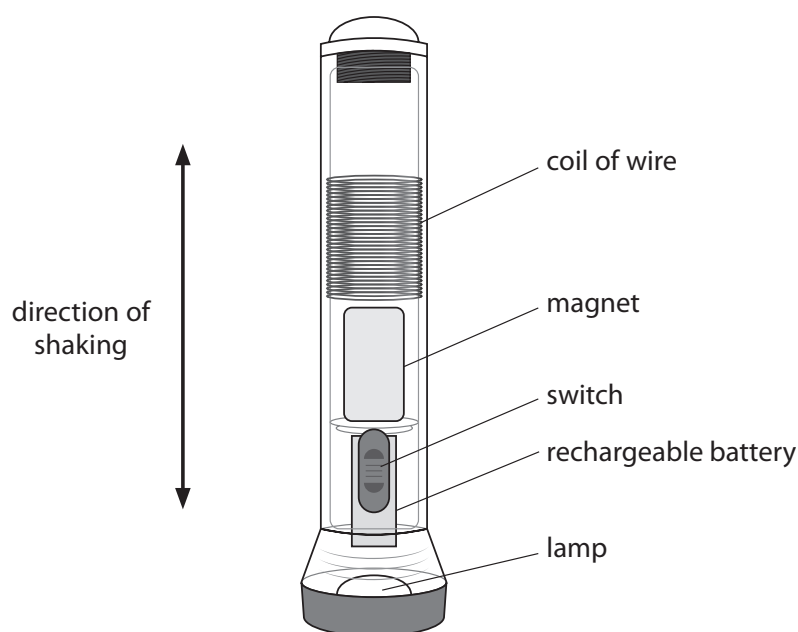
ELECTROMAGNETIC INDUCTION AND GENERATORS

Sub-topic 6.3 · 7 questions · 67 marks · lowest tariff first



3 The diagram shows a torch that uses a rechargeable battery.

The battery is recharged by shaking the torch up and down.



(Source: adapted from © www.shutterstock.com/1328720216)

(a) Shaking the torch causes the magnet to move up and down inside the coil of wire.

Explain why the movement of the magnet causes a current in the coil.

(3)

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(b) Using a stronger magnet could increase the current in the coil of wire.

State two other factors that could increase the current in the coil.

(2)

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2

(Total for Question 3 = 5 marks)



10 This question is about bar magnets.

- (a) Describe an investigation to show the shape and direction of the magnetic field for a bar magnet.

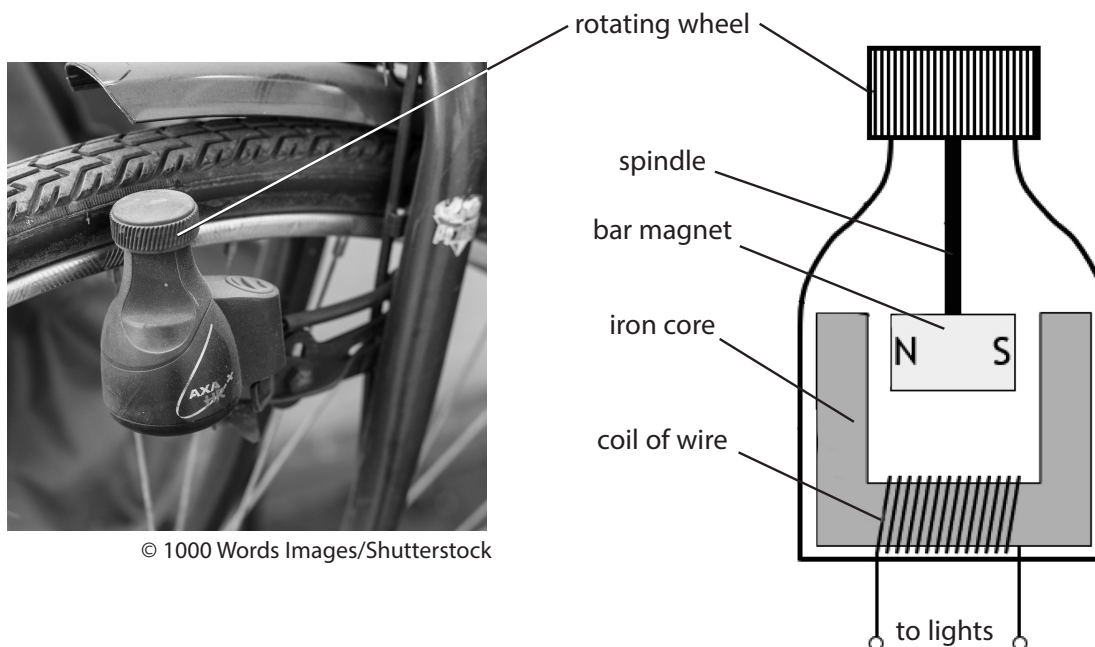
You may draw a diagram to help your answer.

(3)



(b) A bar magnet is used in a bicycle dynamo.

The diagram shows a cross-section of a bicycle dynamo.



The dynamo has a rotating wheel that presses against the tyre of the bicycle.

The rotating wheel is connected to a bar magnet by a spindle.

When the rotating wheel spins, the bar magnet spins.

(i) The dynamo is connected to the lights on the bicycle.

Explain how the dynamo causes the lights to turn on when the bicycle is moving.

(4)

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(ii) Suggest a disadvantage of using the dynamo to power the bicycle lights.

(1)

(Total for Question 10 = 8 marks)



- 8 (a) Describe how two magnets can be arranged to produce a uniform magnetic field.

You may draw a diagram to support your answer.

(2)

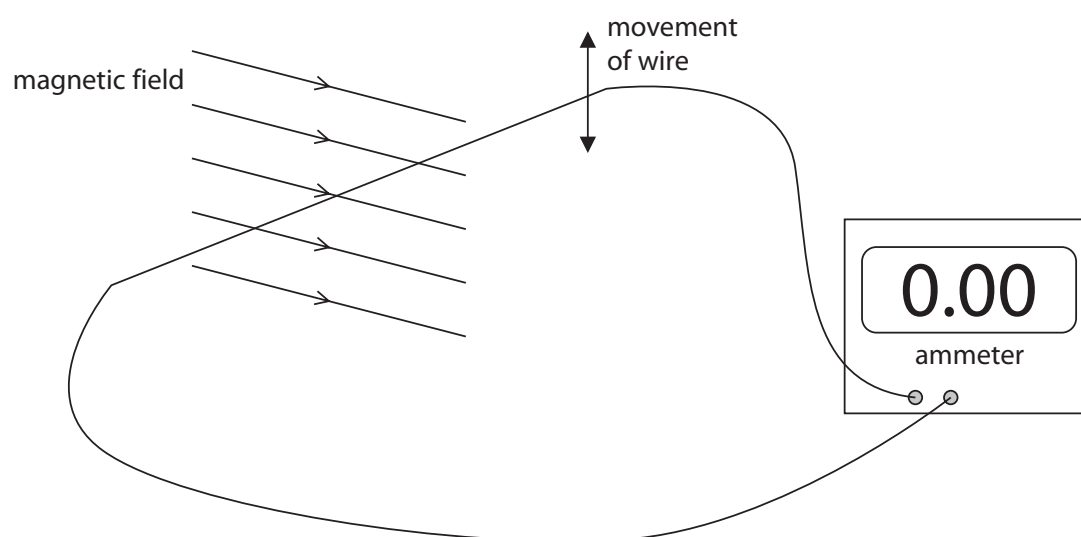
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- (b) The diagram shows a wire in a uniform magnetic field.



- (i) The wire is moved up and down repeatedly in the magnetic field.
Explain the effect that this movement has on the ammeter reading.

(3)

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- (ii) Explain the effects on the ammeter reading of moving the wire with the same amplitude but at a higher frequency.

(4)

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(Total for Question 8 = 9 marks)



- 10** Diagram 1 shows a generator inside a small wind turbine. The generator is connected to a lamp and the windmill blades.

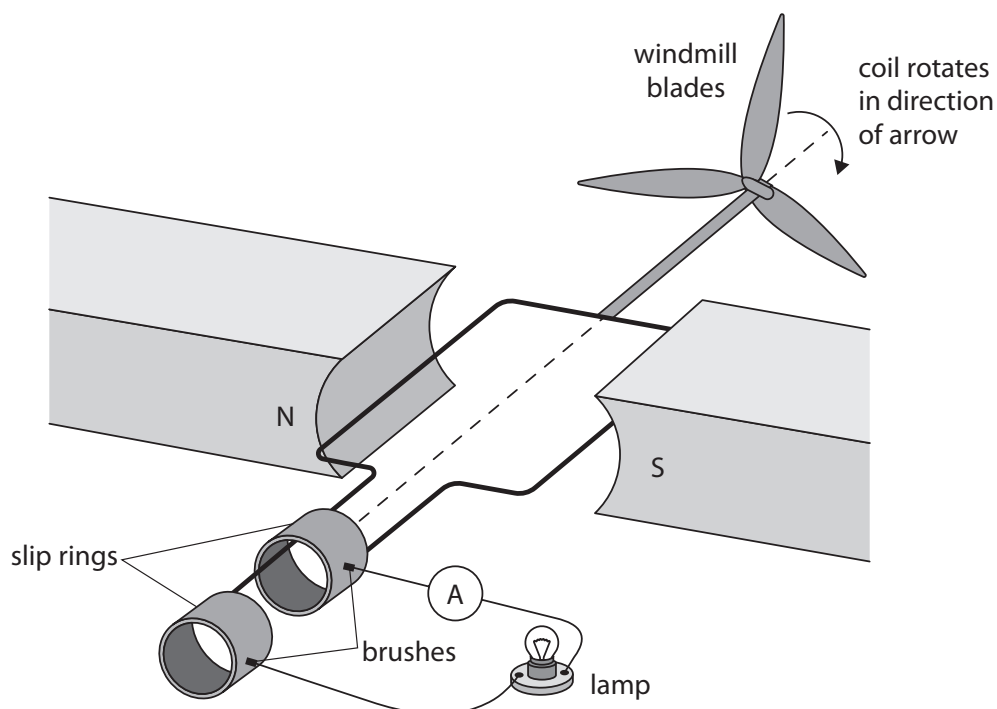


Diagram 1

- (a) When the coil rotates in the direction of the arrow, the ammeter displays a small current.

Explain how the generator produces a current.

(2)

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- (b) The generator in the wind turbine acts as an alternating current (a.c.) power supply.

Diagram 2 shows an electric circuit containing the generator being used to charge a mobile phone battery.

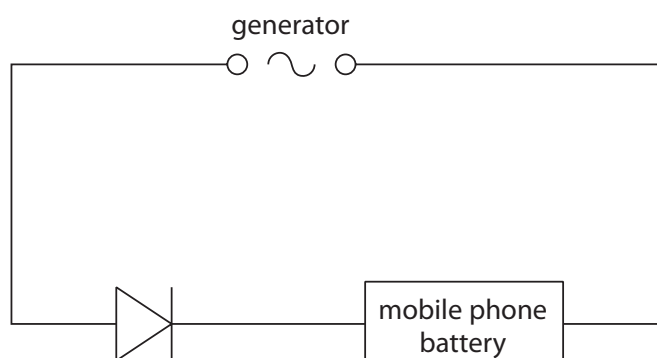


Diagram 2

- (i) Direct current (d.c.) is needed to charge the battery.

Explain why there is a diode in the circuit.

(2)

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- (ii) Explain how the current in the battery will change if the wind speed increases.

(2)

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(c) The mean voltage across the battery is 7.2V.

The battery gains 14 kJ of energy in 8400 seconds.

Calculate the mean current in the battery.

(3)

mean current = ... A

(Total for Question 10 = 9 marks)



12 A device called a metal detector can be used to find metal buried underground.



(Source: © mArt88/Shutterstock)

The metal detector has two circuits, each containing a coil of copper wire.

Diagram 1 shows the circuit for the transmitter coil.

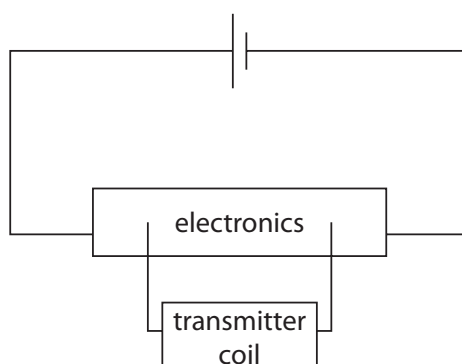


Diagram 1

(a) Suggest why there is a magnetic field around the transmitter coil.

(1)

(b) The cell supplies direct current (d.c.). The electronics in diagram 1 change the direct current into alternating current (a.c.) in the coil.

(i) Describe the difference between direct current (d.c.) and alternating current (a.c.).

(2)

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- (ii) Alternating current is supplied to the transmitter coil.

Diagram 2 shows a gold ring in the soil below the metal detector.

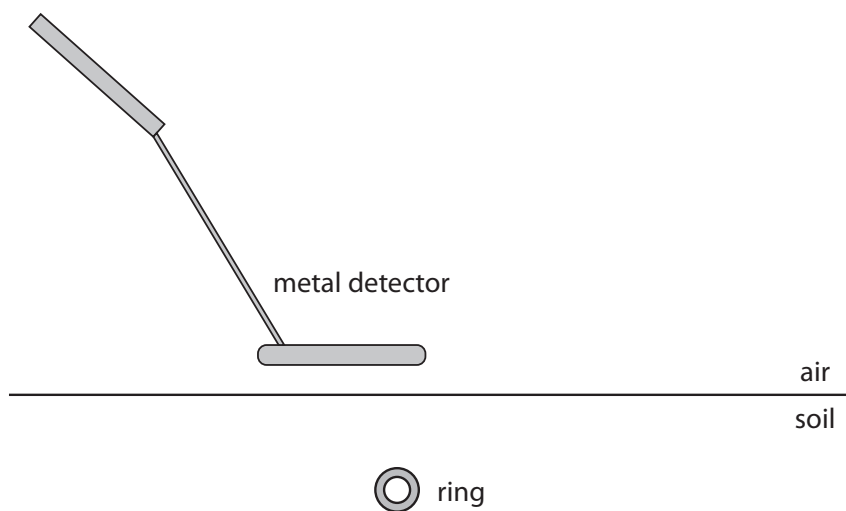


Diagram 2

Explain why there is an alternating current in the gold ring.

(3)

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QUESTION 12 CONTINUES ON NEXT PAGE

(c) Diagram 3 shows the circuit for the receiver coil.

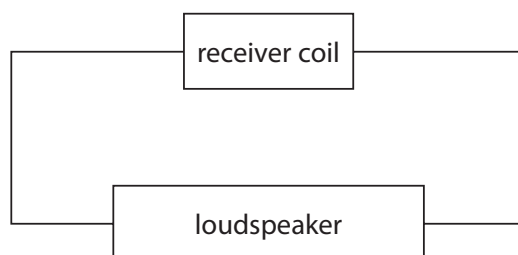


Diagram 3

As a result of the alternating current in the gold ring, there is an alternating current in the receiving coil.

Explain how an alternating current in the receiving coil causes a sound to be emitted from the loudspeaker.

(4)

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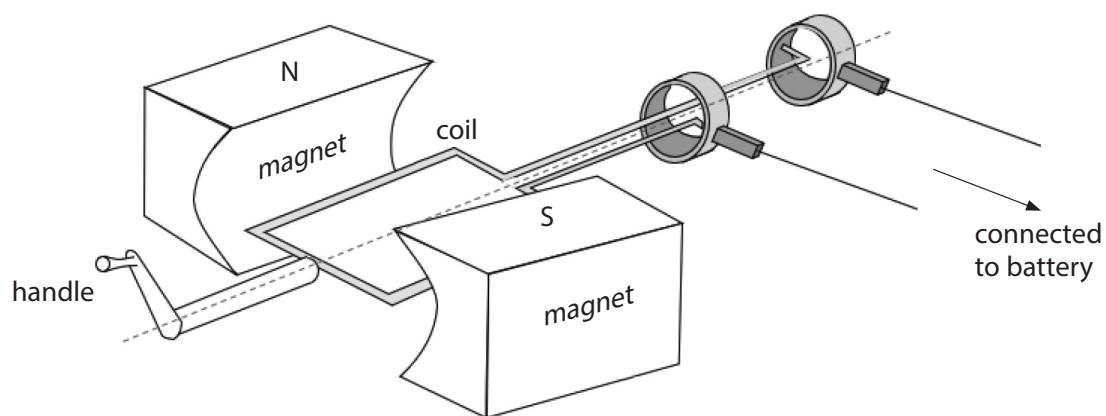
(Total for Question 12 = 10 marks)

9 This question is about a radio powered by a person turning a handle.

The radio has a battery which stores energy when the handle is turned.

(a) The diagram shows the part of the radio called a generator.

The generator produces a voltage which does electrical work on the battery.



Explain how the generator produces a voltage.

(3)

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(b) The radio receives a radio wave of frequency 93 MHz.

(i) State the formula linking speed, frequency and wavelength of a wave.

(1)

(ii) Calculate the wavelength of the radio wave.

[speed of radio waves = 3.0×10^8 m/s]

(3)

wavelength = ... m

(c) The signal received by the radio is converted into an alternating current (a.c.) signal.

(i) Describe how the loudspeaker in the radio converts this a.c. signal into a sound wave.

(4)

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(ii) State a modification that would increase the force on the loudspeaker coil.

(1)

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(Total for Question 9 = 12 marks)



9 (a) The diagrams show a spring hanging from a nail.

- diagram 1 shows the spring with no weight added
- diagram 2 shows the spring stationary, after a weight has been added
- diagram 3 shows the spring after the weight has been pulled down

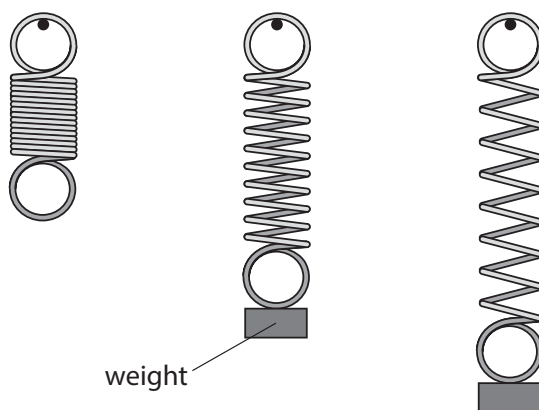


Diagram 1

Diagram 2

Diagram 3

(i) Which energy store has increased for the spring in diagram 2 compared to the spring in diagram 1?

(1)

- ☒ A chemical
- ☒ B elastic
- ☒ C gravitational potential
- ☒ D kinetic

(ii) The spring is released from the position shown in diagram 3.

Describe the energy transfers that take place until the spring stops vibrating.

(6)

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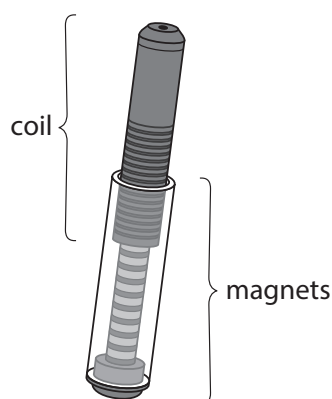
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- (b) Shock absorbers containing springs are used on motorcycles. Shock absorbers are designed to compress and expand as the motorcycle moves across a rough surface.

A new type of shock absorber has been developed to generate electricity from the movement of the motorcycle.

This new type of shock absorber consists of magnets that slide inside a coil when the motorcycle goes over a bump.



Some of the energy that would normally be wasted can be recovered, so fuel is saved.

- (i) Which of these statements best describes the advantage of this new type of shock absorber?

(1)

- ☐ **A** it increases the energy transferred to a thermal store from the fuel
- ☐ **B** it increases the efficiency of the motorcycle
- ☐ **C** it decreases the speed of the motorcycle
- ☐ **D** it decreases the braking power of the motorcycle

- (ii) Explain how this new type of shock absorber can generate electricity.

(3)

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(iii) Road X has a rough surface.

Road Y has a smooth surface.



(Source: © MikhailSh / Shutterstock)

Road X



(Source: © BearFotos / Shutterstock)

Road Y

A motorcycle travels at the same speed along road X and road Y.

Explain why the new type of shock absorber will generate more electricity for this motorcycle on road X than on road Y.

(3)

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(Total for Question 9 = 14 marks)

SUB-TOPIC 6.4

TRANSFORMERS AND THE TRANSMISSION OF ELECTRICITY

Sub-topic 6.4 · 11 questions · 102 marks · lowest tariff first



- 4 The photograph shows transmission cables used for long-distance transmission of electricity.



(Source: © Paul Maguire / Shutterstock)

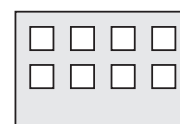
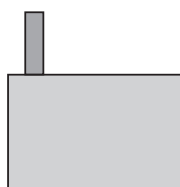
- (a) The diagram shows a power station and a school.

Add to the diagram by drawing the structures needed to efficiently transfer energy from the power station to the school using electricity.

(3)

Power station

School



- (b) Explain how the amount of current in the transmission cables increases the efficiency of the transmission of electricity.

(3)

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(Total for Question 4 = 6 marks)

2 A student investigates a transformer.

This is the student's method.

- use a primary coil with 10 turns
- connect the primary coil to a constant maximum input voltage
- measure the output voltage across the secondary coil
- repeat using an increasing number of turns on the primary coil

The table shows the student's results.

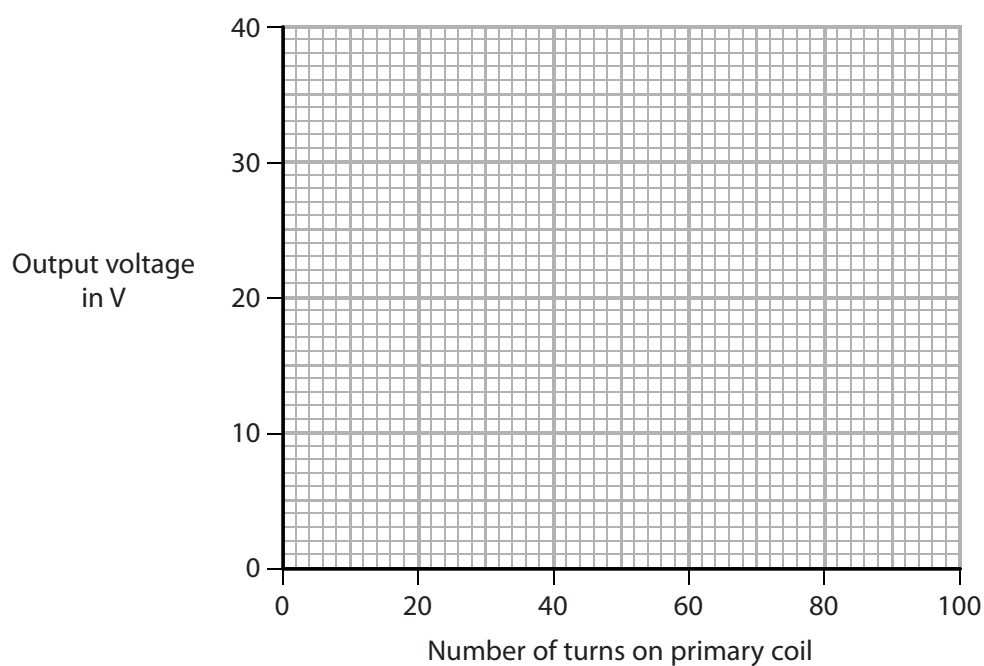
Number of turns on primary coil	Output voltage in V
10	39.6
20	19.7
40	9.9
60	6.6
80	5.0
100	4.0

(a) (i) Plot a graph of the student's results on the grid.

(1)

(ii) Draw a curve of best fit.

(1)



(iii) Describe the relationship between the output voltage and the number of turns on the primary coil.

(2)

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(b) (i) State the formula linking input and output voltages and the turns ratio for the transformer.

(1)

(ii) The input voltage of the transformer is 6.8 V.

Calculate the number of turns on the secondary coil.

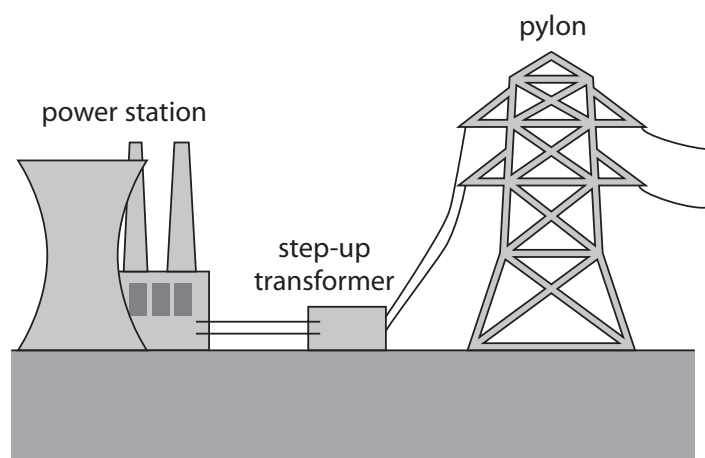
(2)

number of turns = ...

(Total for Question 2 = 7 marks)



- 6 The diagram shows the first stages in a method of transferring energy electrically through long distances.



The table shows data about the step-up transformer.

number of turns in primary coil	2600
input voltage in kV	15
output voltage in kV	330

- (a) (i) State the formula linking input voltage, output voltage, number of primary turns and number of secondary turns for a transformer.

(1)

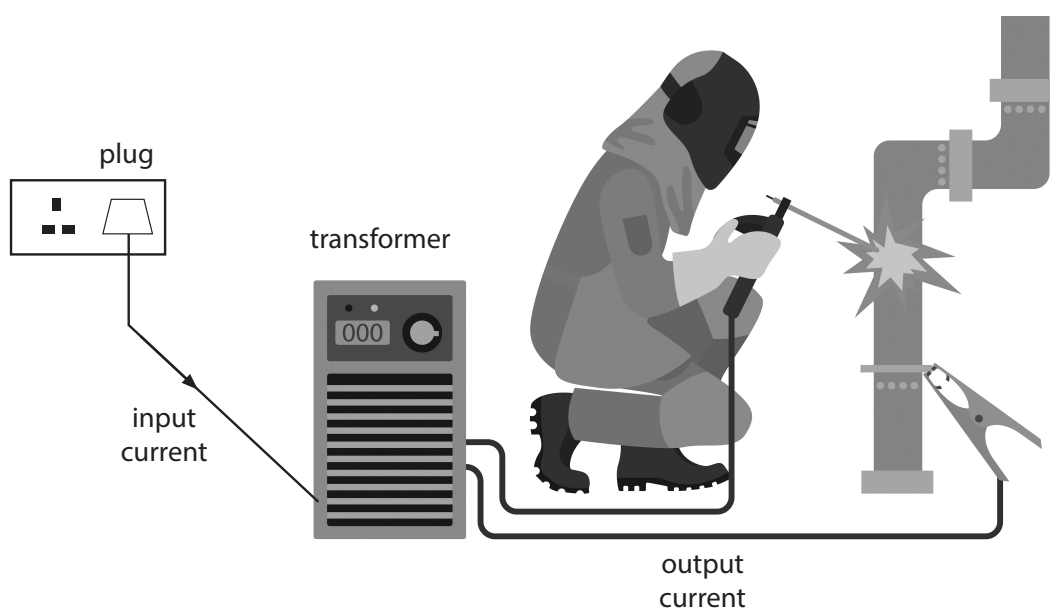
- (ii) Calculate the number of turns on the secondary coil.

(3)

number of turns = ...

8 Welding is a process where pieces of metal are melted and then joined together.

The diagram shows apparatus used for welding.



© Olha1981/Shutterstock

The welding apparatus uses the transformer to decrease the voltage from 230V.

(a) State the name of this type of transformer.

(1)

(b) State the formula linking the turns ratio, the input voltage and the output voltage for a transformer.

(1)

(c) The table gives some information about the transformer.

input voltage in V	230
number of turns on input coil	16
number of turns on output coil	4
input current in A	11

(i) Use information from the table to calculate the output current of the transformer.

Assume that the transformer is 100% efficient.

(5)

current = ... A

(ii) A fuse is installed in the plug which supplies the input current.

Which fuse should be used in this plug?

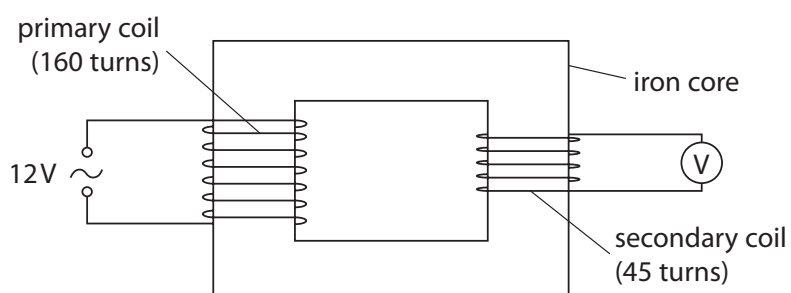
(1)

- ☐ **A** 3 A
- ☐ **B** 5 A
- ☐ **C** 10 A
- ☐ **D** 13 A

(Total for Question 8 = 8 marks)



8 The diagram shows a step-down transformer.



(a) Explain the operation of a step-down transformer.

(4)

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- (b) (i) State the formula linking input voltage, output voltage and the turns ratio of a transformer.

(1)

- (ii) Calculate the output voltage for the transformer.

(3)

voltage = ... V

(Total for Question 8 = 8 marks)



- 6 The National Grid is used in the United Kingdom for the large-scale transmission of electricity. The photograph shows solar panels connected to the National Grid.



(Source: © Jenson/Shutterstock)

- (a) Solar panels provide direct current to a device that outputs an alternating current so that the energy from the solar panels can be supplied to the National Grid.
- (i) Explain why a step-up transformer is used to supply the National Grid.

(2)

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(ii) This is the label on the step-up transformer.

input voltage = 15 kV

output voltage = 340 kV

number of turns on primary coil = 1400

State the formula linking input voltage, output voltage and turns ratio for a transformer.

(1)

(iii) Calculate the number of turns on the secondary coil of the step-up transformer.

(3)

number of turns = ...

(b) Solar panels produce constant direct current (d.c.).

Explain why a transformer will not work when connected to constant direct current.

(3)

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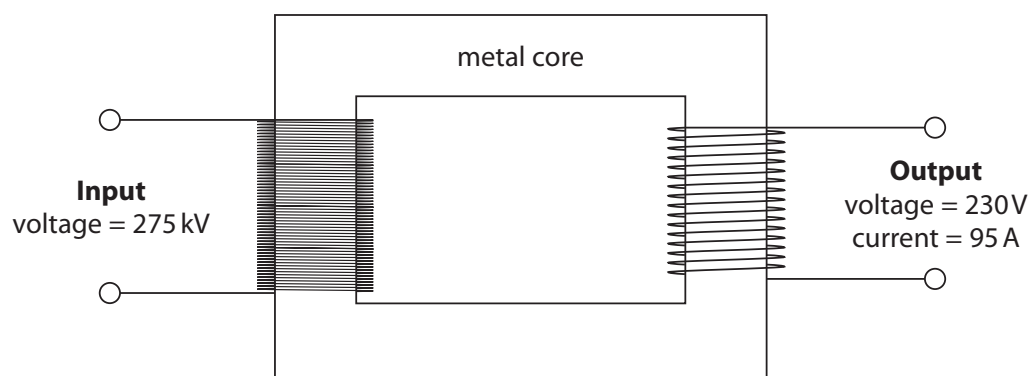
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(Total for Question 6 = 9 marks)



5 Transformers are useful in the transmission of electricity.

(a) The diagram shows a step-down transformer.



(i) Give the name of a suitable metal that could be used in the core of the transformer. (1)

(ii) State the formula linking input power and output power for a transformer. (1)

(iii) The step-down transformer has an input voltage of 275 kV and an output voltage of 230V.

The transformer has an output current of 95 A.

Calculate the input current to the transformer.

Assume the transformer is 100% efficient.

(3)

input current = ... A

6 This question is about electromagnetism.

(a) Diagram 1 shows the construction of an electromagnet.

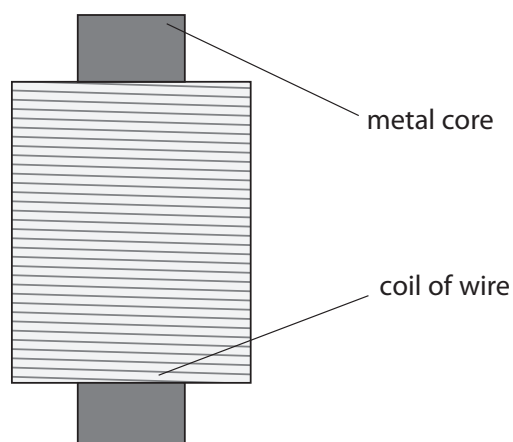


Diagram 1

(i) Name a suitable metal for the core.

(1)

(ii) State what must be done to the coil of wire to produce a magnetic field.

(1)

(b) Electromagnets are used in transformers to change the size of a voltage.

Diagram 2 shows the construction of a simple transformer.

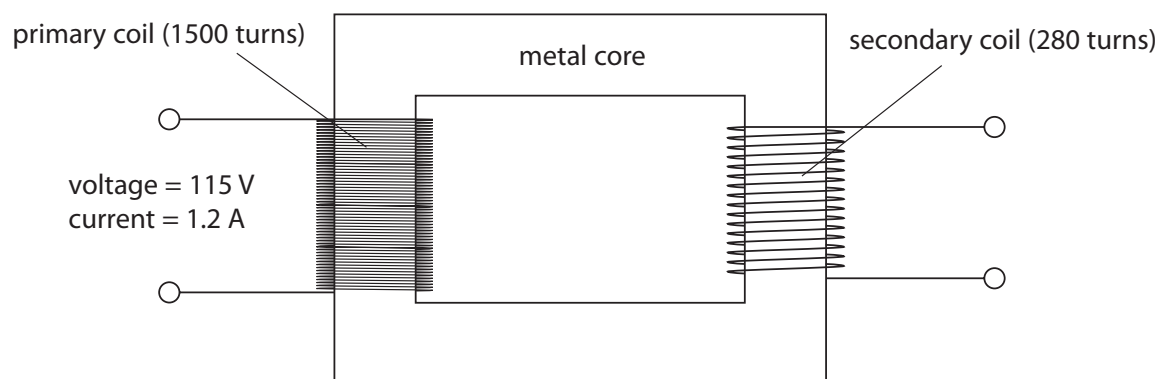


Diagram 2

(i) State the formula linking the input (primary) voltage, output (secondary) voltage and the turns ratio for a transformer.

(1)

(ii) The input voltage to the transformer is 115V.

Show that the output voltage is approximately 20V.

(3)

(iii) The input current to the transformer is 1.2 A.

Calculate the output current.

Assume that the transformer is 100% efficient.

(3)

output current = ... A

(iv) State two factors that would increase the output current of the transformer.

(2)

1

.....

2

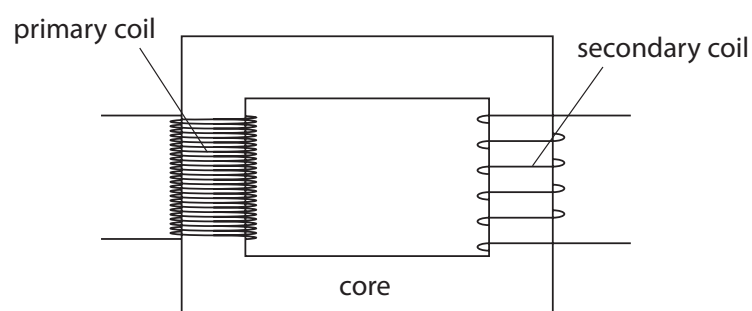
.....

(Total for Question 6 = 11 marks)



6 A student investigates transformers.

(a) The diagram shows a typical transformer.



State the name given to this type of transformer.

(1)

(b) The student investigates the effect of changing the number of turns in the secondary coil.

This is his method.

- apply a constant maximum voltage to a primary coil with 1200 turns
- use a secondary coil with 100 turns
- measure the output voltage of the transformer
- replace the secondary coil with one that has 200 turns
- measure the output voltage again

The student repeats this method using different numbers of turns in the secondary coil.

(i) Suggest how the student could improve the reliability of his investigation.

(1)

.....

.....

.....

(ii) These are the student's results.

number of turns = 100, output voltage = 1.3 V	number of turns = 400, output voltage = 5.0 V
number of turns = 200, output voltage = 2.5 V	number of turns = 500, output voltage = 6.3 V
number of turns = 300, output voltage = 3.8 V	number of turns = 600, output voltage = 7.5 V

Draw a table of these results.

(3)

(iii) Suggest how the student could improve the precision of his voltage measurement.

(1)

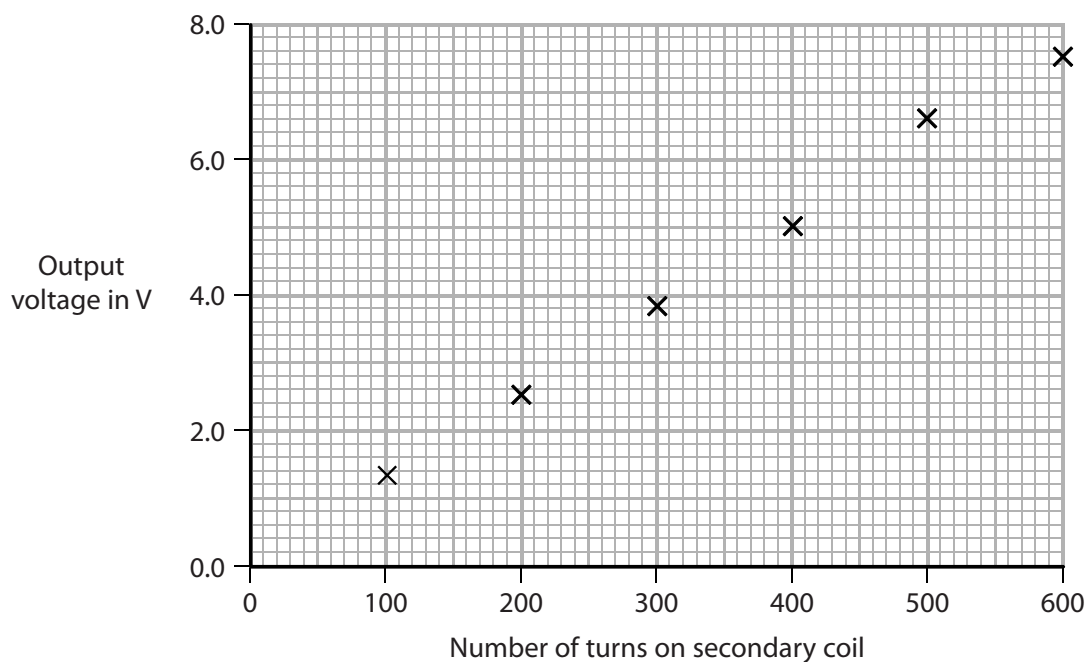
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(c) The student plots this graph to show the results of his investigation.



(i) The student plots one of his results incorrectly.

Draw a circle around the incorrectly plotted result on the graph.

(1)

(ii) Draw the line of best fit.

(1)

(iii) Describe the relationship shown by the graph.

(2)

.....

.....

.....

.....

(d) The primary coil has 1200 turns.

Using the student's data, calculate the primary voltage used in his investigation.

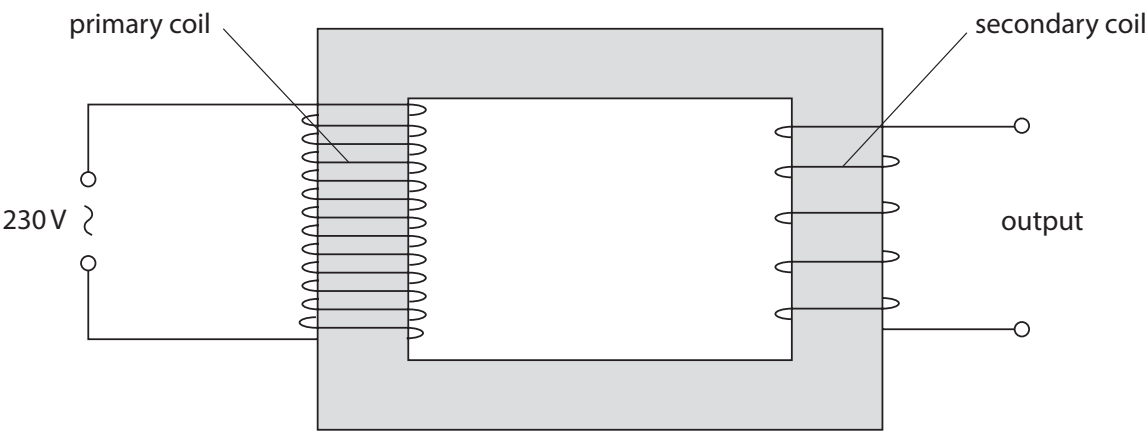
(4)

primary voltage = ... V

(Total for Question 6 = 14 marks)



- 7 This question is about transformers.
- (a) The diagram shows a step-down transformer.



The table gives some data for the step-down transformer.

Input (primary) voltage	230V
Input (primary) current	1.3 A
Output (secondary) current	4.0 A
Number of turns on primary coil	1000
Number of turns on secondary coil	300

- (i) State the formula linking input (primary) voltage, output (secondary) voltage and the turns ratio for a transformer.

(1)

- (ii) Use data from the table to calculate the output (secondary) voltage of the transformer.

(3)

output (secondary) voltage = ... V

- (iii) This transformer is not 100% efficient.

The efficiency of a transformer can be calculated using the formula

$$\text{efficiency} = \frac{\text{useful output power}}{\text{total input power}} \times 100\%$$

Calculate the efficiency of the transformer.

(5)

efficiency = ...%



- (b) Explain how transformers are used in the efficient, large-scale transmission of electrical energy.

You may draw a diagram to help your answer.

(5)

(Total for Question 7 = 14 marks)



4 This question is about transformers.

(a) Describe the structure of a step-up transformer.

You may draw a diagram to help your answer.

(3)

.....

.....

.....

.....

.....

(b) A step-up transformer has an input voltage of 230V and an input current of 4.5 A.

The output current of the transformer is 0.21 A.

(i) State the formula linking input power and output power for a transformer that is 100% efficient.

(1)

(ii) Calculate the output voltage of the transformer.

(3)

output voltage = ... V

(Total for Question 4 = 7 marks)



MARK SCHEMES

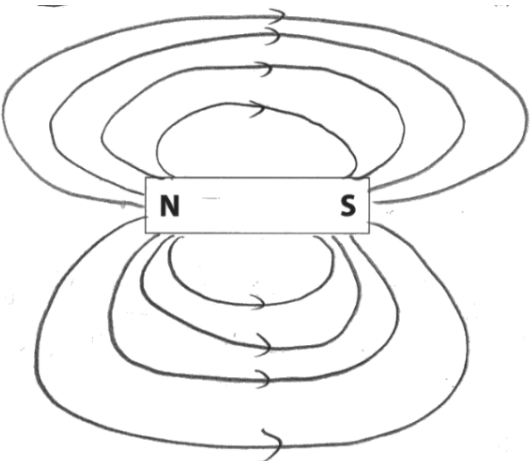
official mark schemes



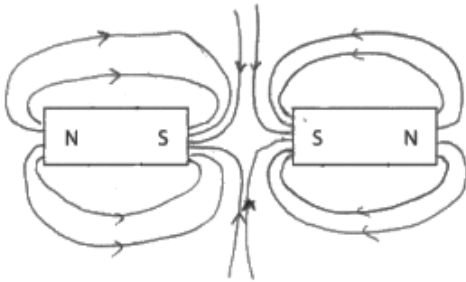
Question number	Answer	Notes	Marks
1	north; steel; hard; north; soft;	this order only	5

Total for Question 1 = 5 marks



Question number	Answer	Notes	Marks
8 (a)	at least four lines leaving/entering poles; at least one loop 'above' and one loop 'below'; arrowheads on at least four lines which are self-consistent; 	accept part loops ignore field lines that cross	3
(b)	idea of wire cutting field lines; idea of an <u>induced voltage</u>;	allow higher order ideas involving flux linkage	2

(Total for Question 8 = 5 marks)

Question number	Answer	Notes	Marks
2 (a)	MP1. method to show shape; e.g. use compass(es) use of iron filings / powder MP2. use of plotting compass to show direction; MP3. a further method detail; e.g. move compass / multiple compasses in different positions idea of another line or lines added sprinkle iron filings (on to card) tap card (to distribute iron filings)	all marks may be given from diagram allow if compass seen in diagram pointing in a suitable direction allow equivalent materials to card e.g. paper, plastic etc.	3
(b)	correctly drawn field line patterns for both bar magnets; correctly drawn field line pattern for region between the magnets; at least three field line directions given from north to south; 	should show no lines linking south poles not every line needs to have an arrow reject mark if directions contradict 2 marks max. if any lines overlap condone lines touching	3

Total for Question 2 = 6 marks

Question number	Answer	Notes	Marks
2 (a)	(plotting) compass(es);	allow suspended magnet, magnetometer allow higher level responses e.g. Hall probe, search coil	1
(b)	one mark for each correct indication;;;	2 marks max. if more than three indications given	3
(c)	any two from: difficult to magnetise; difficult to demagnetise; idea that it retains its magnetism;	allow idea of taking a long time to magnetise allow idea of taking a long time to demagnetise	2

Total for Question 2 = 6 marks

Question number	Answer	Notes	Marks
7 (a)	substitution into momentum = mass $\times$ velocity; evaluation; e.g. $p = 0.0041 \times 0.15$ (p =) 0.00062 (kgm/s)	allow use of standard symbols e.g. $p = m \times v$ -1 for POT error allow decimal or standard form allow 0.000615	2
(b)	velocity of ball increases; momentum increases;	allow ball speeds up	2
(c)	substitution into $F = (mv - mu) / t$; rearrangement; evaluation; e.g. $1.3 = 0.0041 \times v (-0) / 0.0025$ (v =) $1.3 \times 0.0025 / 0.0041$ (v =) 0.79 (m/s)	-1 for POT error allow 0.79268...	3

Total for Question 7 = 7 marks

Question number	Answer	Notes	Marks
3 (a)	(to the) left; (because) repulsion (due to like magnetic poles);	allow towards A, away from B ignore backwards reject if mention of charge	2
(b) (i)	0.045 (kg m/s);	allow 'the same'	1
(ii)	momentum of B after collision = $0.045 - (-0.021)$; evaluation; e.g. $0.045 - -0.021$ (momentum =) 0.066 (kg m/s)	allow 0.024 for 1 mark allow $0.045 + 0.021$	2
(iii)	substitution into $F = \text{change in momentum} / \text{time taken}$; evaluation; e.g. $F = 0.066 / 0.19$ (F =) 0.35 (N)	allow ECF from (ii) use of 0.024 from (ii) gives 0.126... (N)	2
(iv)	(to the) right;	allow 0.347... (N) allow towards B, away from A	1

(Total for Question 3 = 8 marks)

Question number	Answer	Notes	Marks
6 (a)	arrows drawn on at least two field lines pointing towards the south pole;	condone if arrows are not drawn on the existing field lines reject if any arrows point away from the south pole	1
(b)	B (nickel); A is incorrect because copper is not a magnetic material C is incorrect because plastic is not a magnetic material D is incorrect because zinc is not a magnetic material		1
(c)	field line spacing/density changes (with distance from south pole); further apart field lines shows weaker field strength;	allow field lines aren't parallel scores both marks allow RA ignore references to forces	2
(d)	(i) idea that a north pole is induced on the side of the iron nearest the bar magnet; idea that opposite poles attract;	allow if shown on diagram allow north attracted to south ignore references to charge	2
	(ii) iron is a soft magnetic material; iron loses its magnetism (when it is removed from the magnetic field);	ignore iron is a soft magnet ignore iron is a temporary magnet allow iron is (easily) demagnetised allow iron is only magnetic when it is in a field	2

Total for Question 6 = 8 marks

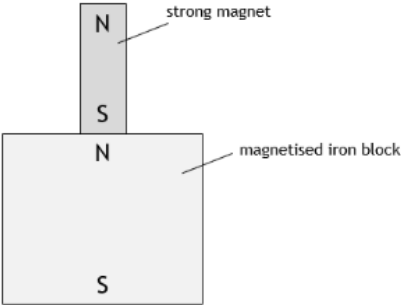
Question number	Answer	Notes	Marks
11 (a)	MP1. method to show shape; e.g. use compass(es) use of iron filings/powder MP2. use of plotting compass to show direction; MP3. a further method detail; e.g. move compass / multiple compasses in different positions idea of another line or lines added sprinkle iron filings (on to card) tap card (to distribute iron filings)	all marks may be given from diagram	3
(b) (i)	both arrows correctly pointing from north to south;	reject if arrows contradict	1
(b) (ii)	idea that field lines are closer together / further apart; (showing that) field strongest near the poles / weaker away from the poles;	allow "magnet" for "poles"	2
(c)	any pair of readings read from the graph; correct substitution into formula to find constant; different pair of readings used correctly to find constant; statement that the results agree with the conclusion; e.g. when distance = 30mm, magnetic field strength = 2.3 mT ($2.3 \times 30^2 =$) 2070 ($0.8 \times 50^2 =$) 2000 constants are approximately the same so results agree with conclusion	DOP allow idea that the constants are different so the results do not agree with the conclusion	4

Total for Question 11 = 10 marks



Question number	Answer	Notes	Marks
7 (a)	north pole labelled on magnet Y; lines drawn straight and vertical between magnets; lines are equally spaced with arrows pointing upwards;	ignore curved lines at the edges of the magnets	3
(b) (i)	any two from: MP1. iron is (a) magnetic (material); MP2. iron ball becomes a magnet / becomes magnetised (N pole at top); MP3. iron ball is attracted to the magnet;		2
(ii)	downward arrow drawn shorter than magnetic force arrow;	ignore starting point of arrow, judge length and direction only	1
(iii)	weight = mass × gravitational field strength;	allow standard symbols and rearrangements e.g. $m = W / g$	1
(iv)	calculation of weight; dimensionally correct substitution into weight formula; rearrangement; evaluation; e.g. weight = (165 – 124 =) 41 (mN) 0.041 = mass × 10 (mass =) 0.041 / 10 (mass =) 0.0041 (kg)	ECF if incorrect weight or 165, 124, 289 used as the weight allow $g=9.8, 9.81$ -1 for POT error provided 10 (N/kg) is used somewhere 0.0165, 0.0124, 4.1 gets 3 marks max 16.5, 12.4 gets 2 marks max	4
(v)	any two from: MP1. weight (of the iron ball) stays the same; MP2. magnetic force increases; MP3. magnetic field strength increases;	allow greater attraction from magnet	2

Total for Question 7 = 13 marks

Question number	Answer	Notes	Marks
2 (a)	opposite poles labels; horizontal straight lines drawn joining poles; minimum 3 lines drawn equally spaced; arrows drawn on lines consistent with labelling of poles;	ignore orientation ignore lines drawn outside the region between the poles judge 'straight' by eye i.e. from N to S	4
(b) (i)	north (pole)/N drawn at the top and south (pole)/S drawn at the bottom; e.g. 	condone away from top and bottom provided 'N' is above 'S'	1
(ii)	(will not work because) iron will lose its magnetism; (because) iron is a (magnetically) soft material;	allow iron cannot be permanently magnetised	2

Total for Question 2 = 7 marks

Question number	Answer	Notes	Marks
7	any five from: MP1. current in coil produces magnetic field; MP2. direction of this magnetic field is (continuously) changing; MP3. field of coil interacts with field of magnet; MP4. producing a force on coil/wire; MP5. direction of the force changes; MP6. cone/coil/wire vibrates; MP7. air particles (next to the cone) are made to vibrate;	allow coil is magnetised / becomes an electromagnet allow cone moves in and out / backwards and forwards	5

Total for Question 7 = 5 marks

Question number	Answer	Notes	Marks
6 (a)	solenoid / coil (of wire); (direct/d.c.)current in the wire/coil/solenoid;	all ideas may be shown on diagram e.g. labelled wire wrapped multiple times around a box shape on diagram condone idea of connection to a voltage source e.g. battery, powerpack, cell etc ignore alternating current / a.c.	3
	(soft) iron core;	ignore steel accept 'magnetically soft material' reject indication of a complete (iron) loop reject explicit reference to bar magnet	
(b) (i)	idea of upwards/ towards top of page;	may be shown on diagram ignore 'north'	1
(ii)	any TWO from: force (always) at right angles (to velocity); causes the proton's direction to change; (because) proton motion is equivalent to a current; (this causes) the direction of the force on the proton to change; idea of magnitude of force is constant;	may be shown on the diagram	2
(iii)	(velocity changes because) the direction changes;	ignore idea of speed or magnitude of velocity changes	1

Total for Question 6 = 7 marks

Question number	Answer	Notes	Marks
8 (a)	(i) idea that proton and plate have opposite charges;	allow proton is positive ignore different charges	1
	(ii) substitution into $a = (v-u)/t$; rearrangement; evaluation to 2 s.f. or more; e.g. $1.90 \times 10^{11} = 1.38 \times 10^5 / t$ $t = 1.38 \times 10^5 / 1.90 \times 10^{11}$ $t = 7.26... \times 10^{-7} \text{ (s)}$	award full marks for using given time to calculate either acceleration or speed to 4 s.f. or more allow 0.000 000 73, $7.3 \times 10^{-7} \text{ (s)}$ condone 0.000 000 72, $7.2 \times 10^{-7} \text{ (s)}$	3
(b)	(i) into the page / eq;	allow $\otimes$	1
	(ii) any two from: idea that force increases; acceleration increases; proton moves in tighter circle / hits detector further to the left;	ignore (proton) speed increases allow hits detector closer to hole allow path of proton is shorter allow if seen on diagram	2

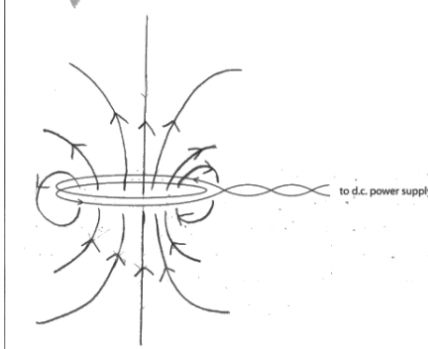
Total for Question 8 = 7 marks

Question number	Answer	Notes	Marks
7 (a)	opposite poles facing; held (very) close together;	reject if magnets described as touching	2
(b) (i)	arrow directed towards the centre of the circle in line with the position of the proton;	judge by eye condone arrow that does not originate at the position of the proton	1
(ii)	correct diameter given to 1 significant figure = 1 mark; correct diameter given to 2 or 3 significant figures = 2 marks;;	6 (cm) 5.8-6.1 (cm)	2
(iii)	use of radius; dimensionally correct substitution into $v = 2 \times \pi \times r / T$; evaluation; e.g. $r = (6.0 / 2 =) 3.0 \text{ cm}$ $v = 2 \times \pi \times 0.030 / 8.7 \times 10^{-6}$ ($v =$) 22 000 (m/s)	allow ecf from (b)(ii) -1 for POT error accept alternative method using $v = \pi \times d / T$ allow 21 000-22 000 (m/s)	3

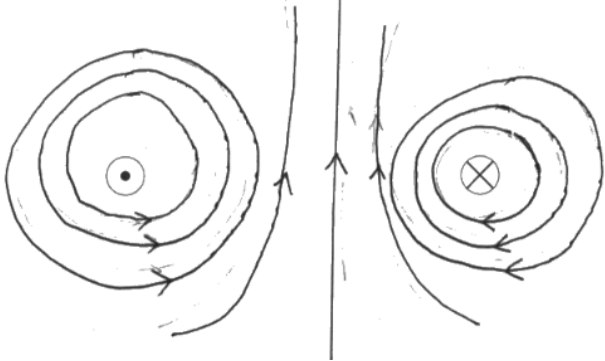
Total for Question 7 = 8 marks

Question number	Answer	Notes	Marks
7 (a)	coil of wire; current in the wire; iron core;	current may be inferred from diagram	3
(b)	down;	allow force arrow drawn pointing down on diagram	1
(c) (i)	time taken; for {activity / number of (radioactive) nuclei / amount of isotope / count rate} to halve;	allow atoms for nuclei	2
(ii)	any two from: MP1. radiation unlikely to penetrate out of walls; MP2. (more than) two half-lives have passed; MP3. amount of barium-133 remaining is less (than 25%); MP4. visitors exposed to radiation for very short time;	allow idea that activity / amount of radiation is (much) less than before	2

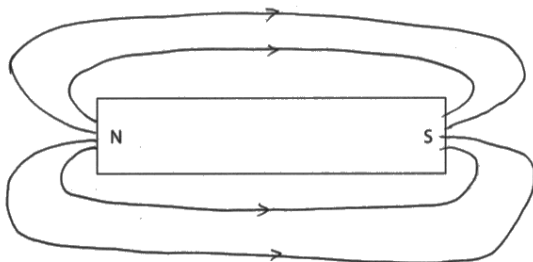
Total for Question 7 = 8 marks

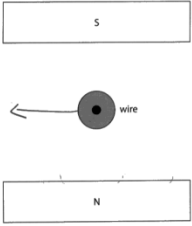
Question number	Answer	Notes	Marks
8 (a)	A (into the page); B is incorrect because this field would produce a force into the page C is incorrect because this field would produce a force to the left D is incorrect because this field would not produce a force at all		1
(b)	at least one straight, vertical central field line; at least one field line drawn circling the wire / at least one peripheral field loop; field direction correct and consistent throughout and shown on at least two field lines; 	ignore breaking of field lines as they pass through the centre of the coil judge by eye condone spiral drawn around wire DOP	3
(c) (i)	any three of: MP1. (current produces) alternating magnetic field (in charging base coil); MP2. idea that field is cut by coil in phone; MP3. voltage induced (across coil in phone); MP4. therefore current in battery (from coil in phone);	allow equivalent words for alternating e.g. variable, changing etc. allow higher level responses in terms of flux linkage	3
(ii)	any one advantage; e.g. battery will charge faster / stronger magnetic field any one disadvantage; e.g. causes a great(er) heating effect	condone 'greater risk of electric shock'	2

Total for Question 8 = 9 marks

Question number	Answer	Notes	Marks
7 (a)	EITHER plotting compass; multiple compasses or repeated use of single compass; joining up of dots/idea of compasses forming continuous line(s); OR iron filings; sprinkled; card tapped;	all marks can be awarded for a correctly labelled diagram	3
(b)	one field line passing through middle from top to bottom; circular/elliptical field lines around wires; field line spacing increasing further from wires; arrows correct direction; 		4
(c) (i)	A; B is not right as the force cannot be generated by the LHR. C and D are not right as the force cannot be parallel to the magnetic field.		1
(ii)	current (in one wire) and field (from other wire) both reversed; the two effects cancel (so no change);	DOP allow relevant reference to (F)LHR	2

Total for Question 7 = 9 marks

Question number	Answer	Notes	Marks
4 (a)	B (copper); A is incorrect because it is magnetic C is incorrect because it is magnetic D is incorrect because it is magnetic		1
(b)	field line connecting one pole to the other; at least two complete field lines, but none touching / crossing; all directions shown on field lines correct (N to S); 	allow small gap where field line joins magnet ignore field lines inside the magnet ignore field lines that start outside the pole region only one arrow required for the mark but contradictory directions negates the mark ignore arrow(s) inside the magnet	3
(c)	steel is magnetic / eq; (therefore) magnet stays magnetised (for a long period of time) / eq ;	allow 'steel is a hard magnetic material' for both marks reject reference to charge	2

(d)	(i) arrow drawn is horizontal; arrow drawn is to the left; 	ignore starting position of arrow judge by eye ignore field lines	2
	(ii) Any two from: MP1 reference to weaker field MP2 moving magnets further apart MP3 use weaker magnets MP4 reference to lower current MP5 decreasing diameter of wire MP6 decrease voltage (of supply)	increasing length of wire (in circuit)	2

Total for Question 4 = 10 marks

Question number	Answer	Notes	Marks
10 (a)	use of voltage = current $\times$ resistance; calculation of voltage across 240 ohm resistor (2.88 V); idea that voltages of two resistors in series adds up to supply voltage; evaluation of voltage across R; e.g. $V = I \times R$ $V_{240} = (0.012 \times 240 =) 2.88 \text{ (V)}$ $V_R + V_{240} = 9.2$ $(V_R =) 6.3 \text{ (V)}$	allow rearrangements and standard symbols calculate total resistance of circuit (767 Ω) evaluation of resistance of R (527 Ω) evaluation of voltage across R (using $V = IR$) allow 2.9 (V) allow 9.2 – 2.88 or $V + 2.88 = 9.2$ allow 6.32 (V) if mA not converted to A and 2880 seen then award 2 marks max.	4
(b) (i)	any three from: MP1. coil produces a magnetic field; MP2. (which) interacts with the magnetic field of the (permanent) magnet; MP3. producing a force acting on the coil; MP4. opposite forces on either side of coil; MP5. coil rotates / turns;	allow coil becomes an electromagnet allow one side is pushed up and the other is pushed down allow coil spins, pointer moves (to the left)	3
(ii)	vertical arrow UP (on wire CD);		1
(iii)	any three from: MP1. more turns on the coil; MP2. stronger (permanent) magnet; MP3. add an iron core; MP4. producing a larger force (for the same current); MP5. use of a longer pointer; MP6. use of a weaker return spring; MP7. producing a greater movement at the end of the pointer (for the same current);	allow “more coils” allow method to increase field strength e.g. moving magnets closer together allow producing the same force for a smaller current allow same movement for a smaller current	3

Total for Question 10 = 11 marks



Question number	Answer	Notes	Marks
12 (a)	A - arrangement W; B cannot be correct as arrangement X would give a downwards force C and D cannot be correct because at the position of the wire, the magnetic field is zero, so there cannot be a magnetic force on the wire		1
(b) (i)	substitution into “ $W = mg$ ”; evaluation; e.g. $W = 0.0065 \times 10$ $W = 65 \text{ (mN)}$	ignore POT for this mark accept use of $g = 9.8(1) \text{ m/s}^2$ giving 63.7 or 63.8 (mN)	2
(ii)	resultant force is difference between weight and magnetic force; resultant force = 31 mN; substitution in “ $F=ma$ ”; re-arrangement; evaluation; e.g. resultant force = $65 - 34 = 31 \text{ mN}$ resultant force = $31 \times 10^{-3} = 6.5 \times 10^{-3} \times a$ $a = 31 \times 10^{-3} / 6.5 \times 10^{-3}$ $a = 4.8 \text{ (m/s}^2\text{)}$	allow ecf from (b)(i) POT error gives 1 mark penalty 5.2(3) scores 3 MAX (no evidence of resultant idea)	5
(iii)	EITHER - increase the current; OR - by increasing the voltage of power supply; - increase the magnetic field strength; - by using stronger magnets/moving the poles closer together;	ignore unqualified reference to increasing the turns/creating a coil	2
(iv)	use a.c. rather than d.c.; since a.c. current has alternating/changing current direction;		2

Total for Question 12 = 12 marks



Question number	Answer	Notes	Marks														
6 (a)	idea that there must be a current in the wire; this current must be to the right;	allow charge/electrons moving in the wire reject references to positive electrons allow electrons moving to the left	2														
(b) (i)	any one of: MP1. idea of avoiding fall objects from hitting hands/feet etc; MP2. taking care of heating effect of current; MP3. idea of protecting floor from damage;	ignore electric shocks, safety glasses, gloves allow idea of not standing underneath	1														
(ii)	correct calculation of mean; answer given to 3 significant figures; e.g. (mean current =) 1.833...(A) (mean current =) 1.83 (A)	independent mark	2														
(iii)	y-axis scale with a sensible, continuous scale such that plotted data covers 50% of the grid; y-axis labelled with current/I AND amps/A; all data plotted correctly; <table border="1"><thead><tr><th>Mass of load in g</th><th>Mean current in A</th></tr></thead><tbody><tr><td>100</td><td>0.30</td></tr><tr><td>200</td><td>0.58</td></tr><tr><td>300</td><td>0.89</td></tr><tr><td>400</td><td>1.23</td></tr><tr><td>500</td><td>1.50</td></tr><tr><td>600</td><td>1.83</td></tr></tbody></table>	Mass of load in g	Mean current in A	100	0.30	200	0.58	300	0.89	400	1.23	500	1.50	600	1.83	reject if scale uses multiples of 0.3, 0.7 or 0.9 or if discontinuous allow ecf from (ii) reject if scale is discontinuous data should be plotted to within half a small square	3
Mass of load in g	Mean current in A																
100	0.30																
200	0.58																
300	0.89																
400	1.23																
500	1.50																
600	1.83																
(iv)	straight line drawn with approximately equal distribution of points either side;	allow ecf from incorrect plotting/scale line does not need to pass through origin	1														
(v)	any three from: MP1. indication that 1.0 kg is 1000 g; MP2. use of data from table to show that ratio supports 3.0 A current value; MP3. (because) current is (directly) proportional to mass; MP4. idea that 1.0 kg is (far) beyond range of collected data/graph; MP5. idea that pattern may not continue outside range of data collected/graph;	can be inferred from working e.g. $2 \times 500\text{g} = 1\text{kg}$ e.g. 500g gives 1.50A and 1000g is double 500g, 100g gives 0.30A and 1000g is 10 times 100g	3														

Total for Question 6 = 12 marks



Question number	Answer	Notes	Marks
4 (a)	(i) recall of equation: speed = frequency $\times$ wavelength; substitution or re-arrangement; correct evaluation; correct answer = 0.013 (m) e.g. speed = frequency $\times$ wavelength wavelength = speed $\div$ frequency wavelength = $330 \div 25000$ wavelength = 0.0132... (m)	allow use of standard symbols e.g. $v = f \times \lambda$ condone s for speed reject w for wavelength answer to 3sf is 0.0132 (m)	3
	(ii) amplitude corresponds to 2 squares; 2 squares gives 10 V for amplitude;	ecf incorrect number of squares for amplitude e.g. 4 squares giving 20V scores 1 mark	2
(b)	(i) field lines outside of coil appear to loop from end to end; arrow directions self-consistent; no overlapping field lines;	allow field lines approximately uniform through solenoid condone incorrect poles	3
	(ii) any THREE from: MP1. idea of force on coil from magnet; MP2. idea of alternating force on card; MP3. card vibrates; MP4. idea that card forces air to vibrate; MP5. longitudinal wave formed;	allow idea of interaction between fields of bar magnet and coil allow idea of series of compressions and rarefactions	3
	(iii) idea that 25 kHz is outside the range of human hearing; upper limit of human hearing is 20 kHz;	ignore reference to 20Hz or lower limit	2
	(iv) increase current (amplitude)/ increase strength of (bar) magnet/ increase number of turns on coil;	allow increase density of turns on coil condone change card for a different material allow change size or shape of card allow moving magnet closer to the coil allow higher order answers in terms of resonance	1

Total for Question 4: 14 marks

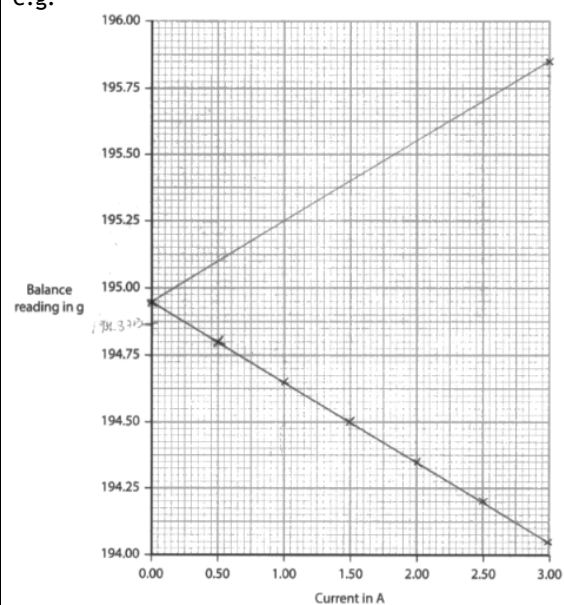


Question number	Answer	Notes	Marks
5	any six from: MP1. current/coil has magnetic field; MP2. interaction between (magnetic) fields; MP3. (produces a) force on coil; MP4. brushes allow (sliding) contact between split ring/commutator/coil and wires; MP5. split ring/commutator reverses the direction of the current (in the coil); MP6. (which) reverses the direction of the force on (each side of) the coil; MP7. current/force is reversed every half turn (when coil is vertical);	allow coil becomes an electromagnet allow current/coil has electromagnetic field allow (magnetic) fields overlap ignore cutting of field ignore current interacting with field allow idea that brushes allow the coil to spin without tangling (connecting) wires allow idea that brushes prevent circuit being broken / allow a current to always flow allow idea of swapping negative and positive charges / terminals	6

Total for Question 5 = 6 marks

Question number	Answer	Notes	Marks																
10 (a)	any two from: idea that current causes a heating effect; reduce risk of burns; maintain a constant resistance for the rod;	ignore comments relating to electric shock allow rod/wire/power supply might get hot, prevents overheating of the rod/wire/power supply ignore risk of fire	2																
(b)	evaluation of change in mass; conversion of g to kg; substitution into $W = mg$; evaluation of force; e.g. $\Delta m = 194.95 - 193.80 = 1.15 \text{ (g)}$ $\Delta m = 0.00115 \text{ (kg)}$ force = 0.00115×10 (force =) 0.0115 (N)	allow ecf from incorrect/no unit conversion allow use of $g = 9.8$, 9.81 ignore any minus signs allow 0.01127 , 0.0112815 (N)	4																
(c) (i)	all points plotted correctly to within $\frac{1}{2}$ small square; <table border="1"><thead><tr><th>Current in A</th><th>Balance reading in g</th></tr></thead><tbody><tr><td>0.00</td><td>194.95</td></tr><tr><td>0.50</td><td>194.80</td></tr><tr><td>1.00</td><td>194.65</td></tr><tr><td>1.50</td><td>194.50</td></tr><tr><td>2.00</td><td>194.35</td></tr><tr><td>2.50</td><td>194.20</td></tr><tr><td>3.00</td><td>194.05</td></tr></tbody></table>	Current in A	Balance reading in g	0.00	194.95	0.50	194.80	1.00	194.65	1.50	194.50	2.00	194.35	2.50	194.20	3.00	194.05		1
Current in A	Balance reading in g																		
0.00	194.95																		
0.50	194.80																		
1.00	194.65																		
1.50	194.50																		
2.00	194.35																		
2.50	194.20																		
3.00	194.05																		
(ii)	continuous straight line of best fit;	allow ecf from incorrect plotting in (i) reject if clearly drawn dot to dot	1																
(iii)	straight line drawn of positive gradient; line starts at same mass reading for zero current as previous line; line ends at 195.85 g when current is 3.00 A ;	to within ± 1 small square	3																

e.g.



Total for Question 10 = 11 marks

Question number	Answer	Notes	Marks
3 (a)	magnet moves through / near coil of wire; field lines of magnet are cut by coil; idea that voltage is induced across the coil;	allow idea that magnet enters / leaves coil ignore references to the coil having its own field ignore references to current	3
(b)	any two from: MP1. shaking torch harder / faster; MP2. increasing the number of turns on the coil; MP3. using a less resistive metal for the coil of wire;	allow moving coil/magnet faster ignore “larger coil”	2

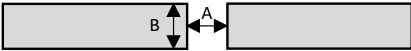
Total for Question 3 = 5 marks



Question number	Answer	Notes	Marks
10 (a)	method to show shape; e.g. use compass(es) use of iron filings/powder use of plotting compass to show direction; a further method detail; e.g. mark card/move compass/multiple compasses idea of another line or lines added sprinkle (iron filings) tap card (to distribute iron filings)	all marks may be awarded from a labelled diagram	3
(b) (i)	any four from: MP1. idea that core gains a magnetic field; MP2. idea of a changing magnetic field; MP3. idea that field lines cut by wire; MP4. voltage induced (across coil); MP5. (causing a) current in the wire;	allow higher level ideas in terms of flux and flux linkage	4
(ii)	any one from: MP1. idea that dynamo-wheel friction makes bicycle harder to pedal; MP2. idea that lights would vary in brightness; MP3. lights will be off when bicycle is stationary;	allow current / brightness of lamps depends on how fast bicycle is moving	1

Total for Question 10 = 8 marks



Question number	Answer	Notes	Marks
8 (a)	two magnets with opposite poles facing; poles brought close to each other; 	accept annotated diagram for either mark accept from diagram if magnets drawn closer together than the thickness of their poles i.e. $A < B$ (on diagram)	2
(b) (i)	any three from: MP1. ammeter displays a current/reading (in one direction); MP2. (because) a voltage is induced; MP3. induced voltage gives a current; MP4. ammeter reading goes negative / shows current in opposite direction; MP5. (because) wire changes direction;	allow 'an alternating current / a.c. is produced'	3
(ii)	any four from: MP1. ammeter reading / current is greater (than before); MP2. because wire moving quicker; MP3. more field lines cut (per second); MP4. gives a larger induced voltage; MP5. frequency of alternating current increases;	allow idea that direction of current changes more frequently	4

Total for Question 8 = 9 marks

Question number	Answer	Notes	Marks
10 (a)	(coil rotates) through magnetic field / cutting field lines; voltage is <u>induced</u> ;	allow idea of coil experiencing a changing flux ignore current is induced accept p.d. or potential difference for 'voltage'	2
(b) (i)	idea that d.c. is current in one direction only; diode allows current flow in one direction only/eq;		2
(ii)	higher speed generates higher voltage; higher voltage causes higher current;	ignore references to energy allow higher tier answers in terms of increased flux linkage i.e cutting field lines faster accept p.d. or potential difference for 'voltage'	2
(c)	substitution into given equation ' $E = IVt$ '; rearrangement; evaluation; e.g. $14\,000 = I \times 7.2 \times 8400$ (current =) $14000 / (7.2 \times 8400)$ (current =) 0.23 (A)	-1 POT error treat misconversion of time as a POT error allow 0.23...(A) allow 0.2 (A)	3

Total for Question 10 = 9 marks

Question number	Answer	Notes	Marks
12 (a)	idea of a current (in the coil);	ignore references to electromagnets	1
(b) (i)	d.c. travels in one direction only; idea of a.c. continuously changing direction;	allow keeps changing direction, changes direction constantly etc.	2
(ii)	idea of changing magnetic field (from transmitter coil); idea of gold ring cutting field lines; idea of induced voltage for gold ring;	allow field moving through ring ignore ring interacting with field ignore induced current	3
(c)	any four from: MP1. alternating current in loudspeaker ; MP2. magnetic fields interact (in loudspeaker); MP3. causing a force (on loudspeaker cone); MP4. a.c. causes changing force direction; MP5. loudspeaker (cone) vibrates;	ignore fields cutting allow coil for cone allow coil for cone allow description of vibrations e.g. “back and forth”	4

Total for Question 12 = 10 marks

Question number	Answer	Notes	Marks
9 (a)	(turning handle makes) coil turn / rotate ; coil cuts through; magnetic field (of the permanent magnets);	reject if suggested that coil rotation is due to motor effect ignore 'interacts with'	3
(b) (i)	speed = frequency × wavelength;	allow standard symbols and rearrangements allow v, c, s for speed allow λ for wavelength	1
(ii)	substitution; rearrangement; evaluation; e.g. $3.0 \times 10^8 = 93 (\times 10^6) \times \text{wavelength}$ $\text{wavelength} = 3.0 \times 10^8 / 93 (\times 10^6)$ (wavelength =) 3.2 (m)	ignore units until evaluation 1 mark may be awarded in the absence of any others for correctly converting MHz to Hz POT error scores 2 marks max. allow 3.2258...(m)	3
(c) (i)	any four from: MP1. loudspeaker (coil) has a current / magnetic field; MP2. interaction between magnetic fields; MP3. causes a force to be exerted on speaker (cone); MP4. a.c. changes direction; MP5. force on speaker (cone) changes direction; MP6. causes speaker (cone) to vibrate;	allow 'interferes' for interacts	4
(ii)	any one from: increase strength of magnet; use a larger current; use more turns of wire on loudspeaker coil;	ignore references to adding iron core ignore 'increase size of magnet' allow larger voltage (across coil) allow 'more coils of wire'	1

Total for Question 9 = 12 marks

Question number	Answer	Notes	Marks
9 (a) (i)	B (elastic); A is incorrect because there is no transfer from a chemical store C is incorrect because the gravitational potential store decreases D is incorrect because the spring is stationary in both cases		1
(ii)	any six from: MP1. elastic energy (store) decreases (on way up); MP2. kinetic energy (store) increases (on way up); MP3. gravitational (store) increases (on way up); MP4. idea of process reversing as mass moves downwards; MP5. energy transferred mechanically; MP6. idea of amplitude of oscillations decreasing over time; MP7. (eventually all) energy is transferred to thermal store of spring/surroundings; MP8. (mechanically) by friction between spring and surroundings	 allow reference to 'slowing down' to mean 'max speed decreasing' allow reference to reduction in total energy of mass/spring condone heat for thermal alternate energy transfer scheme: MP1 EPE converted to KE (on way up) MP2 EPE converted to GPE (on way up) MP3 KE converted to GPE (after midway point)	6
(b) (i)	B (it increases the efficiency of the motorcycle);		1

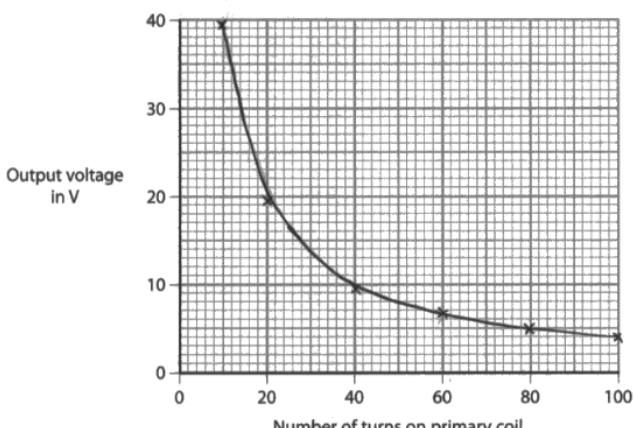
	A is incorrect because it decreases the energy transferred from fuel each second C is incorrect because it does not affect the speed D is incorrect because it does not affect the braking power		
(ii)	magnet(s) move through coil; idea of coil cutting magnetic field lines;	allow RA condone 'magnet slides through coil' (candidate has realised this is relevant) ignore fields interacting accept reference to changing magnetic flux	3
(iii)	inducing a voltage; bigger or more (frequent) bumps; magnet(s) have bigger amplitude of motion / magnet(s) caused to move more times (per metre of road); (so) induced voltage / voltage generated is larger or for a longer time in total;	accept potential difference, p.d. or EMF for voltage condone 'induces a current' allow RA allow idea of shorter time between bumps allow up and down for bump ignore unqualified 'moves more' (needs idea of a quantity e.g. size, speed) allow coil for magnet allow current for voltage	3

Total for Question 9 = 14 marks



Question number	Answer	Notes	Marks
4 (a)	at least one transformer drawn in the space between power station and school; second similar object drawn in the space between power station and school; transformer/object nearest power station labelled “step-up” and transformer/object nearest school labelled “step-down”;	drawing must be clearly recognisable as a transformer (e.g. two coils) or correctly labelled ignore pylons and transmission lines allow if transformers drawn accurately i.e. more turns on secondary coil for step-up etc.	3
(b)	(because) current causes wires/cables to heat up; idea of low/decreased/less current; reduces <u>energy</u> loss (to the surroundings);	link between current and heating must be clear allow reduces <u>energy</u> dissipated/wasted ignore heat loss	3

Total for Question 4 = 6 marks

Question number	Answer	Notes	Marks														
2 (a) (i)	Points plotted to within half a small square; <table><thead><tr><th>Number of turns on primary coil</th><th>Output voltage in V</th></tr></thead><tbody><tr><td>10</td><td>39.6</td></tr><tr><td>20</td><td>19.7</td></tr><tr><td>40</td><td>9.9</td></tr><tr><td>60</td><td>6.6</td></tr><tr><td>80</td><td>5.0</td></tr><tr><td>100</td><td>4.0</td></tr></tbody></table> 	Number of turns on primary coil	Output voltage in V	10	39.6	20	19.7	40	9.9	60	6.6	80	5.0	100	4.0	Points should lie on a very good curved line.	1
Number of turns on primary coil	Output voltage in V																
10	39.6																
20	19.7																
40	9.9																
60	6.6																
80	5.0																
100	4.0																
(ii)	Best fit line is smooth curve;	ECF their data points.	1														
(iii)	As number of (primary) turns increases, (secondary) voltage decreases; At a decreasing rate/is non-linear;	Allow RA Allow unqualified 'inversely proportional' for 2 marks. Ignore: 'negative exponential'	2														

b) (i)	$(N_p/N_s) = (V_p/V_s);$	Allow any correct rearrangement. Allow "i(nput) and o(utput)" or "1 and 2" for "p(rietary) and s(econdary)". Allow correct word equation. Ignore 'P' for 'N' Condone 'T', 't' or 'n' for 'N' Condone 'coils' for 'turns'	1
(ii)	Substitution of values for N_p, V_p and V_s ; Evaluation of N_s ; e.g. $40 / N_s = (6.8/9.9) = 0.686....;$ $N_s = 40 / 0.601.. = 58(.2....) ;$	Allow any row of data from table or co-ordinates for a point on the line on the graph Accept answer in range 57-60. Accept non-integer number of turns.	2

Question number	Answer	Notes	Marks
6 (a) (i)	$\frac{\text{input voltage}}{\text{output voltage}} = \frac{\text{primary turns}}{\text{secondary turns}}$	allow standard symbols and rearrangements e.g. $V_p / V_s = N_p / N_s$ allow T, n for turns allow 1,2 in,out for p and s	1
(ii)	substitution; rearrangement; evaluation; e.g. $15/330 = 2600/N_s$ $N_s = 2600 \times 330 / 15$ $N_s = 57\,000$	allow kV or V for voltages -1 for POT error allow 57 200	3
(b)	any four from: MP1. step-up transformer increases voltage; MP2. step-up transformer decreases current; MP3. idea that $P_{in} = P_{out} / V_{in}I_{in} = V_{out}I_{out}$ (assuming 100% efficient); MP4. idea that transmission current is reduced; MP5. idea that energy losses are reduced; MP6. (because) current causes heating (in transmission cables); MP7. idea that step-down transformer used to reduce voltage to safe level;	credit ideas seen in diagram allow RA allow RA allow increasing the voltage decreases the current allow heating losses reduced	4

Total for Question 6 = 8 marks



Question number	Answer	Notes	Marks
8 (a)	step-down;		1
(b)	$\frac{\text{input (primary) voltage}}{\text{output (secondary) voltage}} = \frac{\text{primary turns}}{\text{secondary turns}};$	allow V for voltage, n or N or t or T for turns, allow subscripts 'i' and 'o' or 'p' and 's' or '1' and '2'	1
(c) (i)	substitution into correct turns ratio equation; rearrangement to find V_s ; substitution into $V_p I_p = V_s I_s$; rearrangement to give I_s ; evaluation; e.g. $230/V_s = 16/4$ $V_s = 230 / 4 = 57.5 \text{ (V)}$ $230 \times 11 = 57.5 \times I_s$ $I_s = 230 \times 11 / 57.5$ $I_s = 44 \text{ (A)}$	ecf from incorrect V_s	5
(ii)	D; A, B and C are all rated below the nominal current of the input coil, so would all 'blow' instantly.		1

Total for Question 8 = 8 marks

Question number	Answer	Notes	Marks
8 (a)	any four from: MP1. idea that step-down means secondary voltage is less than primary voltage; MP2. current in (primary) coil produces magnetic field; MP3. the current is changing / has frequency of 50 Hz; MP4. causing a (changing) magnetic field in the core; MP5. the core strengthens the magnetic field; MP6. the secondary coil experiences a changing magnetic field; MP7. which induces a voltage in the secondary coil;	allow RA allow recognition that alternating current is used allow 'secondary is cut by (changing) field lines' allow current for voltage	4
(b) (i)	$(N_p/N_s) = (V_p/V_s);$	allow any correct rearrangement allow "i(nput) and o(utput)" or "1 and 2" for "p(ri)mary and s(econdary)" allow correct word equation ignore 'P' for 'N' condone 'T', 't' or 'n' for 'N' condone 'coils' for 'turns'	1
(ii)	substitution; rearrangement; evaluation; e.g. $(160/45) = 12/V_s$ $V_s = 12 / (160/45)$ $(V_s =) 3.4 \text{ (V)}$	 allow 3.375 (V)	3

Total for Question 8 = 8 marks)

Question number	Answer	Notes	Marks
6 (a) (i)	(stepping up voltage) reduces current; reducing current reduces heating in the wire;	allow idea of less energy loss or less power loss ignore unqualified reference to efficiency	2
(ii)	$(N_p \div N_s) = (V_p \div V_s)$	input (primary) voltage $\div$ output (secondary) voltage = primary turns $\div$ secondary turns; allow any correct rearrangement allow T or n for turns condone 'coils' for 'turns' reject phrase 'turns ratio'	1
(iii)	substitution; re-arrangement; correct evaluation; correct answer: 32 000 $(N_p \div N_s) = (V_p \div V_s)$ $(1400 \div N_s) = (15 \div 340)$ $N_s = (340 \div 15) \times 1400$ $N_s = 31\,733$	-1 for PoT allow full credit for correct answer with no working rounding at different stages gives correct answers in range 31700 - 35000 worth full marks	3
(b)	constant current gives constant magnetic field; induction (in transformers) requires a changing magnetic field; no voltage will be induced;	ignore references to a.c. allow 'flux' or 'field lines' for 'magnetic field' allow idea about requiring field line cutting for induction condone current for voltage	3

Total for question 6: 9 marks

Question number	Answer	Notes	Marks
5 (a) (i)	(soft) iron;	accept other suitable ferromagnetic materials	1
(ii)	input power = output power; OR primary voltage × primary current = secondary voltage × secondary current;	allow • formula in words or symbols • standard abbreviations: i.e. s, p, in, out, 1, 2	1
(iii)	substitution; rearrangement; evaluation; e.g. $275\,000 \times I_p = 230 \times 95$ $(I_p =) 230 \times 95 / 275\,000$ $(I_p =) 0.079 \text{ (A)}$	-1 for POT error 79.45...(A) scores 2 marks allow 0.07945...	3
(b)	any five from: MP1. step-up transformer used before transmission; MP2. voltage is increased before transmission; MP3. current is reduced before transmission; MP4. less heating in transmission cables; MP5. less energy wasted in transmission cables; MP6. step-down transformer used after transmission; MP7. voltage is decreased after transmission for safety ;	allow any mark if clear from diagram	5

Total for question 5 = 10 marks

Question number	Answer	Notes	Marks
6 (a)	(i) (soft) iron;		1
	(ii) pass a current in the coil / eq;	condone reference to 'electricity'	1
(b)	(i) $N_p/N_s = V_p/V_s$;	allow any correct rearrangement allow "i(nput) and o(utput)" or "1 and 2" for "p(rietary) and s(econdary)" allow correct word equation ignore 'P' for 'N' condone 'T', 't' or 'n' for 'N' condone 'coils' for 'turns'	1
	(ii) substitution; rearrangement; evaluation to 2s.f. or more; e.g. $1500/280 = 115/V_s$ $(V_s =) 115 \times 280 / 1500$ $(V_s =) 21 \text{ (V)}$	allow 21.4666...(V)	3
	(iii) use of transformer power formula; substitution OR rearrangement; evaluation; e.g. input power = output power OR $V_p I_p = V_s I_s$ $115 \times 1.2 = 20 \times I_s$ OR $I_s = V_p I_p / V_s$ $(I_s =) 6.9 \text{ (A)}$	allow use of 20, 21, 21.5 etc. for output voltage allow use of turns ratio i.e. step-down voltage means step-up current allow 7 (A) allow range of 6.4-6.9	3
	(iv) any two from: MP1. increase input voltage/current; MP2. decrease number of turns on secondary coil; MP3. increase number of turns on primary coil;	condone "decrease number of secondary coils" condone "increase number of primary coils"	2

Total for Question 6 = 11 marks



Question number	Answer	Notes	Marks
6 (a)	step-down (transformer);		1
(b) (i)	idea of taking repeats (and removing anomalies);	allow repeating the investigation or individual readings	1
(ii)	only two columns or rows with headings of 'number of turns' and '(output) voltage'; correct units included only in voltage heading; all data correctly included in body of table to same precision as given in the paper;	columns can be in either order allow use of standard symbols e.g. n/N for number of turns and V for voltage allow volts or V reject if units given with data values ignore any units given for number of turns	3
(iii)	idea of increasing sensitivity of voltmeter e.g. 'using a voltmeter that measures to more decimal places';		1
(c) (i)	500 turns reading circled;		1
(ii)	straight line passing through all points except reading at 500 turns;	allow straight line with points evenly distributed either side	1
(iii)	simple pattern statement e.g. 'as the number of turns increases, the output voltage increases'; further detail e.g. linear relationship;	allow "they are proportional" for both marks only if line passes through origin	2

(d)	pair of readings correctly read from the graph / results table; substitution into correct transformer formula; rearrangement; evaluation; e.g. number of turns = 600, output voltage = 7.5 V $V_1 / 7.5 = 1200 / 600$ $(V_1 =) (1200 \times 7.5) / 600$ $(V_1 =) 15 \text{ (V)}$	allow if seen anywhere in calculation either in symbols or numbers <table><tr><th>N</th><th>V in V</th></tr><tr><td>100</td><td>1.3</td></tr><tr><td>200</td><td>2.5</td></tr><tr><td>300</td><td>3.8</td></tr><tr><td>400</td><td>5.0</td></tr><tr><td>500</td><td>6.3</td></tr><tr><td>600</td><td>7.5</td></tr></table> allow range of 15–16 (V)	N	V in V	100	1.3	200	2.5	300	3.8	400	5.0	500	6.3	600	7.5	4
N	V in V																
100	1.3																
200	2.5																
300	3.8																
400	5.0																
500	6.3																
600	7.5																

Total for Question 6 = 14 marks

Question number	Answer	Notes	Marks
7 (a) (i)	input (primary) voltage / output (secondary) voltage = primary turns / secondary turns;	allow recognisable symbols and rearrangements e.g. $V_2 = (N_2/N_1) \times V_1$ condone coils for turns condone T for turns allow 1 and 2 for input and output	1
(ii)	substitution; rearrangement; evaluation; e.g. $230 \div V_2 = 1000 \div 300$ $V_2 = 300 \times 230 \div 1000$ ($V_2 =$) 69 (V)	accept in either order substitution into an incorrectly arranged formula scores zero	3
(iii)	use of power = current $\times$ voltage; evaluation of input power; evaluation of output power; substitution into given formula; evaluation of efficiency; e.g. power = current $\times$ voltage input power = $(1.3 \times 230 =)$ 299 (W) output power = $(4.0 \times 69 =)$ 276 (W) efficiency = $276 \div 299 (\times 100\%)$ (efficiency =) 92 (%)	e.g. a correct substitution allow ECF from (ii) allow ECF from incorrect power values if clear from working allow 92.3... (%)	5
(b)	any five from: MP1. step-up transformer used before transmission; MP2. voltage is increased before transmission; MP3. current is reduced before transmission; MP4. less heating in transmission wires / cables; MP5. less energy wasted; MP6. step-down transformer used after transmission; MP7. voltage is decreased after transmission for safety ;	allow ideas seen/expressed in a diagram allow larger current required for some household devices	5

Total for Question 7 = 14 marks

Question number	Answer	Notes	Marks
4 (a)	two coils (of wire); secondary coil has more turns than primary coil; iron core (linking the coils);	all marking points can be awarded from labelled diagram allow two coils drawn in diagram even if not labelled as “coils” allow RA condone more coils on secondary relative numbers of turns can be inferred from diagram allow “magnetically soft” for iron allow both coils wound round a single iron core	3
(b) (i)	input power = output power;	allow if expressed in terms of voltages and currents e.g. $V_p I_p = V_s I_s$ allow p/s, 1/2, in/out, i/o for subscripts	1
(ii)	substitution; rearrangement; evaluation; e.g. $230 \times 4.5 = V \times 0.21$ $V = 230 \times 4.5 / 0.21$ $(V =) 4900 \text{ (V)}$	allow 5000, 4930, 4929, 4928.6, 4928.57... (V) condone 4928, 4928.5 (V)	3

Total for Question 4 = 7 marks