

Loudspeakers microphones and electromagnetic devices

AQA GCSE Separate Physics 8463 only | Higher tier only | Paper 2

23 parts | 44 marks | Separate Higher only | Timing estimated/untrialled

Specification points covered

4.7.2.4 / 4.7.3.3: moving-coil loudspeakers, headphones and microphones (Separate Higher only)
4.7.2.2 / 4.7.3.1: motor force and direction; induced potential difference and current (selected content)
4.6.1.2: period and frequency from current traces (supporting skill; selected content)

A railway-station designer tests a public-address system on a low-level workshop bench: moving-coil microphone, amplifier and loudspeaker. Diagnose each stage using the correct electromagnetic mechanism.

Original PhysicsUK practice, not official AQA. Separate Physics Higher only, not Combined/Foundation. 23 parts/44 marks; no required-practical completion claim. Figure 1 shows local conductor sections, not a complete device. Use precise moving-part and cause/effect language.

1 Checking the conversion chains

The microphone detects the announcer's voice. The amplifier provides a varying current to the loudspeaker. The tests below use moving-coil devices, not capacitor microphones.

1(a) Name the principal electromagnetic effect used when the amplifier drives the loudspeaker. **[1 mark]**

Answer / mark points: Motor effect. [1] Current in a magnetic field produces force on the coil; do not name the generator effect for the principal driven conversion.

1(b) Name the principal effect that produces the moving-coil microphone's electrical signal. **[1 mark]**

Answer / mark points: Generator effect / electromagnetic induction. [1] "Electromagnetism" alone does not distinguish the two devices.

1(c) In a test, a steady current gives a click and the cone then settles at a displaced position. Explain why this does not produce a continuous sound wave. **[2 marks]**

Answer / mark points: After settling, the cone is not vibrating. [1] It therefore does not keep producing pressure variations in the air. [1] The initial movement/click does not mean a steady current gives a sustained tone.



2 Forces in the loudspeaker

Figure 1 shows two separate local cross-sections of active conductors in one loudspeaker coil, not a complete device. Dot = current out of the page; cross = into the page. The upper section has an upward local field; the lower section has a downward local field.

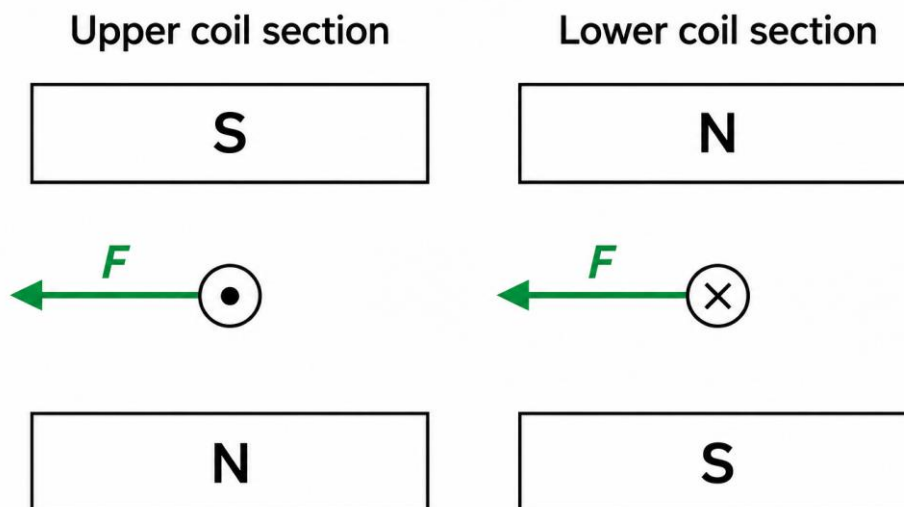


Figure 1

2(a) Use Fleming's left-hand rule and the supplied local field directions to state the force direction on each of the upper and lower conductor sections in Figure 1. **[2 marks]**

Answer / mark points: Upper: leftwards. [1] Lower: also leftwards. [1] Out-of-page current with upward field and into-page current with downward field both give leftward force by Fleming's left-hand rule; they add rather than cancel.

2(b) Both current directions are reversed while the magnet stays fixed. State the new direction of the resultant magnetic force on the coil. **[1 mark]**

Answer / mark points: Rightwards. [1] Reversing current reverses the motor force; no movement of the permanent magnet is required.

2(c) Explain how a continuously alternating current in the coil produces a sound wave. Include the coil's magnetic field, the force and the attached cone. **[4 marks]**

Answer / mark points: The current produces a magnetic field around the coil. [1] This interacts with the permanent-magnet field to produce force on the coil. [1] Alternating current reverses the force, so the coil and attached cone vibrate. [1] The vibrating cone produces pressure variations in the air, forming sound waves. [1] "The coil is attracted to the magnet" alone does not explain both directions.



3 Choosing an active coil

In this separate calculation model the active wire is perpendicular to a uniform 0.40 T field. Active length is 2.5 m unless a different coil is stated. Count only wire in the field; do not measure lengths from Figure 1.

3(a) The peak current is 80 mA. Calculate the peak magnetic force on the 2.5 m active wire. **[2 marks]**

Answer / mark points: 80 mA = 0.080 A. [1] $F = B I \ell = 0.40 \times 0.080 \times 2.5 = 0.080$ N. [1] The length symbol ℓ is not the current I .

3(b) The same 2.5 m coil needs a peak force of 0.12 N. Calculate the required peak current in A. **[2 marks]**

Answer / mark points: $I = F/(B\ell) = 0.12/(0.40 \times 2.5)$. [1 for valid rearrangement/substitution] $I = 0.12$ A (120 mA). [1]

3(c) At 0.080 A in the same field, coil X has 3.0 m active wire and coil Y has 3.5 m. The design needs at least 0.10 N peak force. Calculate each force and choose a coil. Show your working. **[3 marks]**

Answer / mark points: X: $F = 0.40 \times 0.080 \times 3.0 = 0.096$ N. [1] Y: $F = 0.40 \times 0.080 \times 3.5 = 0.112$ N. [1] Choose Y: it meets 0.10 N; X does not. [1 for both comparisons] For this show-your-working task an unsupported correct choice alone can earn only its one decision mark; do not apply this restriction to every short calculation.

3(d) A technician substitutes the coil's full 6.0 m wire length even though only 2.5 m is in the field. Explain the error in this model. **[1 mark]**

Answer / mark points: Only the active perpendicular wire in the stated magnetic field contributes to this $F = B I \ell$ calculation; the remaining wire is outside that field. [1] Do not count inactive connecting wire.



4 Testing the microphone

The station's dynamic microphone has a flexible diaphragm attached to a light coil in a fixed permanent-magnet field. Its input circuit is complete unless stated otherwise. Pressure changes make the diaphragm and attached coil vibrate back and forth.

4(a) Explain how the sound at the microphone creates an alternating electrical signal in its complete input circuit. Include the diaphragm, the coil, induced potential difference and current. **[4 marks]**

Answer / mark points: Sound-pressure variations make the diaphragm and attached coil vibrate. [1] The coil moves relative to/cuts through the permanent magnetic field. [1] A potential difference is induced across its ends, reversing as the motion reverses. [1] Because the circuit is complete, an alternating current flows. [1] Do not say induced current is what first makes this microphone's diaphragm vibrate.

4(b) The diaphragm and coil are held stationary in the unchanged magnet field. What happens to the sound-generated signal? Give a reason. **[1 mark]**

Answer / mark points: No sound-generated induced signal: there is no coil motion relative to the unchanged magnetic field. [1 for outcome with reason] Merely being near a magnet is not enough.

4(c) The coil still vibrates, but a broken lead opens the circuit. State whether a potential difference can still be induced and whether current flows. **[2 marks]**

Answer / mark points: A potential difference can still be induced by the coil's relative motion. [1] No current flows through the open circuit. [1] Do not make circuit closure a condition for induced potential difference.

4(d) At the same sound frequency, the diaphragm's vibration amplitude increases. Explain why this can increase the peak induced potential difference. **[2 marks]**

Answer / mark points: It travels further back and forth in the same time per cycle, so its peak speed is greater. [1] The coil then cuts the field more rapidly, giving a larger peak induced potential difference. [1] No numerical induction law is needed.

4(e) The magnet's polarity is reversed but the coil repeats exactly the same motion. State the change to the induced signal's polarity. **[1 mark]**

Answer / mark points: The polarity/direction of the induced signal reverses for the same coil motion. [1] Do not conclude that its frequency doubles.

4(f) A spare moving-coil loudspeaker is disconnected from the amplifier and connected to a recorder. Sound makes its cone and coil vibrate. Explain why it can act as a moving-coil microphone. **[2 marks]**

Answer / mark points: The vibrating coil moves relative to the fixed magnetic field. [1] This induces a varying potential difference/signal by the generator effect. [1] Its normal name does not prevent the reverse conversion; no capacitor microphone is being described.



5 Reading the drive signals

Figure 2 shows two separate drive tests with the same loudspeaker, field and active length. For these graphs, define positive current as giving a rightward magnetic force. For (d), assume a linear response at this fixed frequency: a greater force amplitude gives greater cone-vibration amplitude.

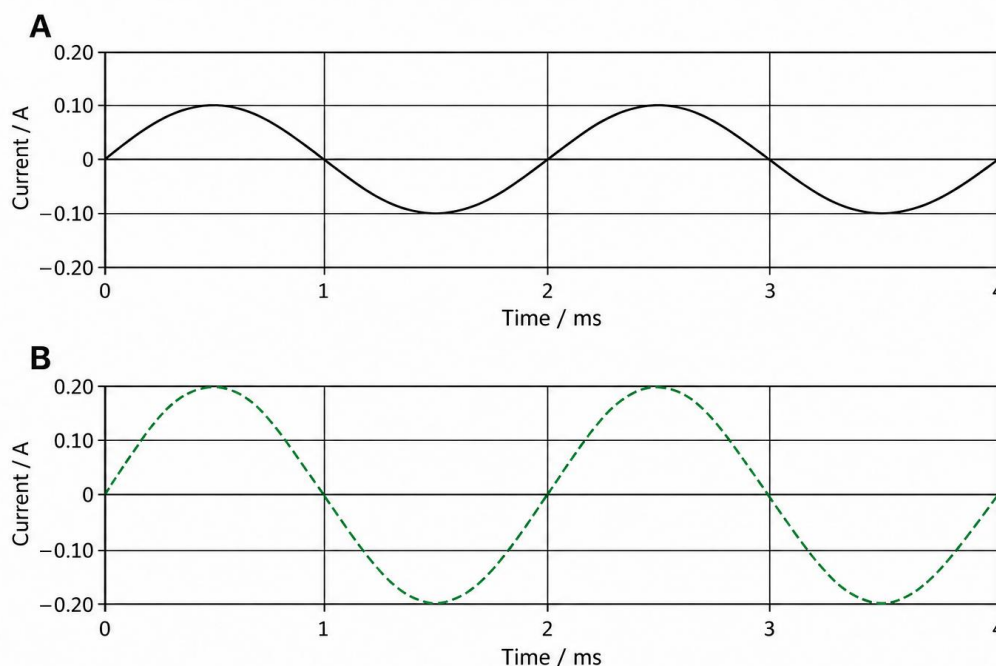


Figure 2

5(a) State the peak current magnitude for trace A and for trace B. [1 mark]

Answer / mark points: A: 0.10 A; B: 0.20 A. [1 for both] Peak-to-peak values 0.20 A/0.40 A are not peak magnitudes.

5(b) Determine the period of trace A and calculate its frequency. Use $f = 1/T$. [2 marks]

Answer / mark points: $T = 2.0 \text{ ms} = 0.0020 \text{ s}$. [1 for period correctly expressed in seconds] $f = 1/0.0020 = 500 \text{ Hz}$. [1] B has the same period; a zero crossing every 1 ms is only half a cycle.

5(c) For trace A at 1.5 ms, calculate the magnetic force magnitude using $B = 0.40 \text{ T}$ and active length 2.5 m, and state its direction. [2 marks]

Answer / mark points: $I = -0.10 \text{ A}$; magnitude $F = 0.40 \times 0.10 \times 2.5 = 0.10 \text{ N}$. [1] Leftwards because the current is negative. [1] This is magnetic force, not a measurement of instantaneous cone velocity.

5(d) Under the stated fixed-frequency linear-response assumption, compare the loudness and pitch when the drive changes from A to B. Link your answer to the traces. [2 marks]

Answer / mark points: B has twice the current/force amplitude, giving a larger cone-vibration amplitude and a louder sound under this assumption. [1] The period/frequency is unchanged, so the pitch is unchanged. [1] Do not claim more cycles merely because the peaks are taller.



6 Diagnosing the station system

An isolated speaker bench test gives the correct alternating microphone signal at the amplifier input and the expected alternating current at the speaker coil. The cone is physically jammed and cannot vibrate. These are test observations, not instructions to work on a live station system.

6(a) Explain why the jammed cone can make the speaker silent even though the measured alternating coil current is correct. Identify the stage at fault. **[2 marks]**

Answer / mark points: The jam prevents cone vibration and hence repeated air-pressure variations. [1] The fault is in the loudspeaker's mechanical output stage, not the already-verified microphone signal. [1] Current alone does not prove a sound wave is produced.

6(b) After the jam is removed, the two speaker leads are swapped. Explain why reversed leads alone would not normally make this single isolated speaker silent. **[2 marks]**

Answer / mark points: The current and magnetic-force directions reverse for each part of the same signal. [1] The cone still vibrates at the signal frequency and produces sound; the phase reverses rather than the oscillation disappearing. [1] No multi-speaker cancellation/phase-array claim is needed.

6(c) A replacement headset uses a small moving-coil earpiece. An engineer calls its principal effect "the generator effect" because it contains a coil and magnet. Correct the explanation for normal driven use. **[2 marks]**

Answer / mark points: Its driven current experiences motor force in the magnetic field, making the attached diaphragm vibrate. [1] That produces sound-pressure variations, so the principal conversion is motor effect, not microphone-style generation. [1] Similar components can support different principal conversions.

Review and improve

Keep the principal conversion chain in the correct order. In normal use the microphone's diaphragm moves the coil; its small induced signal is not what initially pushes it. In the loudspeaker current causes force on the coil and attached cone. Do not infer cone position or velocity from current alone. Reject "current is used up" or "the permanent magnet vibrates". Require linked explanations and award only the printed marks.

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