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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

PRINT EDITION

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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 Ω. 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 m s^{-1} at a location where the vertical component of the Earth's magnetic field is 45 μT. 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 2.0 Ω 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 2.5×10^{-3} m^2
Coil Q: 350 turns, area 1.2×10^{-3} 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]