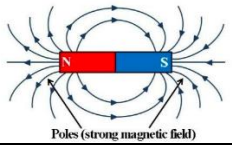
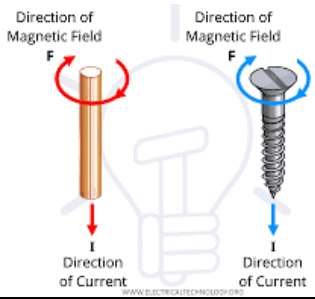
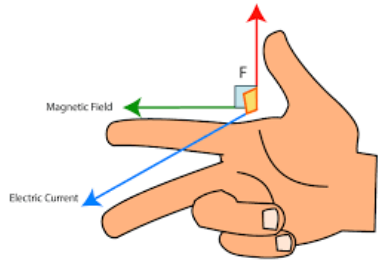
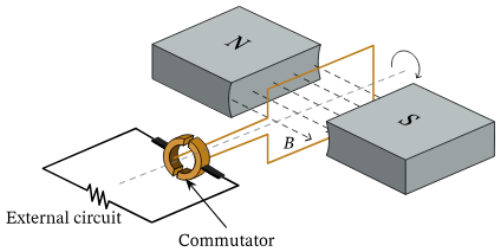
# Magnetism and Electromagnetism

| | | |
|---|---|---|
| 1 | **Describe the force between like poles** | **Repels** |
| 2 | **Describe the force between unlike poles** | **Attracts** |
| 3 | **What is a permanent magnet?** | **A magnet that produces its own magnetic field** |
| 4 | **What is an induced magnet?** | **A material that becomes a magnet when it is placed in a magnetic field** |
| 5 | What direction does a magnetic field always act in? | From north to south |
| 6 | **Where is a magnetic field the strongest?** | **Next to the poles of the magnet**<br>  |
| 7 | What happens to the strength of a magnetic field as you move further from the magnet? | It decreases |
| 8 | How do magnetic compasses provide evidence that the Earth's core must be magnetic? | A magnetic compass contains a small bar magnet. The Earth has a magnetic field. The compass needle points in the direction of the Earth's magnetic field |
| 9 | **What is the magnetic field like around a current-carrying wire?** | **Circular around the wire**<br>  |
| 10 | What factors affect the strength of a magnetic field due to a current-carrying wire? | Strength of the current, distance from the wire |
| 11 | **Describe three ways the strength of an electromagnet can be increased** | **Increasing the current in the wire, adding an iron core, adding more coils of wire** |
| 12 | How does an electric motor work? | The force on a current-carrying wire in a magnetic field pushes one side of a coil down and the other side up |
| 13 | (HT) Describe the motor effect | When a current carrying wire is placed in a magnetic field, the magnet producing the field and the conductor and the conductor exert a force on each other. This can be represented using Fleming's left hand rule<br>  |

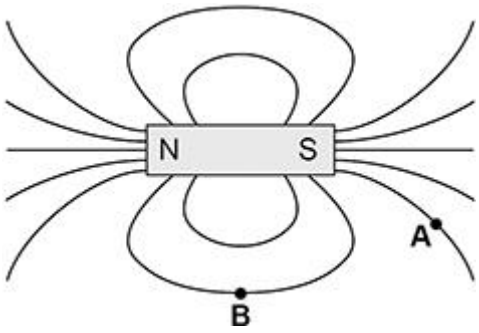
# Answer Key

| | | |
|---|---|---|
| 1. | (HT) What does a changing magnetic field around a conductor produce? | A potential difference that can create a current |
| 2. | (HT) What direction is the magnetic field around an induced current? | The opposite direction to the field that induced the current |
| 3. | (HT) How does an AC generator work? | A rectangular coil is made to spin in a uniform magnetic field, causing an alternating current to be induced in the coil. |
| 4. | (HT) What type of current is generated by an alternator? | Alternating current (AC) |
| 5. | (HT) What type of current is generated by a dynamo? | Direct current (DC) |
| 6. | (HT) Explain how a dynamo works | A split-ring commutator is used with an alternator to reverse the connection of the coil every half-turn, causing the output to be DC   |
| 7. | **(HT) Explain how a transformer works** | **Alternating current passes through the primary coil and induces an alternating magnetic field in the iron core. This induces an alternating magnetic field in the iron core. This induces an alternating potential difference across the secondary coil.** $\boldsymbol{P = I_1V_1 = I_2V_2}$ |
| 8. | (HT) What does the ratio of potential difference in a transformer depend on? | The ratio of the number of turns on the primary and secondary coil $\frac{v_p}{v_s} = \frac{n_p}{n_s}$ |
| 9. | (HT) How does a microphone work? | Sound waves make a diaphragm vibrate – the diaphragm is attached to a coil in a magnetic field and an alternating current is induced in the coil as it vibrates |
| 10. | (HT) How do loudspeakers and headphones work? | An alternating current flows through a coil in a magnetic field, causing the coil to vibrate – the coil is attached to a diaphragm which vibrates and creates sound waves. |
| 11. | (HT) Why are transformers important for transferring electrical power efficiently? | A step-up transformer increases the potential difference so that power can be transported by cables with minimal loss due to heating. |
| 12. | (HT) How is the force on a conductor in a magnetic field used to turn a coil in an electric motor? | Because the conducting wire is in a loop, the current is flowing in opposite directions on each side of the coil – so there is a force acting up on one side of the coil and down on the other – causing rotation |

## Q1.

**Figure 1** shows the magnetic field pattern around a bar magnet.

**Figure 1**




(a) Draw an arrow at point **A** and point **B** to show the direction of the magnetic field at each point.

**(1)**

(b) A bar magnet produces its own magnetic field.

Complete the sentence.

Choose the answer from the box.

| **an electromagnet** | **an induced magnet** | **a permanent magnet** |
|---|---|---|

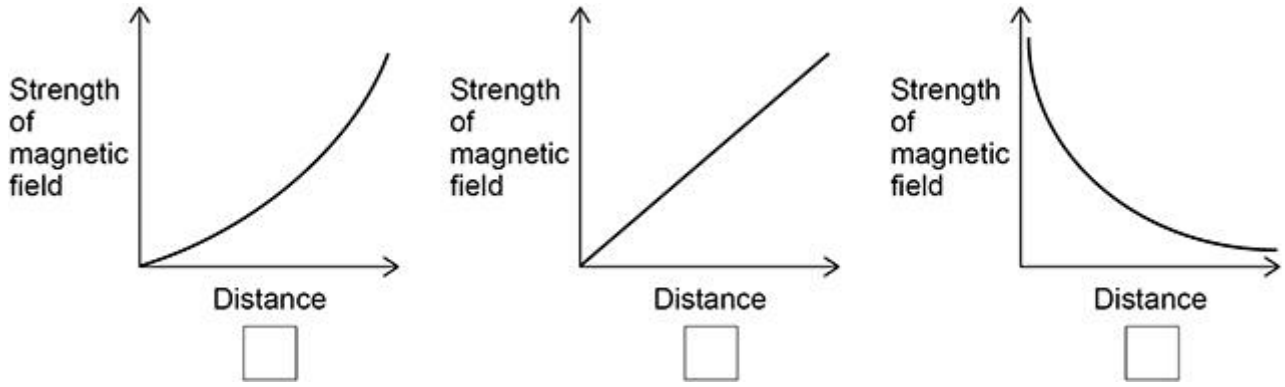
A bar magnet is an example of _____.

**(1)**

(c) Which graph shows how the strength of the magnetic field varies with distance from the bar magnet?

Give a reason for your answer.

Tick (✓) **one** box.



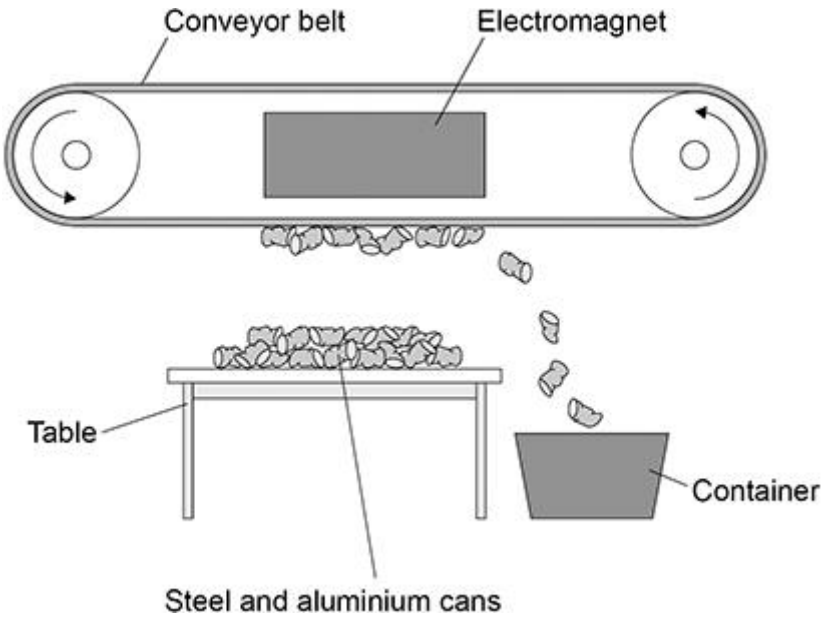

Reason _____

_____

**(2)**

**Figure 2** shows an electromagnet being used to separate aluminium cans from steel cans.

**Figure 2**




(d) Explain how the electromagnet and conveyor belt are used to separate the steel cans from the aluminium cans.

_____

_____

_____

_____

**(2)**

(e) At the top of the table the strength of the magnetic field is only just enough to pick the cans up.

Describe **two** ways to increase the strength of magnetic field at the top of the table.

1 _____

_____

2 _____

_____

**(2)**

(f) Write down the equation which links distance travelled (*s*), speed (*v*) and time (*t*).

_____

**(1)**

(g) The conveyor belt moves a can at a speed of 1.7 m/s.

Calculate the time taken to move the can 3.3 m at this speed.

Give your answer to 2 significant figures.

_____

_____

_____

_____

_____

Time taken (2 significant figures) = _____ s

**(4)**

**(Total 13 marks)**

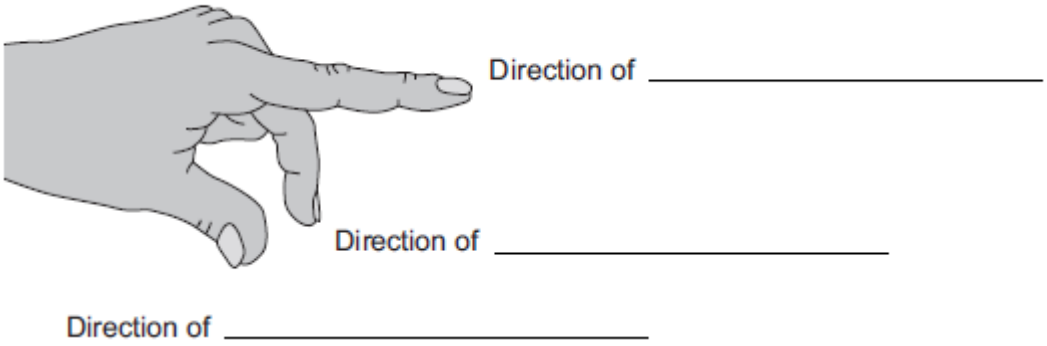
## Q2.

The left-hand rule can be used to identify the direction of the force acting on a current-carrying conductor in a magnetic field.

(a) Use words from the box to label **Figure 1**.

| | | | |
|---|---|---|---|
| **current** | **field** | **force** | **potential difference** |

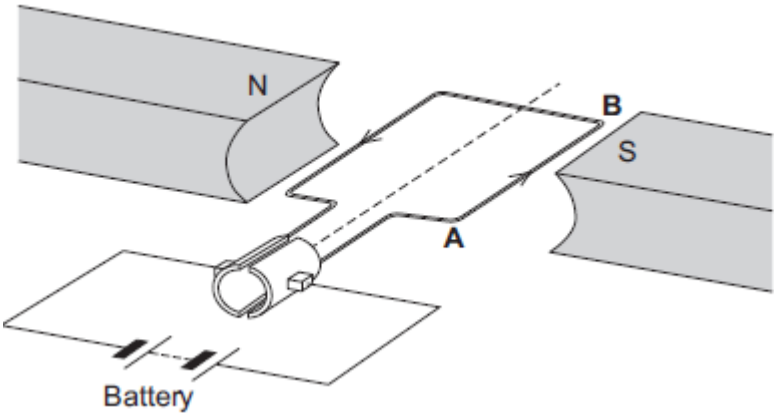
**Figure 1**




**(3)**

(b) **Figure 2** shows an electric motor.

**Figure 2**




(i) Draw an arrow on **Figure 2** to show the direction of the force acting on the wire **AB**.

**(1)**

(ii) Suggest **two** changes that would increase the force acting on the wire **AB**.

1. _____

2. _____

**(2)**

(iii) Suggest **two** changes that would reverse the direction of the force acting on the wire **AB**.

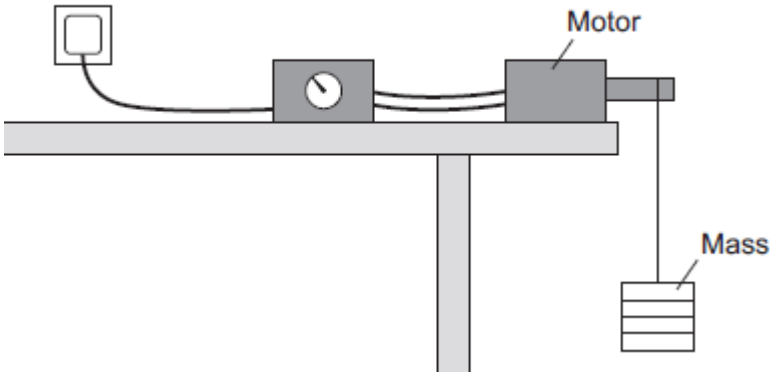
1. _____

2. _____

**(2)**

(c) A student used an electric motor to lift a mass. This is shown in **Figure 3**.

**Figure 3**




The student varied the electrical input power to the motor. For each different electrical input power, he recorded the time taken to lift the mass and calculated the output power of the motor.

The results are shown in the table.

| Test | Electrical input power in watts | Work done lifting the mass in joules | Time taken to lift the mass in seconds | Output power in watts |
|---|---|---|---|---|
| **A** | 20 | 24 | 2.4 | 10 |
| **B** | 40 | 24 | 1.2 | 20 |
| **C** | 60 | 24 | 0.8 | 30 |
| **D** | 80 | 24 | 0.2 | 120 |

The result for **Test D** is anomalous.

(i) Calculate the efficiency of the motor in **Test D**.

_____

_____

Efficiency = _____

**(2)**

(ii) Comment on your answer to part (c)(i).

_____

_____

**(1)**

(iii) Suggest a reason for this anomalous result.

_____

_____

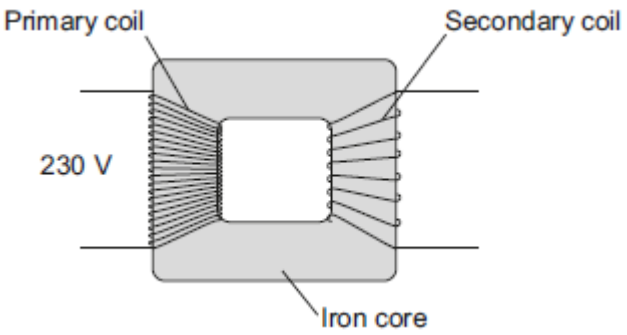
**(1)**

**(Total 12 marks)**

## Q3.

**Figure 1** shows the structure of a traditional transformer.

**Figure 1**




(a) There is an alternating current in the primary coil of the transformer.

State what is produced in the iron core.

_____

_____

**(2)**

(b) A transformer has only **one** turn of wire on the secondary coil.
The potential difference across the secondary coil is 11.5 V
The potential difference across the primary coil is 230 V

Calculate the number of turns on the primary coil.

_____

_____

_____

_____

Number of turns on the primary coil = _____

**(2)**

(c) In most transformers, the power output is less than the power input.

State why.

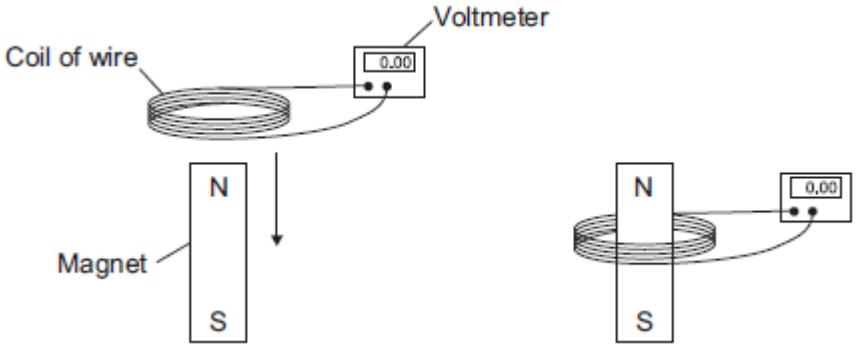
_____

_____

**(1)**

(d) Two students investigated how magnets can be used to produce a potential difference.
The students held a coil of wire above a magnet. The students quickly lowered the coil so that the magnet was inside the coil, as shown in **Figure 2**.

**Figure 2**




The students recorded the maximum potential difference for coils with different numbers of turns of wire. The results are shown in the table.

| **Number of turns of wire in the coil** | **Maximum potential difference in volts** | |
|---|---|---|
| | **Results from student 1** | **Results from student 2** |
| 5 | 0.09 | 0.08 |
| 10 | 0.20 | 0.15 |
| 15 | 0.31 | 0.25 |
| 20 | 0.39 | 0.33 |
| 25 | 0.51 | 0.39 |

(i) State the resolution of the voltmeter.

Give **one** reason why the resolution of the voltmeter is suitable for this investigation.

Resolution _____

Reason _____

_____

**(2)**

(ii) The two students used exactly the same equipment to carry out their investigations. Both students recorded their results correctly.

Give the reason why student 2 got different results from student 1.

_____

_____

**(1)**

(iii) The students decided that even though the results were different, there was no need to repeat the investigation.

How do the results show that the investigation is reproducible?

_____

_____

**(1)**

(iv) State the name of the process which causes the potential difference to be produced in this investigation.

_____

**(1)**

(e) A transformer has been developed that can be used with many different devices.

Suggest **one** advantage of having a transformer that can be used with many different devices.

_____

_____

**(1)**

**(Total 11 marks)**

HIGHER QUESTIONS

## Q1.

(a) Electromagnets are often used at recycling centres to separate some types of metals from other materials.

Give **one** reason why an electromagnet would be used rather than a permanent magnet.

_____

_____

**(1)**

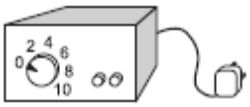
(b) **In this question you will gain marks for using good English, organising information clearly and using scientific words correctly.**

Some students want to build an electromagnet.

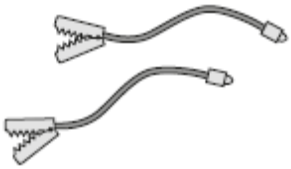
The students have the equipment shown below.

Insulated wire

Iron nail

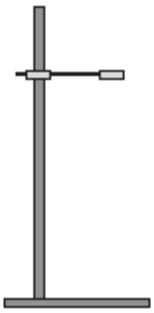



Power supply



Connecting leads

Steel paperclips



Wooden clamp and stand

Describe how the students could build an electromagnet. Include in your answer how the students should vary and test the strength of their electromagnet.

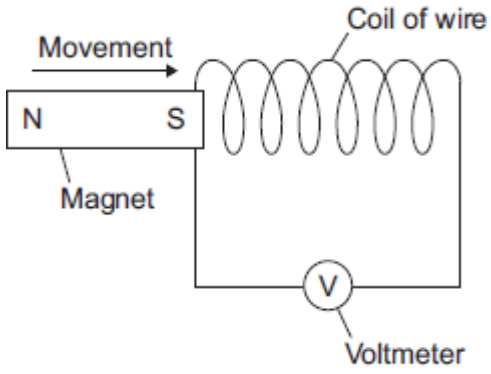
**(6)**

**(Total 7 marks)**

## Q2.

**Figure 1** shows a magnet moving into a coil of wire. This movement causes a reading on the voltmeter.

**Figure 1**




(a) Use the correct word from the box to complete the sentence.

| | | |
|---|---|---|
| **generated** | **induced** | **produced** |

Moving the magnet into the coil of wire causes a reading on the voltmeter because a potential difference is _____ across the ends of the wire.

**(1)**

(b) A student investigated how the number of turns on the coil of wire affects the maximum voltmeter reading. The student changed the number of turns on the coil of wire, then moved the magnet into the coil. The student recorded the maximum voltmeter reading.

To obtain valid data, suggest **two** variables that the student should control in this investigation.

1. _____

_____

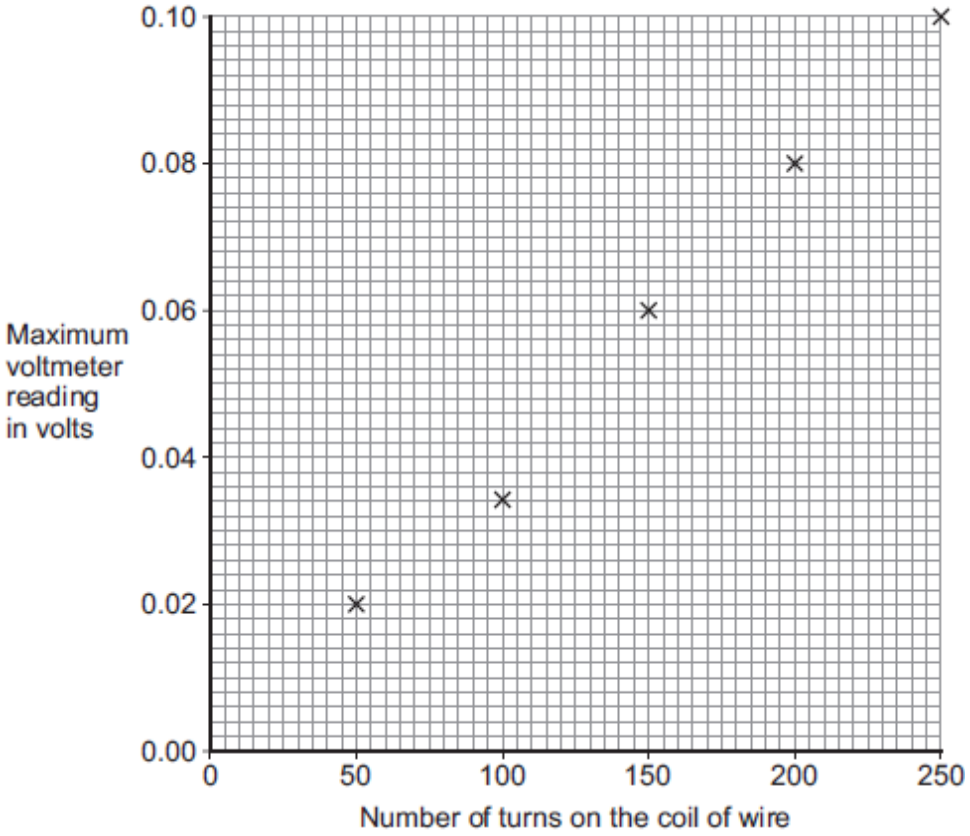
2. _____

_____

**(2)**

(c) The student's results are shown in **Figure 2**.

**Figure 2**




(i) One of the results is anomalous.
Suggest a reason for the anomalous result.

_____

**(1)**

(ii) Draw a line of best fit on **Figure 2**.

**(1)**

(d) A data-logger can automatically record and store data.

It may have been better for the student to have used a data-logger in his investigation rather than a voltmeter.

Suggest **one** reason why.

_____

_____

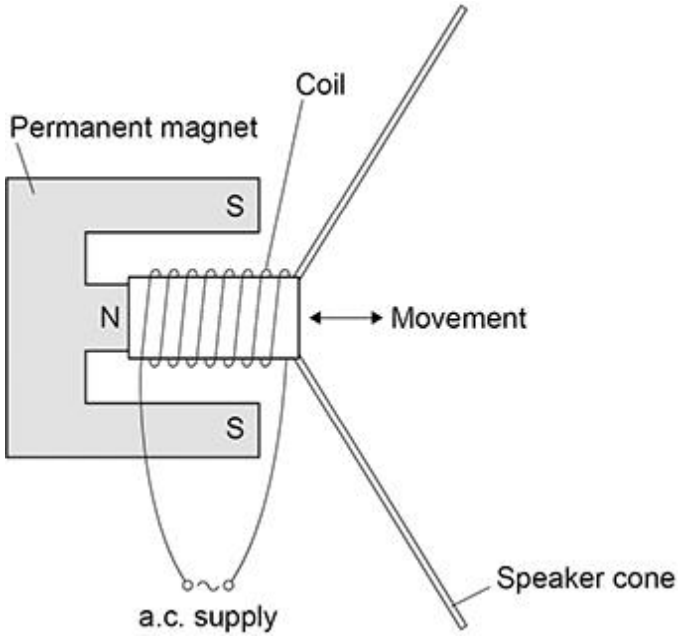
**(1)**

**(Total 6 marks)**

**Q3.**

A student made a moving-coil loudspeaker.

The figure below shows a diagram of the loudspeaker.




(a) What is the name of the effect used by the moving-coil loudspeaker to produce sound waves?

**(1)**

(b) Explain how a moving-coil loudspeaker produces a sound wave.

**(4)**

(c) A student investigated how the loudness of sound from the loudspeaker depends on:

- the number of turns on the coil
- the frequency of the supply.

The table below shows the results.

| Number of turns | Frequency of supply in Hz | Loudness of sound in arbitrary units |
|---|---|---|
| 100 | 200 | 32 |
| 200 | 400 | 47 |
| 300 | 600 | 63 |

Explain why the results **cannot** be used to make a valid conclusion.

_____

_____

_____

_____

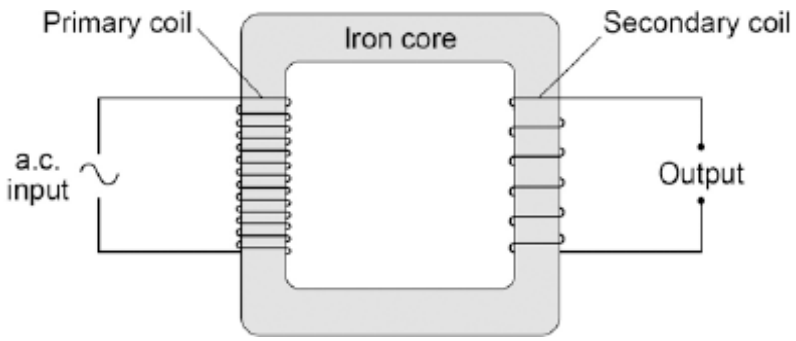
**(2)**

**(Total 7 marks)**

## Q4.

**Figure 1** shows the construction of a simple transformer.

**Figure 1**




(a) Why is iron a suitable material for the core of a transformer?

Tick **one** box.

It is a metal. ☐

It will not get hot. ☐

It is easily magnetised. ☐

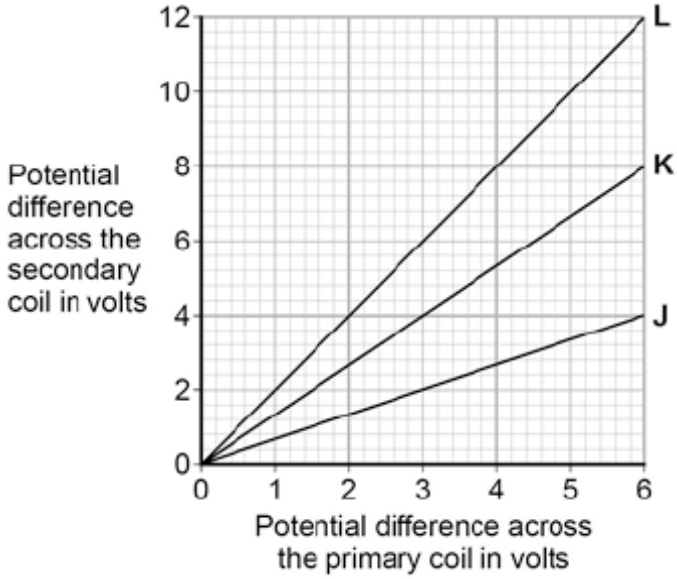
It is an electrical conductor. ☐

**(1)**

(b) A student makes three simple transformers, **J**, **K** and **L**.

**Figure 2** shows how the potential difference across the secondary coil of each transformer varies as the potential difference across the primary coil of each transformer is changed.

**Figure 2**




How can you tell that transformer **J** is a step-down transformer?

_____

_____

**(1)**

(c) Each of the transformers has 50 turns on the primary coil.

Calculate the number of turns on the secondary coil of transformer **L**.

Use the correct equation from the Physics Equations Sheet.

_____

_____

_____

Number of turns on the secondary coil = _____

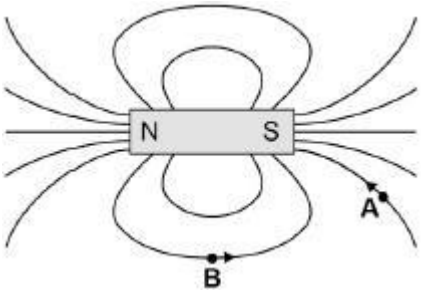
**(3)**

**(Total 5 marks)**

FOUNDATION Mark schemes

## Q1.

(a) both arrows correct

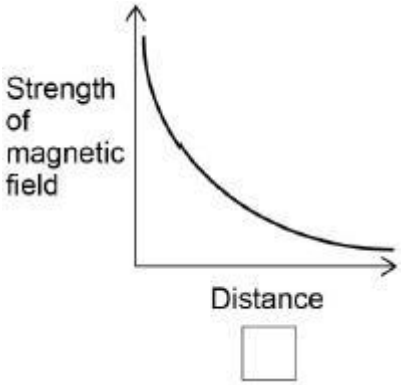



1

(b) a permanent magnet

1

(c) third box ticked




1

any **one** from

- (the only graph) that shows the magnetic field getting weaker (as distance increases)
- both other graphs show the magnetic field getting stronger (as the distance increases)

*only scores if correct box is chosen*

1

(d) steel cans are attracted to the electromagnet and are transferred to the container (by the conveyor belt)

1

aluminium cans are not attracted to the electromagnet and are left behind on the table

*If no other mark scored: Steel cans are attracted (to the electromagnet) but aluminium cans are not – scores one mark*

1

(e) raise the height of the table

*allow longer legs on the table*

*allow put a (non-magnetic) box on top of the table*

*allow lower the electromagnet*

1

use a larger potential difference / current
**or**
use a stronger electromagnet

*allow more turns on the coil (of the electromagnet)*

*do **not** accept insert a (soft) iron core*

1

(f) distance travelled = speed × time
**or**
$s = v\,t$

1

(g) $3.3 = 1.7 \times t$

1

$t = \frac{3.3}{1.7}$

1

$t = 1.941$ (s)

1

$t = 1.9$ (s)

*allow a calculation using the given data incorrectly but correctly rounded to 2 sig figs*

1

**[13]**

## Q2.

(a) field

*correct order only*

1

current

1

force

*accept motion*

*accept thrust*

1

(b) (i) arrow pointing vertically downwards

1

(ii) increase current / p.d.

*accept voltage for p.d.*

1

increase strength of magnetic field

*accept move poles closer together*

1

(iii) reverse (poles of) magnets

1

reverse battery / current

1

(c) (i) 1.5 or 150%

*efficiency = 120 / 80 (× 100)*

*gains **1** mark*

*an answer of 1.5 % or 150*

*gains **1** mark*

2

(ii) efficiency greater than 100%
**or**
output is greater than input
**or**
output should be 40 (W)

1

(iii) recorded time much shorter than actual time

*accept timer started too late*

*accept timer stopped too soon*

1

**[12]**

## Q3.

(a) a magnetic field

*accept electromagnetic field*

*heat is insufficient*

1

that is alternating / changing

1

(b) 20

*allow **1** mark for correct substitution, ie*

$$\frac{230}{11.5}$$

*provided no subsequent step*

2

(c) (most) transformers are not 100% efficient

*allow energy / power is lost to the surroundings*

*allow energy / power is lost as heat / sound*

*power is lost is insufficient*

**1**

(d) (i) 0.01 (V)

**1**

because there is a change in p.d. each time (the number of turns changes)

*allow because all the results (to 2 decimal places) are different*

*accept if results were to 1 decimal place, there might not be a difference*

**1**

(ii) student 2 moved the coil more slowly (than student 1)

*accept student 2 moved the coil at a different speed to student 1*

*do not accept student 2 moved the coil faster (than student 1)*

**1**

(iii) both sets of results show the same pattern

*accept trend for pattern*

*results are similar is insufficient*

*results follow a pattern is insufficient*

**1**

(iv) (electromagnetic) induction

*accept it is induced*

*do not accept electric / magnetic induction*

**1**

(e) any **one** from:

- more economical / cheaper for the consumer

  *allow more convenient*

- easier/cheaper to replace if broken/lost

  *allow in case one gets lost*

- since fewer transformers need to be made less resources are used

  *allow fewer plug sockets are needed*

  *allow fewer transformers are needed*

  *environmentally friendly is insufficient*

**1**

**[11]**

## Q1.

(a) an electromagnet can be switched off

*accept a permanent magnet cannot be switched off*

**or**

an electromagnet is stronger

*accept control the strength*

**1**

(b) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should apply a 'best-fit' approach to the marking.

**Level 3 (5 – 6 marks):**
there is a description of how the electromagnet is made
**and**
there is a description of how the strength of the electromagnet can be varied
**and**
there is a description of how the strength of the electromagnet can be tested

**Level 2 (3 – 4 marks):**
there is a description of how the electromagnet is made
**and either**
there is a description of how the strength of the electromagnet can be varied
**or**
there is a description of how the electromagnet can be tested

**Level 1 (1 – 2 marks):**
there is a basic description of how to make an electromagnet
**or**
there is a basic description of how the strength of the electromagnet can be varied
**or**
there is a basic description of how the electromagnet can be tested

**Level 0 (0 marks):**
No relevant / correct content

**examples of the points made in the response**

Details of how to make an electromagnet

- wrap the wire around the nail
- connect the wire to the power supply (with connecting leads and croc clips)
- switch on the power supply

*accept a current should be sent along the wire*

Details of how to vary the strength of the electromagnet

- change the number of turns (on the coil)
- change the current (through the coil)
- change the separation of the turns

*allow change the potential difference (across the coil)*

*accept wrap the coil more tightly*

Details of how to test the electromagnet

- suspend paperclips from the electromagnet
- the more paperclips suspended, the stronger the electromagnet is
- clamp the electromagnet at different distances from the paperclip(s)
- the further the distance from which paperclips can be attracted the stronger the electromagnet is
- test before and after making alterations to change the strength
- compare the results from before and after making alterations
- use de-magnetised paper clips

*accept count the number of paperclips*

*with different current **or** p.d. **or** no. of turns*

***or** core and see if the number changes/increases*

**6**

**[7]**

## Q2.

(a) induced

**1**

(b) any **two** from:

- use the same (strength) magnet

*same size magnet is insufficient*

- the speed that the magnet is moved

*accept movement of the magnet*

- the area of the turns

*same type / length of wire is insufficient*

- the magnetic pole being moved towards the coil (of wire).

*use the same voltmeter is insufficient*

**2**

(c) (i) voltmeter misread
**or**
number of turns miscounted

*result misread is insufficient*

*human error is insufficient*

*allow the magnet was moved at a (slightly) different speed (into the coil) than for the other readings*

*allow spacing between the turns had changed*

**1**

(ii) line of best fit passing through all points except (100, 0.034)

*line does not need to go back to origin*

**1**

(d) any **one** from:

- can re-check data / readings.

  *accept can go back to data*
- can take more readings (in a given time)

  *can store data is insufficient*
- easier to identify maximum value.

  *automatically records data is insufficient*

  *accept is more accurate*

  *accept eliminates human error*

**1**

**[6]**

## Q3.

(a) motor (effect)

**1**

(b) current creates a magnetic field (around the coil)

**1**

(which) interacts with the permanent magnet field

**1**

producing a (resultant) force causing the coil/cone to move

**1**

(when the) direction of the current reverses, the direction of the (resultant) force reverses (producing a sound wave)

*allow coil/cone for force allow backwards for reverses*

**1**

(c) the student changed two variables at the same time

*allow only one variable should be changed at a time*

**1**

(so) it is not possible to know the effect of each variable

**1**

**[7]**

## Q4.

(a) It is easily magnetised.

**1**

(b) p.d. across the secondary coil is smaller (than p.d. across the primary coil)

**1**

(c) ratio $\frac{V_p}{V_s} = \frac{6}{12}$

*accept any other correct ratio taken from the graph*

**1**

$\frac{6}{12} = \frac{50}{N_p}$

*use of the correct turns ratio and substitution or correct transformation and substitution* **1**

$N_p = 100$

*allow 100 with no working shown for **3** marks* **1**

**[5]**