3.22 Magnetism and the Motor Effect: 30-minute Pack

AQA 8464 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 An electromagnet is a solenoid (a coil of wire) that produces a magnetic field only when a current flows through it.

(a) State three factors that affect the strength of the magnetic field produced by an electromagnet. **(3)**

(b) Explain, in terms of magnetic domains, why adding an iron core inside a solenoid increases the strength of the magnetic field it produces. **(2)**

(Total for Question 1 is 5 marks)

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2 Higher Tier only. A simple d.c. electric motor contains a rectangular coil of wire that rotates between the poles of a permanent magnet.

(a) Describe the function of the split-ring commutator in a d.c. motor. **(3)**

(b) At one instant, one side of the coil (side X) is moving upwards through the magnetic field, while the opposite side of the coil (side Y) is moving downwards through the field at the same point. Using Fleming's left-hand rule, explain how the forces on side X and side Y work together to keep the coil rotating in the same direction. **(3)**

(c) State one advantage of using a coil with many turns of wire, rather than a single loop, in a d.c. motor. **(1)**

(Total for Question 2 is 7 marks)

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3 Higher Tier only. A loudspeaker converts a varying electrical current into sound. It contains a coil of wire attached to a paper cone; the coil sits inside the magnetic field of a permanent magnet. Explain, using ideas about the motor effect, how a loudspeaker produces sound from a varying current in the coil.

(Total for Question 3 is 6 marks)

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4 Higher Tier only. A group of students investigates how the number of turns on a solenoid affects the magnetic flux density it produces at its centre, using a fixed current of 2.0 A and a Hall probe to measure the magnetic flux density, B. Their results: with 50 turns, B = 0.020 T; with 150 turns, B = 0.060 T.

(a) Use the data to show that B is directly proportional to the number of turns, N. **(2)**

(b) Predict the magnetic flux density produced when the solenoid has 250 turns, assuming the same pattern continues. **(2)**

(c) Suggest one way the students could improve the accuracy of their results. **(1)**

(Total for Question 4 is 5 marks)

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Mark scheme · 3.22 Magnetism and the Motor Effect: 30-minute Pack

Question 1

(a) the size of the current in the coil **B1**

(a) the number of turns on the coil (per unit length) **B1**

(a) whether the coil has a core, and the material of the core (e.g. adding an iron core) **B1**

(a) Answer: The size of the current, the number of turns on the coil, and whether it has a core (e.g. an iron core).

(b) the magnetic domains in the iron line up with the solenoid's field, so the core becomes magnetised (an induced magnet), oe **M1**

(b) the induced magnetic field of the core is in the same direction as the solenoid's field and adds to it, increasing the overall (total) field strength, oe **A1**

(b) Answer: The domains in the iron core line up with the solenoid's field, so the core becomes an induced magnet; its own field adds to the solenoid's field, increasing the total field strength.

Question 2

(a) it reverses the direction of the current in the coil, oe **B1**

(a) every half turn (each time the coil passes through the plane at right angles to the magnetic field), oe **B1**

(a) so that the direction of the force (turning effect) on each side of the coil stays the same on each half turn, keeping the coil rotating continuously in the same direction rather than oscillating back and forth, oe **B1**

(a) Answer: It reverses the current in the coil every half turn, so the force on each side of the coil keeps acting in a way that turns the coil continuously in the same direction.

(b) side X and side Y carry current in opposite directions, as they are opposite sides of the same loop of wire, while both sides are in the same direction of magnetic field, oe **M1**

(b) by Fleming's left-hand rule, this means the force on side X acts in the opposite direction to the force on side Y, oe **M1**

(b) because side X and side Y are on opposite sides of the coil (opposite sides of the axis of rotation), these opposite forces both act to turn the coil in the same rotational direction (they form a turning effect/couple), oe **A1**

(b) Answer: Current flows in opposite directions on the two sides of the coil, so by Fleming's left-hand rule the forces on the two sides are in opposite directions; because the sides are on opposite sides of the axis, this pair of forces turns the coil in one consistent rotational direction.

(c) a coil with many turns produces a greater total force / bigger turning effect (for the same current), making the motor more powerful/effective, oe **B1**

(c) Answer: A coil with many turns produces a bigger turning effect (for the same current), making the motor more powerful.

Question 3

Level 0 No relevant content. **0**

Level 1 Simple, isolated statement(s) about the coil, magnet or motor effect are made, with little or no linking to how sound is produced. **1-2**

Level 2 Some of the chain of reasoning linking the varying current to the force on the coil and the movement of the cone is given, but the explanation is incomplete or not fully logically linked. **3-4**

Level 3 A clear, logically linked chain of reasoning is given, from the varying current in the coil, through the motor effect and Fleming's left-hand rule, to the vibration of the cone and the production of a sound wave. **5-6**

Indicative content:

- the coil carries a current and lies within the magnetic field of the permanent magnet
- the current-carrying coil experiences a force because of the motor effect
- the direction of this force can be found using Fleming's left-hand rule
- as the current in the coil varies in size and/or direction, the size and/or direction of the force on the coil varies
- the changing force makes the coil, and the cone attached to it, move back and forth (vibrate)
- the vibrating cone pushes and pulls the air next to it
- this creates areas of compression and rarefaction in the air, forming a sound wave
- the frequency at which the cone vibrates matches the frequency of the varying current, so the current's frequency affects the pitch of the sound produced

Question 4

(a) calculates B / N for both readings: $0.020 / 50 = 4.0 \times 10^{-4}$ (T per turn) and $0.060 / 150 = 4.0 \times 10^{-4}$ (T per turn), oe **M1**

(a) since B / N is the same (constant) for both readings, B is directly proportional to N, oe **A1**

(a) Answer: B / N = 4.0×10^{-4} T per turn for both sets of data, so B is directly proportional to N.

(b) uses the constant ratio from part (a): $B = 4.0 \times 10^{-4} * 250$, oe (allow ecf from (a)) **M1**

(b) B = 0.10 T, cao **A1**

(b) Answer: B = 0.10 T

(c) repeat each reading (at each value of N) and calculate a mean value of B, to reduce the effect of random error, oe (accept: use a more precise/calibrated Hall probe) **B1**

(c) Answer: Repeat each reading and calculate a mean, to reduce the effect of random error.

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