D.4 Induction

Practice Worksheet — name: ________________________ date: _____________

FORMULAS FOR THIS TOPIC

MAGNETIC FLUX $\Phi = BA\cos\theta$ FARADAY'S LAW $\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$ MOVING CONDUCTOR $\varepsilon = BvL$

SECTION A — MULTIPLE CHOICE

A1. A magnet is dropped through a copper ring. As it approaches, the induced current creates a magnetic field that:

- A Attracts the magnet, speeding it up
- B Repels the magnet, slowing it down
- C Has no effect on the magnet
- D Reverses the polarity of the magnet

A2. The peak emf of a rotating-coil generator is doubled when the rotation frequency is doubled because:

- A The flux through the coil doubles
- B The maximum rate of change of flux doubles
- C The number of turns effectively doubles
- D The magnetic field strength doubles

A3. A conducting rod slides at constant velocity along frictionless rails, completing a circuit in a uniform field. The force needed to keep it moving at constant velocity:

- A Is zero, since velocity is constant
- B Equals the magnetic force BIL opposing the motion
- C Increases with time
- D Depends only on the rod's mass

SECTION B — SHORT ANSWER

B1. A 200-turn coil of area 4.0×10^{-3} m^2 sits perpendicular to a field that falls from 0.60 T to zero in 0.30 s. Calculate the average induced emf. [3 marks]

B2. An aircraft with wingspan 60 m flies at 250 m s^{-1} through a region where the vertical component of the Earth's field is 5.0×10^{-5} T. Calculate the emf induced between the wingtips, and explain why it cannot drive a current around a circuit connected inside the aircraft. [4 marks]

B3. Use Lenz's law and energy conservation to explain why induced currents must oppose the change producing them. [3 marks]

ANSWER KEY

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Section A

A1: Repels the magnet, slowing it down — Lenz's law: the induced current opposes the increasing flux, so the ring's face towards the magnet becomes a like pole, repelling it. Energy conservation demands this — the induced electrical energy comes from the magnet's kinetic energy.

A2: The maximum rate of change of flux doubles — The flux amplitude BA is unchanged, but it is swept through twice as fast: $\varepsilon_0 = NBA\omega$. Doubling ω doubles the peak emf and halves the period — sketching both curves is a classic exam task.

A3: Equals the magnetic force BIL opposing the motion — The induced current $I = BvL/R$ flows through the rod in the field, producing a retarding force BIL (Lenz again). Constant velocity requires an equal applied force; the work it does is exactly the electrical power dissipated.

Section B

B1: $\varepsilon = N\frac{\Delta\Phi}{\Delta t} = 200 \times \frac{0.60\times4.0\times10^{-3}}{0.30} = 1.6\text{ V}$.

B2: $\varepsilon = BvL = 5.0 \times 10^{-5} \times 250 \times 60 = 0.75\text{ V}$. Any connecting wires inside the aircraft move through the same field and have an equal emf induced in them, so the net emf around a complete circuit is zero — no current flows.

B3: Suppose instead the induced current reinforced the change: the growing flux would induce more current, which would grow the flux further — a runaway that generates electrical energy from nothing, violating conservation of energy. Opposition ensures the work done against the induced effects is the source of the electrical energy.