



GCSE Workbook Pages 133-4

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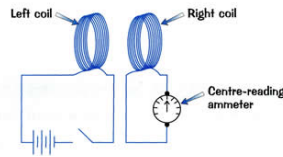
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Q1 The sentences below describe how a **transformer** works but are in the wrong order. Number the boxes 1 to 5 to show the correct order.

- 4 The magnetic field produced inside the secondary coil induces an alternating voltage at the ends of the secondary coil.
- 3 This produces an alternating magnetic field in the iron core.
- 2 An alternating current flows in the primary coil.
- 5 If this is applied to an external circuit, an alternating current will flow in that circuit.
- 1 A source of alternating voltage is applied to the primary coil.

Q2 Look at the diagram to the right showing two electrical circuits.

When the switch is closed, a deflection is seen on the ammeter and then the needle returns to zero. When the switch is opened again, a deflection is seen in the opposite direction.



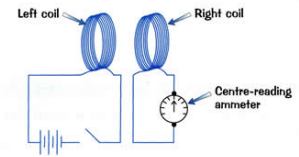
a) Explain why this happens.

When the switch closes this completes the left circuit. A current flows so a magnetic field builds up around the left coil. Flux lines move in around the coil as the change occurs. Coil B cuts through those flux lines inducing a voltage across, and therefore a current in, the right coil. This only happens as there is a change in current and field - once the field is steady no current will flow in the right hand coil. When the switch is opened again the current stops flowing therefore the field line move back out to infinity. As they move out they cut through the right hand coil again but the movement and change of field is in the opposite direction. Therefore the voltage and current are in the opposite direction.

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Q2 Look at the diagram to the right showing two electrical circuits.

When the switch is closed, a deflection is seen on the ammeter and then the needle returns to zero. When the switch is opened again, a deflection is seen in the opposite direction.



a) Explain why this happens.

So, change in magnetic field induces voltage. Voltage makes current flow and the ammeter deflect. On closing the switch this current flow will be in one direction and on opening it in the other - but when the switch is left open or closed there is no change so no induced voltage and no reading on the ammeter.

b) What could you add to the apparatus to make the needle move further?

More turns on the coils, add a soft iron core to the coils (to link the flux pattern more strongly), increase the number of cells in the battery.

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Q3 Tick the boxes to indicate whether the following statements are **true** or **false**.

- | | True | False |
|---|-------------------------------------|-------------------------------------|
| Step-up transformers have more turns on the primary coil than the secondary coil. | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| The iron core conducts the current from the primary coil to the secondary coil. | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| When a transformer is operating it behaves as though a bar magnet was being pushed into and pulled out of the secondary coil. | <input checked="" type="checkbox"/> | <input type="checkbox"/> |
| If you put a DC into the primary coil, a DC will be produced in the secondary coil. | <input type="checkbox"/> | <input checked="" type="checkbox"/> |

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Q4 Many household electrical goods such as computers and radios need a lower voltage than the 230 V mains voltage. What sort of transformer is used to reduce the voltage for these goods?

A step-down transformer

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Q5 A transformer is needed to change 200 V to 20 V. If it has 2000 turns on its primary coil, how many turns would the transformer need on its secondary coil?

200 to 20 is a decrease by a factor of 10.
Therefore the turns need to decrease by the same proportion to 200

You should do this type of reasoning and use the equation in an exam. If they give you the equation they expect you to use it! But do reason out your answer too.

Q6 A transformer has 100 turns in its primary coil and 4000 turns in its secondary coil. What input voltage would produce an output voltage of 10 000 V?

There is a factor of 40 between the primary and secondary therefore the input voltage is $1/40^{\text{th}}$ of 10,000V = 250V

(Do this reasoning and also use the equation if they give it to you they expect you to use it...)

Q7 Power stations produce electrical power as an alternating current. Why is this convenient for transmitting power across the National Grid?



To transfer the electrical energy efficiently they have to send it across the country at a high voltage and low current. Energy transfer to heat in the wires is calculated using $P=I^2R$ so cutting the current to a tenth of its value will cut energy losses as heat by $1/100^{\text{th}}$.

To do this they need to use transformers to step up the voltage at the power station (therefore stepping down the current). However, at the towns it needs to be stepped down to a safe level (230V for domestic use). Transformers are therefore used again.

Transformers can only operate with a.c. current therefore power stations produce power as an alternating current.

Q8 About 8.5% of electricity generated in the UK is lost before it reaches homes and businesses.

a) How is energy "lost" in the National Grid?

When a current flows heat is produced. This is unwanted and therefore 'lost' energy - this happens in the cables and in the transformers themselves.

b) The energy lost in an electrical circuit depends on the current and the resistance of the wires. Use the formulae $P = VI$ and $V = IR$ to find a formula for power lost in terms of current and resistance.

$$P = IV \text{ but } V = IR \text{ so } P = I(IR) = I^2R$$

$$P = I^2R$$

c) If a step-up transformer increases the voltage, what does it do to the current?

Hint - use $P = V \times I$

Decreases the current by the same proportion - see below

d) Work out the current when 1 MW of power is transmitted at:

i) 250 V $P = IV$ so $1,000,000 = 250 \times I$ and $I = 1,000,000/250 = 4,000 \text{ A}$

ii) 250 000 V $P = IV$ so $1,000,000 = 250,000 \times I$ and $I = 1,000,000/250,000 = 4 \text{ A}$

$$\begin{matrix} P_{\text{Primary}} & = & P_{\text{Secondary}} \\ I_{\text{Primary}} V_{\text{Primary}} & = & I_{\text{Secondary}} V_{\text{Secondary}} \end{matrix}$$

e) Use your answers to a)-d) to explain fully why and how transformers are used for the National Grid.

It is more efficient to transmit power at low levels of current, because the power lost as heat is proportional to the current squared. If transformers are used to reduce the current the voltage is increased but the power is the same. Power in the primary is virtually equal to the power in the secondary as transformers are very efficient in transforming the voltages. Therefore they can be used to step up the voltage for power transmission over the country efficiently and then used to step down the power to a safe level at the destination - saving a lot of energy by not having so much changed into unwanted heat and 'wasted'.