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IGCSE PHYSICS 0625 · TOPICAL PAST PAPERS

Electromagnetic Induction — Paper 2

Worked Solutions (Theory / Structured)

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Electromagnetic Induction — Paper 2 · Worked Solutions

Megalecture worked solutions — model answers with working; please verify before classroom use. These structured-answer solutions cover **Electromagnetic Induction (IGCSE Physics 0625, Paper 2)**: induced e.m.f., Faraday's and Lenz's laws, the a.c. generator, and transformers ($V_p/V_s = N_p/N_s$). Each part is solved from first principles with the data given in the question. Final answers are shown in **bold colour with units**.

Question 1 — Solenoid, ammeter & a moving magnet

A plastic-insulated solenoid is connected to a sensitive ammeter; the N-pole of a steel magnet is moved along the axis (Y → X) into the coil at constant speed.

(a) Why a current flows while the magnet moves [3]

As the magnet moves, the magnetic field (flux) **through the solenoid changes**. This changing flux **induces an e.m.f.** across the coil (electromagnetic induction). Because the solenoid forms a complete circuit with the ammeter, the induced e.m.f. **drives an induced current**, which the ammeter detects. No movement means no change of flux, so no current.

(b)(i) State Faraday's law [2]

The magnitude of the induced e.m.f. is **directly proportional to the rate at which the magnetic flux through the coil changes** (i.e. e.m.f. ∝ rate of change of flux linkage). Faster movement or a greater change of flux gives a larger e.m.f.

(b)(ii) State Lenz's law [2]

The induced current always flows in a direction such that its **magnetic effect opposes the change producing it**. So the induced current creates a magnetic pole that **opposes the motion of the magnet** (consistent with conservation of energy).

(c) Two ways to increase the induced current [2]

1. Move the magnet **faster** (greater rate of change of flux).
2. Use a **stronger magnet**, or **increase the number of turns** on the solenoid.

(d) Direction of current in the coil [2]

As the N-pole enters, the near end of the solenoid must become a **N-pole** to repel the incoming magnet (Lenz's law). Viewed from the magnet side that end carries an **anticlockwise** current, so the arrow on the coil should be drawn so that conventional current flows **from X to Y through the front of the windings** (the end facing the magnet acts as a N-pole).

(e) Two ways to reverse the current direction [2]

1. **Reverse the magnet** — move the same N-pole **out** of the solenoid (X → Y) instead of in.
2. **Turn the magnet round** so the **S-pole** is moved into the solenoid in the same direction.

Question 2 — Wire moved between magnetic poles

A straight wire is held between the N and S poles of a magnet and connected to a sensitive centre-zero ammeter. Moving the wire down deflects the needle to the right.

(a) Name of the electrical effect [1]

Electromagnetic induction (generating an induced e.m.f.).

(b) Why the needle deflects [2]

Moving the wire makes it **cut through the magnetic field lines**, so the flux linked with the circuit changes. This **induces an e.m.f.**, which drives an **induced current** round the circuit, and the current deflects the ammeter needle.

(c) Wire moved upwards instead [1]

The motion is reversed, so the induced current reverses: the needle deflects **to the left** (the opposite way), by the same amount if the speed is the same.

(d) Wire held stationary [2]

The needle **stays at zero (no deflection)**. With the wire stationary the flux through the circuit is **not changing**, so **no e.m.f. and no current are induced**.

Question 3 — Simple a.c. generator

A coil rotates between the poles of a magnet; its ends connect through two slip rings and carbon brushes to the output terminals.

(a) Labels on the diagram [2]

C = the rectangular rotating coil (between the magnet poles); **S** = either of the two slip rings on the axle; **B** = a carbon brush pressing against a slip ring. (Coil → rings → brushes → terminals.)

(b) Why there is an e.m.f. between the terminals [3]

As the coil rotates, its sides **cut through the magnetic field lines**, so the magnetic flux linking the coil **continuously changes**. By Faraday's law this **induces an e.m.f.** across the coil. The slip rings and brushes carry this e.m.f. to the output terminals, so a **potential difference appears between them**.

(c) Purpose of the slip rings [1]

They make a **continuous sliding electrical contact** between the rotating coil and the external (stationary) circuit, so current can flow out while the coil keeps turning.

(d) Two other ways to increase the e.m.f. [2]

1. Use a **stronger magnet** (stronger magnetic field).
2. Use **more turns** on the coil (or a coil of larger area / add a soft-iron core).

(e) Coil positions for (i) maximum and (ii) zero e.m.f. [1+1]

(i) Maximum e.m.f.: when the coil is **parallel to the field (horizontal)** — the sides are cutting field lines fastest, so flux changes most rapidly.

(ii) Zero e.m.f.: when the coil is **perpendicular to the field (vertical / plane at right angles to the field lines)** — the sides move along the field lines and momentarily cut none, so the rate of change of flux is zero.

(f) Why the e.m.f. alternates [1]

Each half-turn, each coil side moves **up through the field then down through it**, so the direction in which the field lines are cut **reverses every half rotation**. This reverses the induced e.m.f., making it alternate (positive then negative).

(g) Effect of changes — completed table [3]

Change made	Maximum value of e.m.f.	Frequency of the e.m.f.
Stronger magnets	**Increases**	No change (stays the same)
More turns on the coil	**Increases**	No change (stays the same)
Coil turned faster	**Increases**	**Increases**

Field strength and number of turns affect only the **size** of the e.m.f.; the rotation rate sets both the peak value **and** the frequency.

Question 4 — Rotating-magnet a.c. generator lighting a lamp

A bar magnet rotates near a fixed coil wound on a soft-iron core; the coil is connected to a lamp.

(a) How alternating current differs from direct current [1]

An **alternating current periodically reverses direction** (and its size varies with time), whereas a **direct current always flows in one direction only**.

(b) How the apparatus produces alternating current [4]

As the magnet rotates, the magnetic **field through the coil keeps changing**, so the flux linking the coil changes and an **e.m.f. is induced** (Faraday's law). During each rotation a **N-pole then a S-pole** sweeps past the coil, so the field through the coil **reverses direction every half turn**. By Lenz's law the induced e.m.f. (and hence the current) therefore **reverses each half turn**, giving an alternating current in the lamp.

(c) Two ways to increase the current in the lamp [2]

1. Rotate the magnet **faster** (greater rate of change of flux).
2. Use a **stronger magnet**, or **more turns** on the coil.

Question 5 — Mutual induction with an iron ring (two coils)

Two coils are wound on the same iron ring. The primary is in series with a switch and a d.c. supply; the secondary is connected to a sensitive centre-zero ammeter. The switch starts open.

(a) The switch is closed [3]

As the switch closes, the current in the primary **rises quickly from zero**, so the magnetic flux in the iron ring **grows rapidly**. This **changing flux** through the secondary **induces an e.m.f.**, so the ammeter gives a **brief deflection (a momentary kick) to one side**, then returns to zero.

(b) The switch left closed for a long time [1]

The primary current is now **steady**, so the flux is **constant** (not changing). No e.m.f. is induced, so the ammeter reads **zero**.

(c) The switch is opened [2]

The primary current **falls quickly to zero**, so the flux **collapses**. This changing flux induces an e.m.f. in the secondary again, so the ammeter gives a **brief deflection in the opposite direction** to part (a), then returns to zero.

Question 6 — Simple transformer (action)

A transformer has a primary coil (a.c. supply) and a secondary coil (lamp) wound on a ring-shaped core.

(a) Metal used for the core [1]

Soft iron (it is easily magnetised and demagnetised).

(b) Purpose of the core [1]

To **link / concentrate the magnetic flux from the primary into the secondary**, so that almost all the changing flux passes through the secondary coil (making the transformer efficient).

(c) How a.c. in the primary lights the lamp [3]

The alternating current in the primary produces a **continuously changing magnetic flux** in the soft-iron core. The core carries this changing flux through the **secondary coil**. The changing flux **induces an alternating e.m.f.** in the secondary (Faraday's law), which drives an **alternating current through the lamp**, so the lamp lights.

Question 7 — Transformer calculation (240 V mains, 24 V 36 W lamp)

*A transformer steps 240 V mains down to run a lamp rated **24 V, 36 W**. Primary = 200 000 turns. Treat the transformer as ideal.*

(a) Two ways to make the lamp brighter (without changing the mains) [2]

1. **Increase the number of turns on the secondary coil** (raises V_s).
2. **Decrease the number of turns on the primary coil** (this also raises the secondary voltage, since $V_s/V_p = N_s/N_p$).

(b)(i) Current in the secondary coil [1]

$$P = V_s I_s \Rightarrow I_s = P / V_s = 36 / 24 = 1.5\ \text{A}$$

The lamp draws **1.5 A** in the secondary.

(b)(ii) Current in the primary coil (ideal transformer) [2]

$$\text{Ideal: power in} = \text{power out, so } V_p I_p = V_s I_s$$
$$I_p = V_s I_s / V_p = (24 \times 1.5) / 240 = 36 / 240 = 0.15\ \text{A}$$

Primary current = **0.15 A**. (A step-down transformer draws a smaller current at the higher voltage.)

(b)(iii) Number of turns on the secondary coil [2]

$$V_p / V_s = N_p / N_s \Rightarrow N_s = N_p \times V_s / V_p = 200\ 000 \times 24 / 240 = 200\ 000 \times 0.1 = 20\ 000 \text{ turns}$$

The secondary has **20 000 turns** (one-tenth of the primary, matching the 240 V → 24 V step-down).

Note from Megalecture. These are original Megalecture worked solutions prepared for revision use. The figure labels in the source worksheet (e.g. "Fig. 7.1", "Fig. 8.1") are reproduced as printed and refer to the diagrams in each question. Please verify against your specification before classroom use.