

Exercise walk-through

6.2

Induction and transformers

Pearson Edexcel · International GCSE · Physics

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The method

Method — Induction to transmission

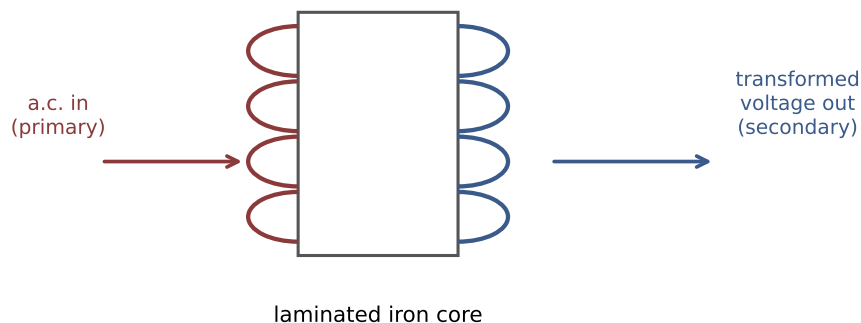
$$\frac{V_p}{V_s} = \frac{N_p}{N_s} \quad V_p I_p = V_s I_s$$

Worked check. Step-up from 25 kV to 400 kV for transmission at 500 MW:
 $I = P/V = 500 \times 10^6 / 400 \times 10^3 = 1250$ A – without the step-up, at 25 kV, the current would be 20 000 A and the cable heating ($I^2 R$) enormous.

Method — Induction to transmission

[$V_p V_s = N_p N_s V_p I_p = V_s I_s$] Worked check.

N_p primary turns : N_s secondary turns set the voltage ratio



A transformer: primary and secondary coils on a laminated iron core.

Exercises 2.1·2.3

2.1 State two ways to induce a voltage in a coil. [2]

2.2 Name two factors that increase the size of an induced voltage. [2]

2.3 A magnet is pushed into a coil. State what happens to the induced voltage if it is pushed in twice as fast. [1]

Exercises 2.1·2.3

2.1 State two ways to induce a voltage in a coil. [2]

2.1 Move the coil (or magnet) so the coil cuts field lines; change the magnetic field through a stationary coil.

2.2 Name two factors that increase the size of an induced voltage. [2]

2.2 Faster movement/rotation; stronger field; more turns (any two).

2.3 A magnet is pushed into a coil. State what happens to the induced voltage if it is pushed in twice as fast. [1]

2.3 It doubles – the rate of cutting field lines doubles.

Exercises 2.4·3.1

2.4 (P) A transformer has 500 primary and 2500 secondary turns; primary 12 V. Calculate the secondary voltage. [2]

2.5 (P) State the power relationship for a 100 % efficient transformer. [1]

3.1 Describe how a generator produces electricity, naming two factors that raise the output voltage. [3]

Exercises 2.4·3.1

2.4 (P) A transformer has 500 primary and 2500 secondary turns; primary 12 V. Calculate the secondary voltage. [2]

2.4 $V_s = 12 \times 2500/500 = 60 \text{ V}.$

2.5 (P) State the power relationship for a 100 % efficient transformer. [1]

2.5 Input power = output power: $V_p I_p = V_s I_s.$

3.1 Describe how a generator produces electricity, naming two factors that raise the output voltage. [3]

3.1 A coil (or magnet) rotates in a magnetic field; the coil continuously cuts field lines, inducing an alternating voltage; output raised by rotating faster and using a stronger field (or more turns).

Exercises 3.2-3.4

3.2 (P) A power station generates at 25 kV. Explain, with a calculation of current at 400 kV for a 200 MW flow, why transmission uses step-up transformers. [4]

3.3 (P) A transformer steps 230 V down to 11.5 V; the secondary supplies 4.0 A. Calculate the primary current and the turns ratio. [4]

3.4 A coil of 200 turns sits in a field that grows steadily from zero to full strength in 0.5 s, inducing 6 V. State the induced voltage if the same change happens in 0.1 s, and explain why. [3]

Exercises 3.2·3.4

3.2 (P) A power station generates at 25 kV. Explain, with a calculation of current at 400 kV for a 200 MW flow, why transmission uses step-up transformers. [4]

3.2 Step-up to 400 kV so the current is $I = P/V = 200 \times 10^6 / 400 \times 10^3 = 500$ A; cable heat loss is $I^2 R$, so lower current means far less energy lost; at 25 kV the current would be 8000 A – $16\times$ larger and $256\times$ the heating.

3.3 (P) A transformer steps 230 V down to 11.5 V; the secondary supplies 4.0 A. Calculate the primary current and the turns ratio. [4]

3.3 $V_p/V_s = 230/11.5 = 20$, so turns ratio $N_p : N_s = 20 : 1$; power out = $11.5 \times 4.0 = 46$ W; $I_p = 46/230 = 0.20$ A.

3.4 A coil of 200 turns sits in a field that grows steadily from zero to full strength in 0.5 s, inducing 6 V. State the induced voltage if the same change happens in 0.1 s, and explain why. [3]

3.4 Five times faster change: $V = 6 \times 0.5/0.1 = 30$ V; the induced voltage is proportional to the rate of change of the field through the coil.