6.2 Induction and transformers

Name: _____ Class: _____ Date: _____ **Total: 23 marks**

Objective

Build the skills to answer exam questions on **electromagnetic induction** : inducing a voltage, factors that change its size and direction, generators, and transformers with $V_p/V_s = n_p/n_s$ and $V_pI_p = V_sI_s$.

You must be able to:

- describe how a voltage is induced in a wire or coil
- explain how a generator and a transformer work
- use $V_p/V_s = n_p/n_s$ and $V_pI_p = V_sI_s$
- explain why electricity is transmitted at high voltage

1 Key knowledge and worked examples

Induction

idea	equation or rule
induction	a voltage is induced when a wire cuts a magnetic field, or the field through a coil changes
bigger voltage	move faster, use a stronger magnet, or use more turns
direction	reversing the motion or the field reverses the voltage
transformer turns	$V_p \div V_s = n_p \div n_s$
transformer power	$V_p \times I_p = V_s \times I_s$ (if 100% efficient)
transmission	high voltage means low current, so less energy is wasted heating the cables

Worked example 1: turns ratio. A transformer has 200 primary turns and 50 secondary turns. The input is 240 V. Find the output.

1. Known: $n_p = 200$; $n_s = 50$; $V_p = 240$ V.
2. Rule: $V_s = V_p \times n_s \div n_p$.
3. Numbers: $240 \times 50 \div 200$.
4. Result: 60 **V**.

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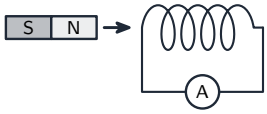
Worked example 2: current. That transformer gives 2.0 A at 60 V. Find the primary current.

1. Known: $V_s = 60$ V; $I_s = 2.0$ A; $V_p = 240$ V.
2. Rule: $V_p I_p = V_s I_s$.
3. Numbers: $I_p = 60 \times 2.0 \div 240$.
4. Result: 0.50 **A**.

Answer shapes: a transformer works only with a.c., because only a changing current makes a changing field.

2 Practice

2.1 A magnet is pushed into a coil connected to a meter. The needle moves to the right. Describe what happens when the magnet is held still, and when it is pulled out. [2]



2.2 Give **two** ways to induce a bigger voltage when the magnet is moved. [2]

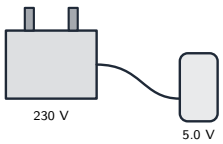


2.3 Explain why a transformer does not work with a steady d.c. supply. [2]



3 Exam-style questions

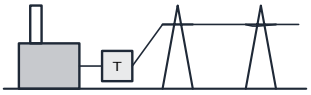
3.1 A phone charger has a transformer that changes 230 V to 5.0 V. Its primary coil has 1840 turns. Calculate the number of turns on the secondary coil. [3]



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3.2 A power station gives 500 kW. A step-up transformer raises the voltage from 25 000 V to 400 000 V for the National Grid.

(a) Calculate the current in the cables at 400 000 V. [2]



(b) Calculate the current at 25 000 V, and how many times smaller the current is at 400 000 V. [3]

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(c) Explain why the grid uses a very high voltage, and why a step-down transformer is needed near homes. [3]

(d) Describe how a transformer changes the voltage. Refer to the coils, the iron core and the magnetic field. [6]

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Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

- held still: no reading
- pulled out: the needle moves to the left

2.2

- move the magnet faster
- use a stronger magnet or more turns on the coil

2.3

- a steady current makes a steady magnetic field in the core
- the field through the secondary coil does not change, so no voltage is induced

3.1

- $n_s = n_p \times V_s \div V_p$
- $1840 \times 5.0 \div 230$
- **40** turns

3.2

(a) $I = P \div V = 500\,000 \div 400\,000 =$ **1.25** A

(b) $500\,000 \div 25\,000 =$ **20** A; $20 \div 1.25 =$ **16** times smaller

(c) a high voltage means a low current for the same power; a low current wastes less energy heating the cables; a step-down transformer lowers the voltage to 230 V, which is safe for homes

(d) points to include:

- an alternating current flows in the primary coil (K)
- it makes a changing (alternating) magnetic field (K)
- the soft iron core carries the changing field to the secondary coil (K)
- the changing field induces an alternating voltage in the secondary coil (K)
- the voltage ratio equals the turns ratio, $V_p \div V_s = n_p \div n_s$ (App)
- more secondary turns steps the voltage up; fewer steps it down (An)

Levels: **5–6** a full, logical answer with correct physics and correct terms; **3–4** several correct points, partly linked; **1–2** one or two relevant points.

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