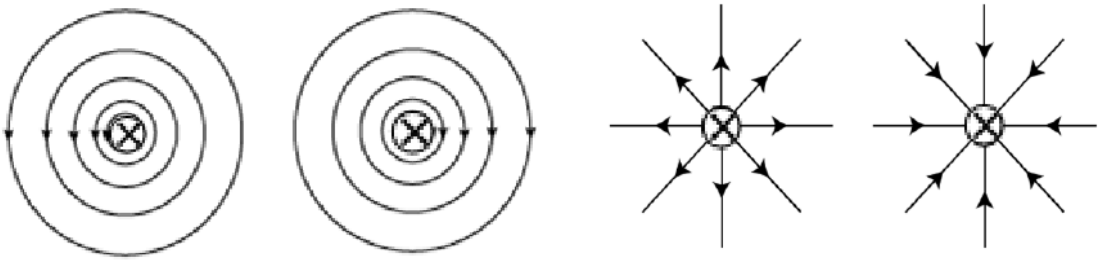
1. This question is about the magnetic effect of an electric current.

(i) Which **one** of the diagrams correctly shows the magnetic field caused by a wire conducting an electric current (electric current flowing **into the paper**)?

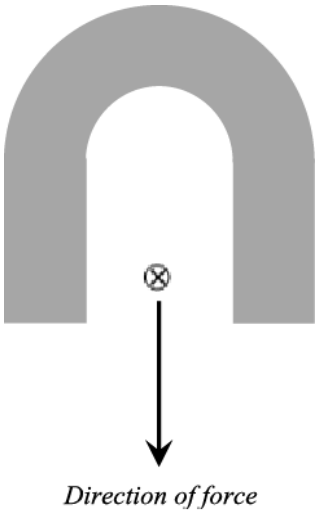


**A** **B** **C** **D**

_____ [1]

A wire is placed between the north and south poles of a permanent magnet and at right angles to the magnetic field.

The current is switched on (electric current flowing **into the paper**). This creates a force on the wire in the direction shown.



(ii) Complete the diagram by labelling the North and South poles of the permanent magnet **and** sketching the resulting magnetic field between the poles.

**[2]**

(iii) The current in the wire in (ii) is 0.2 A, and the magnetic flux density is 0.036 T.

Calculate the length of wire inside the magnetic field if the force experienced is $5.4 \times 10^{-4}$ N.

_____ m **[3]**

2. Motors and generators both contain magnets and coils of wire.

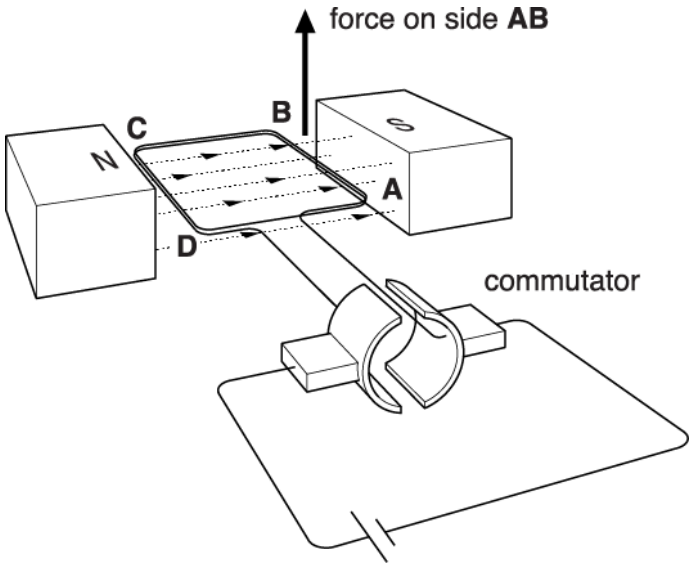
Explain the similarities and differences between a motor and a generator.

*The quality of written communication will be assessed in your answer.*

**[6]**

3(a). Lots of devices use an electric motor.

The diagram shows the main features of a motor.




The arrow on the diagram shows the force acting on side **AB** when a current flows in the coil.

(i) Draw another arrow **on the diagram** showing the force on side **CD**.

**[1]**

(ii) Why are there forces on sides **AB** and **CD**?

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**[2]**

(b). Explain the function of the commutator in this motor.

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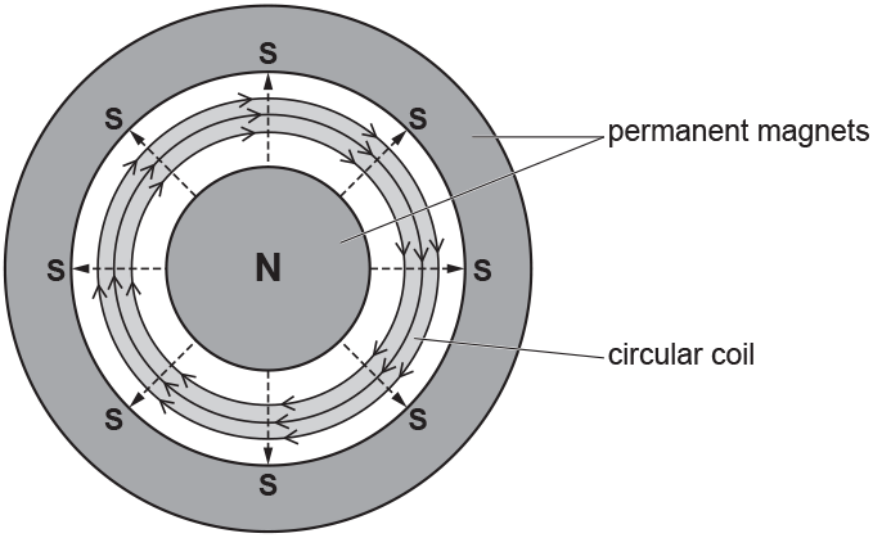
**[3]**

4(a). The diagram shows part of a loudspeaker. It contains specially-shaped permanent magnets with south poles, **S**, in a ring around the outside and a circular north pole, **N**, in the centre.

In the gap between the shaped magnets there is a circular coil carrying electrical current.




The direction of the magnetic field between the poles is shown as ----------► .

The magnetic field through the coil has strength 0.40 T.

The coil has circumference 25 mm and has 200 turns. The diagram shows only 3 turns of this coil.

A clockwise current of 0.60 A in the coil produces a force on the coil.

What is the direction of the force on the coil?

Tick (✓) **one** box.

Anti-clockwise ☐

Clockwise ☐

Into the page ☐

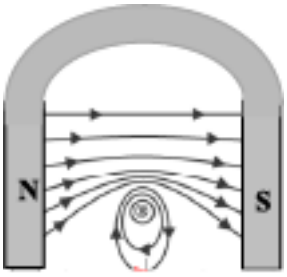
Out of the page ☐

**[1]**

(b). Calculate the magnitude of the force acting on the coil.

Force = ..... N **[4]**

END OF QUESTION PAPER

| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 1 | | i | B | 1 | |
| | | ii | N and S pole correctly labelled (1)<br><br>Magnetic field pattern correct direction between poles **and** over the top of the wire (1)<br><br>  <br> | 2 | |
| | | iii | **FIRST CHECK THE ANSWER ON ANSWER LINE**<br>**If answer = $7.5 \times 10^{-2}$ (m) award 3 marks**<br><br>Select F = BIL<br><br>Rearrange to get L = F ÷ (BI) (1)<br>$5.4 \times 10^{-4}$ N ÷ (0.036 × 0.2) (1)<br>$7.5 \times 10^{-2}$ (m) (1) | 3 | |
| | | | **Total** | **6** | |
| 2 | | | **(Level 3)**<br>Detailed descriptions of the generator and the motor. Some correct comparison of the two. Quality of written communication does not impede communication of the science at this level.<br><br>(5–6 marks)<br><br>**(Level 2)**<br>Brief description of how a motor works and how a generator works or a more detailed description of either one. Quality of written communication partly impedes communication of the science at this level.<br><br>(3–4 marks)<br><br>**(Level 1)** | 6 | **This question is targeted at grades up to A**<br>**Indicative scientific points:**<br>**Motor:**<br><br>• electricity / current produces rotation<br>• uses direct current<br>• attempt to describe use of commutator.<br><br>**Generator:**<br><br>• rotation of coil produces electricity<br>• no need for commutator / explains slip rings<br>• example shown produces alternating current<br>• reference to power station / dynamo etc.<br><br>**Both:**<br><br>• (stationary) magnetic field |

| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | | | Brief description of how a motor works or how a generator works. May be some confusion of difference between them. Quality of written communication impedes communication of the science at this level.<br><br>(1–2 marks)<br><br>**(Level 0)**<br>Insufficient or irrelevant science. Answer not worthy of credit.<br>(0 marks) | | • rotating coil<br>• difference between ac and dc<br>• graphs of ac and dc.<br><br>**Accept**<br>higher level answers regarding interaction of magnetic field and current.<br><br>**Use the L1, L2, L3 annotations in Scoris; do not use ticks.**<br><br>Examiner's Comments<br><br>This was a challenging six-mark extended writing question. The majority of candidates scored 0 marks on this question. The best responses took time to carefully describe how a motor works, using appropriate technical terms, before doing the same for a generator, then finally comparing the two. The majority of the candidates that scored any marks did so for a basic description of a generator as a rotating/moving coil (or magnet) producing electricity in the coil, although many also confusingly described a motor as a generator, therefore restricting their performance to level one. Even basic knowledge of the workings of a motor, as demonstrated here was extremely limited, and technical details such as the commutator for the motor and/or slip rings for the generator were seen in only a minority of responses. The correct use of the term induction was occasionally seen in reference to the generator, but also incorrectly in reference to the motor. |
| | | | Total | 6 | |

| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 3 | a | i | downwards arrow | 1 | needs to be near CD<br><br>**Examiner's Comments**<br><br>Most candidates drew a clear vertical arrow downwards. A small number drew it too far away from side CD. |
| | | ii | current / moving charge / moving electrons (in wires) (1)<br><br>(in) magnetic field (1) | 2 | **not** induced / creates current<br>**allow** magnetic field around the wire (produced by the current)<br><br>**allow** between magnets / poles<br>**ignore** N and S<br><br>**Examiner's Comments**<br><br>Some answers confused the motor with a generator and others misunderstood what the question was asking as their answers gave the purpose of the forces to turn the coil. Magnets were quite often mentioned but not the magnetic field. Many answers lacked clarity and the use of the appropriate scientific terminology. Some candidates described the forces as an interactive pair. |
| | b | | **any THREE** from:<br>• allows coil / motor to spin / rotate<br>• without tangling the wires<br>• allows current to flow (in / out of coil)<br>• reverses direction of current<br>• reverses direction of the coil's magnetic field<br>• keeps forces on coil in same direction<br>• every half turn / each time coil passes vertical | 3 | **Examiner's Comments**<br><br>Less than half the candidates achieved any marks on this part. There was confusion again with a generator. Vague references were made to something changing direction, though some thought it was the coil or the magnets. Very few candidates gave a clear and full description of the function of the commutator. |
| | | | **Total** | 6 | |

| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 4 | a | | Out of the page ✓ | 1<br>(AO 1.2) | Examiner's Comments<br><br>Candidates needed to be able to recall and apply Fleming's left hand rule. At every position, the direction of the current is perpendicular to the magnetic field and so the force or thrust or motion indicated by the thumb is out of the page. |
| | b | | FIRST CHECK THE ANSWER ON ANSWER LINE<br>If answer = 1.2 (N) award 4 marks<br><br>select force = magnetic flux density × current × length of conductor ✓<br><br>calculate length correctly, including unit conversion length = 0.025 × 200 = 5 (m) ✓<br><br>= 0.40 × 0.60 × 5 ✓<br><br>= 1.2 (N) ✓ | 4<br><br>(AO 1.2)<br><br>(AO 2.2)<br><br>(AO 2.1)<br><br>(AO 2.1) | ALLOW 3 marks if 200 turns omitted, 0.0060 N<br><br>ALLOW 3 marks if using 5000mm, 1200N<br><br>ALLOW 2 marks if 200 turns omitted and no conversion of 25mm to m, 6N<br><br>ALLOW 1 mark for a substitution that shows evidence of the formula<br><br>Also gains m.p.1 and m.p.2<br><br>Examiner's Comments<br><br>Most candidates were able to select the correct formula but then failed to calculate the length of the conductor with a correct unit conversion. |
| | | | Total | 5 | |