



QUESTION WORKBOOK

Electromagnetic induction: Faraday and Lenz

Magnetic fields · Year 13

AQA 3.7.5.4 · CIE 20.5.4, 20.5.5 · OCR A 6.3.3(c), 6.3.3(d)(i), 6.3.3(e)

19 questions · 52 marks

NAVY SCREEN EDITION

SECTION A · Warm-up

A1 State Faraday's law of electromagnetic induction. [2]

A2 The flux linkage through a coil changes by 0.60 Wb-turns in 0.20 s. Calculate the magnitude of the average induced emf. [2]

A3 State Lenz's law. [1]

A4 State the SI unit of the rate of change of flux linkage. [1]

A5 A coil sits at rest in a steady magnetic field, so its flux linkage is constant. State the emf induced in the coil and explain your answer. [2]

SECTION B · Standard

- B1** A straight conducting rod of length 0.30 m moves at 4.0 m s^{-1} perpendicular to a magnetic field of flux density 0.25 T. Calculate the emf induced across the ends of the rod. [2]

- B2** A coil of 200 turns and area 0.01 m^2 lies with its plane perpendicular to a magnetic field. The flux density falls steadily from 0.50 T to 0.10 T in 0.40 s. Calculate the average emf induced in the coil. [3]

- B3** The flux linkage of a coil collapses from 0.80 Wb-turns to zero in 0.010 s. Calculate the magnitude of the average induced emf. [2]

- B4** Explain how Lenz's law is a consequence of the conservation of energy. [3]

- B5** The flux through each turn of a 250-turn coil increases steadily by 3.2×10^{-4} Wb in 40 ms. The coil is connected in a circuit of total resistance $4.0 \, \Omega$. Calculate the average induced emf and the average current in the circuit. [3]

- B6** An aeroplane with a wingspan of 60 m flies horizontally at $250 \, \text{m s}^{-1}$ at a location where the vertical component of the Earth's magnetic field is $45 \, \mu\text{T}$. Calculate the emf induced between its wingtips, and state why only the vertical component of the field contributes. [3]

- B7** Two flat coils lie side by side. When a switch in coil A's circuit is closed, a meter in coil B's circuit deflects briefly and then returns to zero, even though the current in coil A remains switched on. Explain these observations. [2]

- B8** A rectangular coil moves at constant velocity into, through and out of a region of uniform magnetic field perpendicular to its plane. Explain why an emf is induced only while the coil enters and leaves the region, and how the two emfs compare. [3]

SECTION C · Stretch

- C1** A coil of 100 turns and area 0.02 m^2 rotates at a frequency of 50 Hz in a uniform magnetic field of flux density 0.30 T. Calculate the peak emf induced in the coil. [3]

- C2** A conducting rod of length 0.20 m slides at a constant 3.0 m s^{-1} along horizontal rails in a magnetic field of flux density 0.40 T. The circuit is completed by a 2.0Ω resistor. Calculate the induced emf, the current in the circuit, and the force needed to keep the rod moving at constant speed. [4]

- C3** A bar magnet is dropped north pole first through a coil connected to a meter. Use Lenz's law to explain the direction of the induced current as the magnet enters the coil, and state what happens to the current direction as the magnet leaves. [3]

- C4** A generator must produce a peak emf of at least 50 V when its coil rotates at 50 Hz in a magnetic field of flux density 0.35 T. Two coils are available.
Coil P: 200 turns, area $2.5 \times 10^{-3} \text{ m}^2$
Coil Q: 350 turns, area $1.2 \times 10^{-3} \text{ m}^2$
Deduce which coil, if either, meets the requirement. [4]

- C5** A coil rotates at a steady rate in a uniform magnetic field. Explain why the induced emf is zero at the instant the coil is face-on to the field, and a maximum when the coil is edge-on. [3]

- C6** A thin aluminium plate hangs from a pivot and swings between the poles of a strong magnet. Aluminium is not ferromagnetic, yet the plate comes to rest after very few swings. Explain fully why the plate stops so quickly and what happens to its energy. [6]
