

19.2 Induction (full D.4, HL)

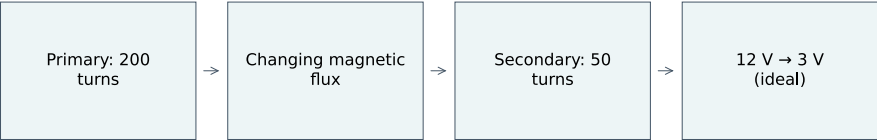
Name: _____ Class: _____ Date: _____ **Total: 24 marks**

KEY WORDS magnetic flux • Faraday’s law of induction
• Lenz’s law

Objective

Practise the full guide D.4 toolkit (HL only): magnetic flux $\Phi = BA \cos \theta$, Faraday’s law $\varepsilon = -N\Delta\Phi/\Delta t$, Lenz’s law as energy conservation, the moving-conductor emf $\varepsilon = BLv$, the sinusoidal emf of a coil rotating in a uniform field with peak $NBA\omega$, and the effect of rotation frequency on the output. Original practice; not an official IB paper.

1 Key knowledge and worked examples



■ The D.4 equation set

$$\Phi = BA \cos \theta \quad \varepsilon = -N \frac{\Delta\Phi}{\Delta t} \quad \varepsilon = BLv \quad \varepsilon_0 = NBA\omega$$

Lenz’s law: the induced current opposes the change producing it – the minus sign in Faraday’s law, and the reason work must be supplied to keep a generator turning.

■ Worked example: from flux to emf

A 50-turn coil of area 0.050 m² sits in a 0.20 T field, its plane tilted 30° from the field-normal: $\Phi = 0.20 \times 0.050 \times \cos 30^\circ = 8.7 \times 10^{-3}$ Wb. If that flux collapses to zero in 0.10 s: $\varepsilon = N\Delta\Phi/\Delta t = 50 \times 8.7 \times 10^{-3}/0.10 = 4.3$ V. Two habits: measure θ from the normal, not the plane; and check whether the question wants one loop’s

emf or the coil’s N -multiplied total.

2 Practice

2.1 Define magnetic flux and state the angle used in $\Phi = BA \cos \theta$. [2]

2.2 State Lenz’s law and explain why it is a consequence of energy conservation. [2]

2.3 A rod of length 0.15 m moves at 3.0 m/s perpendicular to a 0.40 T field. Calculate the induced emf. [2]

2.4 State two changes that increase the peak emf of a coil rotating in a uniform magnetic field. [2]

3 Exam-style questions

3.1 A single loop of area 0.020 m² lies with its plane perpendicular to a 0.50 T field. Calculate the flux through it; then, if the loop is pulled out of the field in 0.040 s, calculate the average induced emf. [4]

3.2 A bar magnet hangs on a spring above a coil. The magnet oscillates, and the coil's ends are connected through a small lamp. Explain, using Lenz's law, why the magnet's oscillation dies away faster when the lamp circuit is closed than when it is open. [4]

3.3 A rectangular coil of 200 turns and area 0.025 m^2 rotates at 25 rev/s in a 0.30 T field. Calculate the angular frequency and the peak emf, and describe how the output changes if the rotation rate is doubled. [5]

3.4 A generator supplies more power when turned faster. Explain this in terms of Faraday's law and the energy the driving source must supply. [3]
