Loudspeakers

4.7.2.4 · Magnetism and electromagnetism · revision notes

A moving-coil loudspeaker, and headphones, which work in the same way, use the motor effect to turn a changing electric current into sound. You need to explain step by step how the alternating current makes the cone vibrate and produce a sound wave. GCSE Physics only (not Combined Science), Higher tier only.

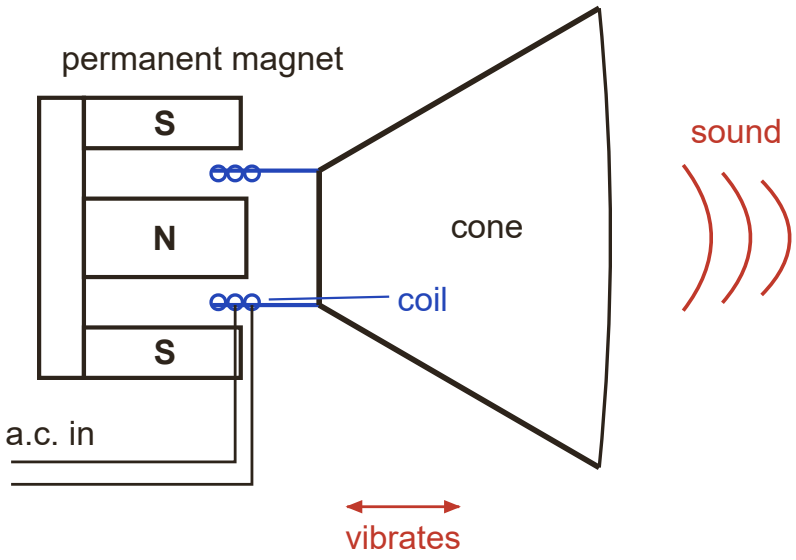
Key facts

- Loudspeaker: alternating current → changing force (motor effect) → vibrating cone → sound
- Current reverses → force on the coil reverses → cone moves back and forth
- Bigger current → bigger force → bigger amplitude → louder sound
- Loudspeaker = motor effect; microphone = generator effect
- Parts: permanent magnet, coil, cone (diaphragm)
- Frequency of the sound = frequency of the current
- Headphones work in the same way

Notes

Structure

- A moving-coil loudspeaker has a **permanent magnet**, shaped so that its magnetic field passes through a **coil** of wire.
- The coil can move freely in the field. It is attached to a light **cone** (a diaphragm).
- The coil is connected to a changing electrical signal: an **alternating current**, e.g. from an amplifier.



The coil sits in the magnet's field; the cone is attached to the coil.

- Headphones contain small loudspeakers that work in the same way.

How it works

- The current in the coil produces a magnetic field, which interacts with the field of the permanent magnet. This gives a **force on the coil**: the **motor effect**.
- When the current reverses, the force reverses. So the coil is pushed out, then pulled in, again and again.
- The cone moves with the coil, so the cone **vibrates**.
- The vibrating cone pushes and pulls on the air, making **pressure variations** (compressions and rarefactions) that travel as a **sound wave**.

Pitch and loudness

- The cone vibrates at the **same frequency** as the current. A higher-frequency current gives a higher-pitched sound.
- A **bigger current** gives a bigger force, so the cone vibrates with a bigger amplitude and the sound is **louder**.
- A moving-coil microphone has the same parts but works the other way round: sound makes the coil move in the field, which induces a current (the generator effect). Grade 8+ only

How to answer each type of question

Explain how a loudspeaker produces sound 4 to 6 marks **Grade 7**

1. The current in the coil is in a magnetic field, so there is a force on the coil (motor effect).
2. The current alternates, so the force keeps changing direction.
3. The coil and cone move back and forth: they vibrate.
4. The vibrating cone makes pressure variations in the air: a sound wave.

Example. Explain how a moving-coil loudspeaker produces a sound when it is connected to an alternating current supply. [4 marks]

Model answer. The current in the coil produces a magnetic field (1). This interacts with the magnetic field of the permanent magnet, producing a force on the coil and cone (the motor effect) (1). The current keeps changing direction, so the force keeps reversing and the coil and cone vibrate (1). The vibrating cone makes pressure variations in the air that travel as a sound wave (1).

Describe how changing the current changes the sound

2 to 4 marks | Grade 7

1. Frequency of the current → frequency of vibration → pitch.
2. Size of the current → size of the force → amplitude of vibration → loudness.
3. Give the reason for each change, not just the effect.

Example. The frequency of the alternating current through a loudspeaker is increased. Then, separately, the size of the current is increased.
Describe how each change affects the sound. Give reasons. [4 marks]

Model answer. Higher frequency: the cone vibrates more times per second / at a higher frequency (1), so the sound has a higher pitch (1). Bigger current: there is a bigger force on the coil, so the cone vibrates with a bigger amplitude (1), so the sound is louder (1).

Calculate using the frequency of the sound

3 to 4 marks | Grade 6

1. The sound has the same frequency as the current.
2. Use wave speed = frequency × wavelength ($v = f\lambda$), rearranged if needed.
3. Give the unit and a sensible number of significant figures.

Example. A loudspeaker is connected to an alternating current supply with a frequency of 440 Hz. The speed of sound in air is 340 m/s.
(a) State the frequency of the sound wave. [1 mark]
(b) Calculate the wavelength of the sound wave. [3 marks]

Model answer.

(a) 440 Hz (1)
(b) $\lambda = v \div f$ (1)
$\lambda = 340 \div 440$ (1)
$\lambda = 0.77$ m (1)

Don’t lose marks

- Saying the magnet vibrates: the coil and cone move, and the magnet stays fixed.
- Explaining it only as 'attraction and repulsion' instead of the force on a current-carrying coil in a magnetic field (the motor effect).
- Forgetting to say the current alternates (changes direction), which is why the force reverses.
- Mixing up loudspeakers (motor effect) and microphones (generator effect).
- Saying a higher frequency makes the sound louder: it makes the pitch higher.

More tips

Memory tricks

- Loudspeaker → motor effect → current turns into movement. Microphone → generator effect → movement turns into current.
- Learn the chain: a.c. → changing force → vibrating cone → vibrating air → sound.
- Frequency in = frequency out: the sound has the same frequency as the current.

Exam technique

- This is a classic chain question: write the steps in order and join each one to the next with 'so'.
- Use the key terms 'motor effect', 'alternating current', 'force changes direction', 'vibrates' and 'pressure variations'.
- If a question asks about headphones, answer exactly as you would for a loudspeaker.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 4 — **Name the main parts of a loudspeaker**
A permanent magnet, a coil of wire in its magnetic field, and a cone attached to the coil.

Grade 5 — **State that loudspeakers use the motor effect**
The coil carries a current in a magnetic field, so there is a force on it.

Grade 6 — **Explain why the cone vibrates**
The current alternates, so the force on the coil keeps reversing, pushing the coil and cone back and forth.

Grade 6 — **Explain how the vibrating cone produces sound**
The cone pushes and pulls on the air, making pressure variations (compressions and rarefactions) that travel as a sound wave.

Grade 7 — **Link the frequency of the current to pitch**
The cone vibrates at the same frequency as the current, so the sound has that frequency.

Grade 7 — **Link the size of the current to loudness**
A bigger current gives a bigger force, so the cone vibrates with a bigger amplitude and the sound is louder.

Grade 8 — **Contrast a loudspeaker with a microphone**
They have the same parts, but a loudspeaker uses the motor effect (current → movement) and a microphone uses the generator effect (movement → current).

Free notes, Full packs, practice papers and mock exams at chhetriacademy.com. Written for this site; not taken from past papers. Stuck? 1-to-1 tutoring with a free 30-minute trial lesson.