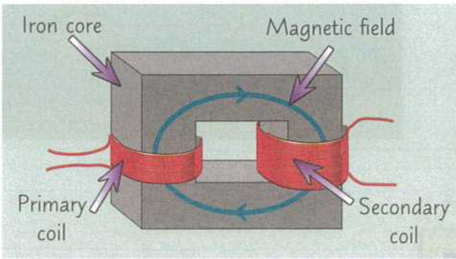
Transformers

Transformers use electromagnetic induction to make transferring electricity between places more efficient.

Transformers Change the p.d. — but Only for Alternating Current

1) Transformers use induction to change the size of the potential difference of an alternating current.
2) They all have two coils of wire, the primary and the secondary coils, joined with an iron core.
3) When an alternating p.d. is applied across the primary coil, it produces an alternating magnetic field.
4) The iron in the core is a magnetic material (see p.196) that is easily magnetised and demagnetised. Because the coil is producing an alternating magnetic field, the magnetisation in the core also alternates.
5) This changing magnetic field induces a p.d. in the secondary coil.



STEP-UP TRANSFORMERS step the potential difference up (i.e. increase it). They have more turns on the secondary coil than the primary coil.

STEP-DOWN TRANSFORMERS step the potential difference down (i.e. decrease it). They have more turns on the primary coil than the secondary.

6) Transformers are almost 100% efficient. So you can assume that the input power is equal to the output power. Using $P = I \times V$ (page 191), you can write this as:

$$V_p \times I_p = V_s \times I_s$$

p.d. across primary coil (V) — Current through primary coil (A) — p.d. across secondary coil (V) — Current through secondary coil (A)

$V_p \times I_p$ is the power output at the primary coil. $V_s \times I_s$ is the power input at the secondary coil.

EXAMPLE: A transformer steps up a 42 V supply to 210 V. The current in the secondary coil is 0.20 A. Calculate the current in the primary coil.

1) Rearrange the transformer equation. $V_p \times I_p = V_s \times I_s$ so $I_p = (V_s \times I_s) \div V_p$
2) Then stick in the values you have. $I_p = (210 \times 0.20) \div 42 = 1.0$ A

Transformers in the National Grid Produce a High p.d. and a Low Current

1) Once the electricity has been generated, it goes into the national grid — a network of wires and transformers that connects UK power stations to consumers (anyone who uses electricity).
2) The national grid has to transfer loads of energy each second, which means it transmits electricity at a high power (as power = energy transferred ÷ time taken, p.191).
3) Electrical power = current × potential difference ($P = IV$, p.191), so to transmit the huge amounts of power needed, you either need a high potential difference or a high current.
4) But a high current makes wires heat up, so loads of energy is wasted to thermal stores.
5) So to reduce these losses and make the national grid more efficient, high-voltage, low-resistance cables, and transformers are used.
6) Step-up transformers at power stations boost the p.d. up really high (400 000 V) and keep the current relatively low.
7) Step-down transformers then bring it back down to safe, usable levels at the consumers' end.

Transformers — NOT robots in disguise...

Make sure you know how transformers work, and then take a stab at using that equation with this question.

Q1 A transformer has an input potential difference of 1.6 V. The output power is 320 W. Calculate the input current. [2 marks]

Transformers

Warm-Up

For each option, circle the word that correctly completes each sentence.

Transformers consist of two coils of wire, wrapped around a(n) (plastic / iron) core.

Transformers can change the size of (alternating / direct) potential differences.

(Step-up / Step-down) transformers decrease the output potential difference.

(Step-up / Step-down) transformers decrease the output current.

1 A transformer is 100% efficient. The current through the primary coil is 20.0 A and the potential difference across it is 30.0 V. The potential difference across the secondary coil is 40.0 V. Calculate the current through the secondary coil. Grade 6-7

Current = ... A

[Total 3 marks]

2* Transformers use electromagnetic induction to increase or decrease the potential difference that is supplied to them. Grade 7-9

Explain how a step-up transformer uses electromagnetic induction to increase its output potential difference. Your answer should refer to the number of turns on each coil of the transformer.

....

....

....

....

....

....

....

....

....

....

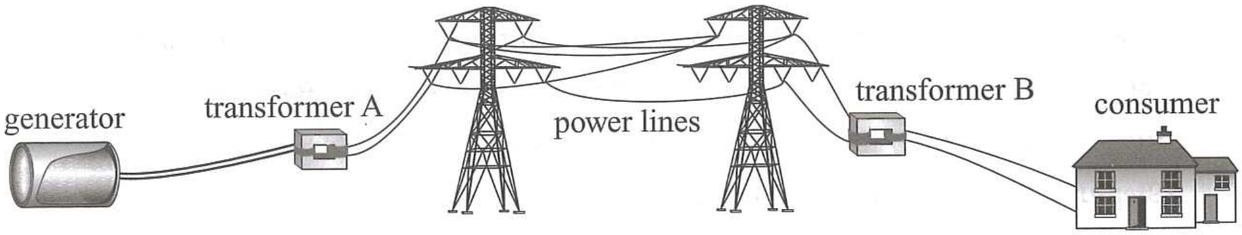
....

[Total 6 marks]

3 **Figure 1** shows a basic model of how the national grid uses step-up and step-down transformers to vary the potential difference and current of the electricity it transmits. The national grid often transmits electricity at 400 000 V.

Grade 7-9

Figure 1



a) State what type of transformer the transformer's labelled A and B are.

Transformer A: ....

Transformer B: ....

[2]

b) The current generated in the secondary coil of any transformer creates its own magnetic field. Describe the direction of this magnetic field in relation to the magnetic field that caused it.

....

....

[1]

c)* Explain the advantages of using transformers and high-voltage cables to transfer large amounts of energy every second via the national grid. You should use equations to justify your answer.

....

....

....

....

....

....

....

....

....

....

[6]

[Total 9 marks]

Exam Practice Tip

The equation you need for question one will be given to you in the exam — you just have to choose the correct equation from the list. To work out which one to use, it might help to make a list of all the values you've been given.