6.1 Generators transformers and the home (P)

Name: _____ Class: _____ Date: _____ **Total: 27 marks**

KEY WORDS transformer • national grid

Objective

Build the skills to answer exam questions on **generating and transmitting electricity** : the generator effect, alternators and dynamos, transformers and the national grid, and mains electricity with fuses and earthing.

You must be able to:

- describe the generator effect and what increases the induced p.d.
- tell an alternator (a.c.) from a dynamo (d.c.)
- use $\frac{V_p}{V_s} = \frac{n_p}{n_s}$ and $V_p I_p = V_s I_s$, and explain the national grid
- explain fuses, earthing and the wires in a plug

1 Key knowledge and worked examples

■ Generators, transformers and mains

idea	equation or rule
generator effect	a wire or coil cutting magnetic field lines has a p.d. induced; bigger with faster movement, a stronger magnet or more turns
alternator, dynamo	an alternator gives a.c. (slip rings); a dynamo gives d.c. (split-ring commutator)
transformer	$\frac{V_p}{V_s} = \frac{n_p}{n_s}$; if 100% efficient, $V_p I_p = V_s I_s$; a switch-mode transformer works at high frequency and is small and light
national grid	step-up transformers raise the p.d. so the current is small and less energy heats the cables; step-down transformers make it safe for homes
mains	a.c. at 230 V, 50 Hz; cells and batteries give d.c.
plug	live (brown), neutral (blue), earth (green and yellow); the fuse is in the live wire; the earth wire stops a metal case becoming live

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Worked example 1: a transformer. A transformer has 2000 turns on the primary coil and 100 on the secondary. The input is 230 V. Find the output p.d.

1. Known: $V_p = 230$ V, $n_p = 2000$, $n_s = 100$.
2. Rule: $V_s = V_p \times \frac{n_s}{n_p}$.
3. Numbers: $230 \times \frac{100}{2000}$.
4. Result: $V_s = 11.5$ **V**.

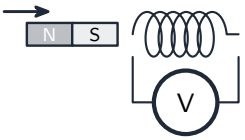
Worked example 2: transformer currents. The same transformer takes 0.50 A from the mains. Find the output current if it is 100% efficient.

1. Known: $V_p = 230$ V, $I_p = 0.50$ A, $V_s = 11.5$ V.
2. Rule: $V_p I_p = V_s I_s$.
3. Numbers: $I_s = \frac{230 \times 0.50}{11.5}$.
4. Result: $I_s = 10$ **A**.

Answer shapes: a step-up transformer has more secondary turns, more p.d. and less current; choose the fuse just above the normal current.

2 Practice

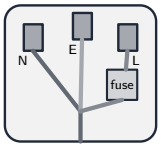
2.1 A magnet is pushed into a coil connected to a meter. Give two ways to make the induced p.d. bigger. [2]



2.2 A transformer has 200 turns on the primary coil and 1000 turns on the secondary coil. The input is 12 V. Calculate the output p.d. Is it a step-up or a step-down transformer? [2]



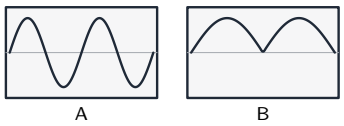
2.3 The diagram shows a plug. Which wire is the fuse connected to? What colour is the earth wire? [2]



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3 Exam-style questions

3.1 The traces show the output of an alternator and a dynamo. Which trace is from the alternator? Explain why the alternator gives this output. [3]

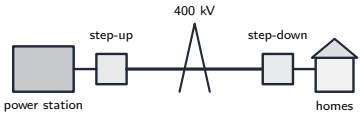


3.2 A kettle has a power of 2300 W and runs on 230 V mains. Calculate the current. Choose a fuse for the kettle: 3 A, 5 A or 13 A. [3]



3.3 A power station sends 100 MW of electrical power along the national grid at 400 000 V. The cables have a total resistance of 2.0 Ω.

(a) Calculate the current in the cables. [3]



(b) Calculate the power wasted heating the cables. What fraction of the 100 MW is this? [3]

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(c) A step-down transformer changes 400 000 V to 230 V. Its primary coil has 40 000 turns. Calculate the number of turns on the secondary coil. [3]

(d) At 25 000 V the current would be 4000 A and the cables would waste 32 MW. Explain why the national grid uses step-up and step-down transformers. [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

- any two: move the magnet faster; use a stronger magnet; use more turns on the coil

2.2

- $V_s = 12 \times \frac{1000}{200} = \mathbf{60}$ V; **step-up**

2.3

- the **live** wire; **green and yellow**

3.1

- trace **A** is the alternator: it is alternating current
- the coil turns, so each side moves up then down through the field and the p.d. reverses every half turn
- slip rings keep each end of the coil joined to the same brush, so the output reverses too

3.2

- $I = P \div V = 2300 \div 230$
- $= \mathbf{10}$ A
- **13 A** fuse: just above the normal current

3.3

(a) $I = \frac{P}{V}$; $\frac{100\,000\,000}{400\,000} = \mathbf{250}$ A

(b) $P = I^2R = 250^2 \times 2.0 = \mathbf{125\,000}$ W; $\frac{125\,000}{100\,000\,000} = 0.00125$, about 0.1%

(c) $n_s = n_p \times \frac{V_s}{V_p}$; $40\,000 \times \frac{230}{400\,000} = \mathbf{23}$ turns

(d) points to include:

- for the same power, a higher p.d. means a smaller current ($P = VI$)
- power wasted in cables is I^2R, so a smaller current wastes much less energy
- at 400 kV only 0.125 MW is wasted, against 32 MW at 25 kV
- step-up transformers at the power station raise the p.d.
- step-down transformers lower it to a safe 230 V for homes

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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