

Magnetic flux, Faraday's law and Lenz's law

AP Physics 2 (algebra-based) · Test answers (mark scheme)

Marks are given for the correct relationship, for a correct substitution and for the answer with its unit. In direction questions, explicit reference to the change in flux is needed to reach full marks.

Level: AP Physics 2 (algebra-based) · **Curriculum:** AP P2 Unit 12

Question 1 Flux through a coil (2 marks)

$A = 0.12 \times 0.080 = 9.6 \times 10^{-3} \text{ m}^2$. $\Phi = BA \cos \theta = 0.25 \times 9.6 \times 10^{-3} \times \cos 40^\circ = \mathbf{1.8 \times 10^{-3} \text{ Wb}}$.

Marking: 1 for area; 1 for flux with unit.

Question 2 Induced emf (3 marks)

(a) $\Delta\Phi = 1.0 - 4.0 = -3.0 \text{ mWb}$, a magnitude of $\mathbf{3.0 \times 10^{-3} \text{ Wb}}$.

(b) $\epsilon = N\Delta\Phi/\Delta t = 300 \times 3.0 \times 10^{-3} / 0.050 = \mathbf{18 \text{ V}}$.

(c) The rate of change doubles, so the emf **doubles to 36 V**.

Marking: 1 mark each part.

Question 3 Approaching south pole (3 marks)

(a) **Clockwise** as seen from the magnet.

(b) Approaching the south pole increases the flux through the loop. The loop must oppose this increase, so it produces a south face towards the magnet, which repels it. The right-hand grip rule then gives a clockwise current seen from the magnet.

Marking: (a) 1; (b) 1 for opposing the increase in flux; 1 for the right-hand rule step.

Question 4 Rod on rails (4 marks)

(a) $\epsilon = BLv = 0.35 \times 0.60 \times 2.5 = \mathbf{0.53 \text{ V}}$.

(b) $I = \epsilon/R = 0.525 / 1.5 = \mathbf{0.35 \text{ A}}$.

(c) $F = BIL = 0.35 \times 0.35 \times 0.60 = \mathbf{0.074 \text{ N}}$.

(d) $P = Fv = 0.0735 \times 2.5 = \mathbf{0.18 \text{ W}}$.

Marking: 1 mark each part; allow follow-through.

Question 5 Slow fall in a tube (2 marks)

Aluminium is a conductor, so the moving magnet induces eddy currents in the tube. By Lenz's law these currents oppose the motion of the magnet, giving an upward force and a smaller acceleration. Plastic is an insulator, so no currents flow and the magnet falls freely.

Marking: 1 for eddy currents induced; 1 for opposing the motion.

Question 6 Faraday's law in words (2 marks)

The induced emf equals the rate of change of magnetic flux linkage: $\varepsilon = -N\Delta\Phi/\Delta t$. The minus sign shows that the induced current opposes the change in flux (Lenz's law, conservation of energy).

Marking: 1 for the statement; 1 for the meaning of the minus sign.

Question 7 Units (2 marks)

$\Phi = BA$, with B in $T = N/(A \cdot m)$. So $Wb = T \cdot m^2 = N \cdot m/A = J/A$. Dividing by seconds, $Wb/s = J/(A \cdot s) = J/C = V$.

Marking: 1 for the unit of Wb in base form; 1 for $J/C = V$.

Question 8 Loop leaving a field (2 marks)

(a) The flux into the page decreases, so the induced field must also point into the page: the current is **clockwise**.

(b) The flux changes twice as fast, so the emf **doubles**.

Marking: 1 mark each part.