Clarendon Sixth Form College

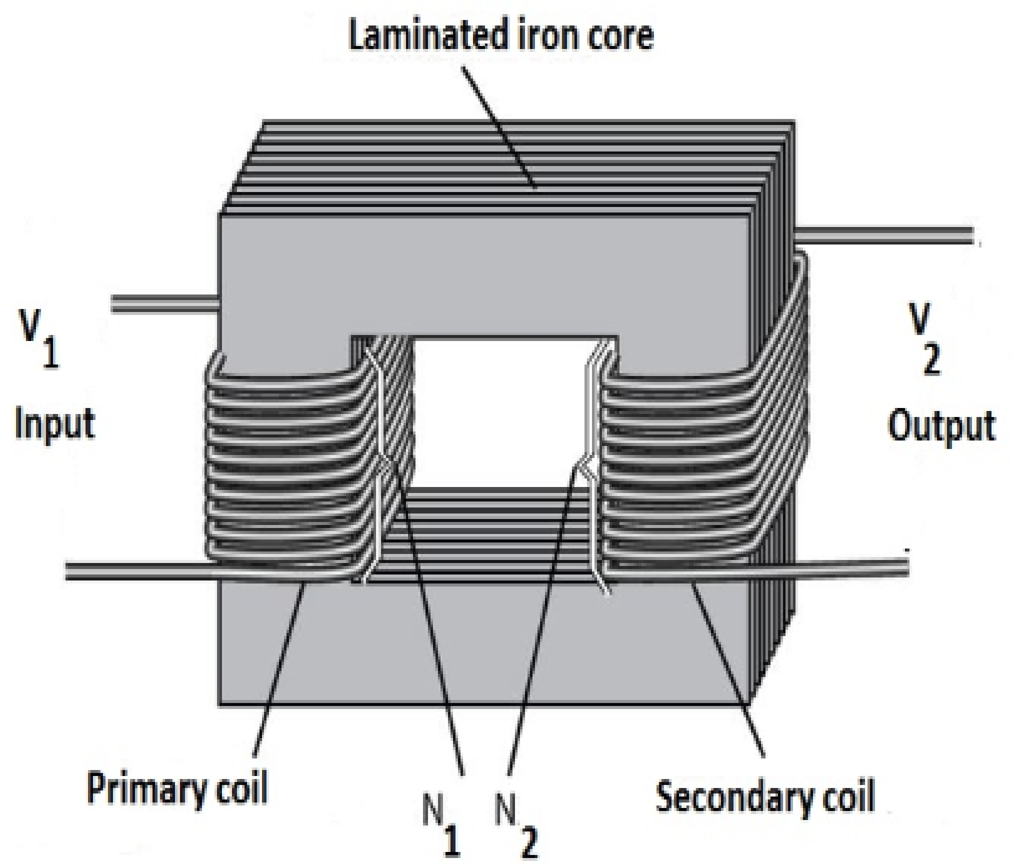
Electromagnetics

Transformers

Applicant Study Pack

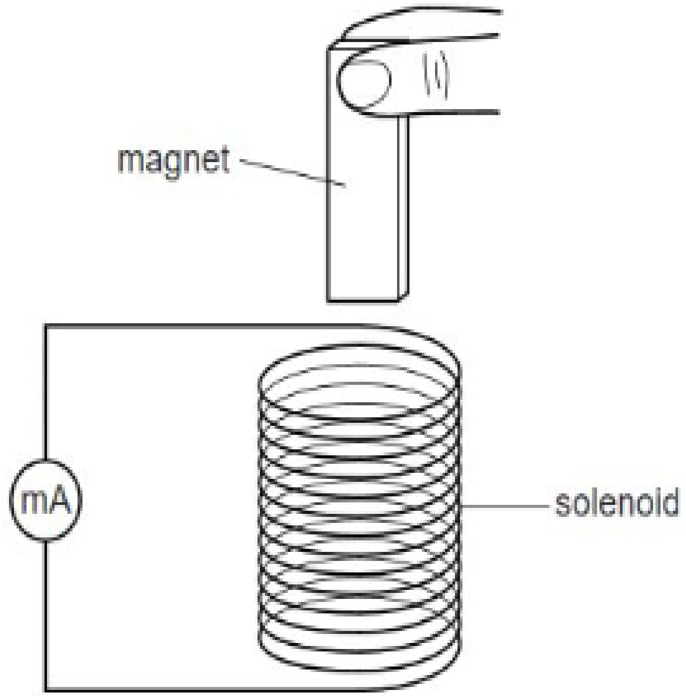
How do they work?

- Transformers use electromagnetic induction to change alternating potential difference to larger or smaller values
- There are two types of transformers: Step-up and Step-down
- An alternating potential difference is applied to the primary coil
- This produces an changing magnetic field in the iron core
- The changing magnetic field links a secondary coil
- An alternating voltage is produced across the secondary coil as the changing magnetic field links the secondary coil.



How do they work (2) ?

- The crucial element of the working of a transformer is the production of a changing magnetic field
- When changing magnetic field lines cuts a conductor a potential difference is generated across the conductor.
- Transformers will not work with a dc supply, since this will not produce a changing magnetic field within the iron core.



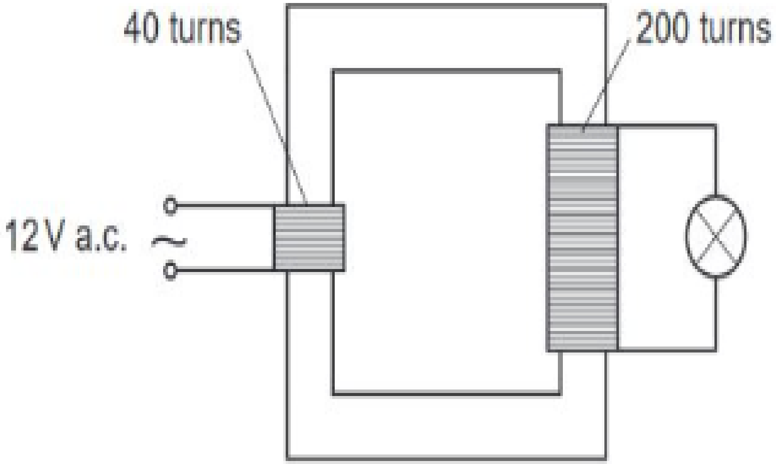
Here a magnet is lowered into the coil. The changing magnetic field lines (magnetic flux) linking the coil induces a current in the ammeter. A current will be induced whenever there is relative movement between the coil and magnet

Step-up transformers

- In a step-up transformer the secondary (output) coil has a greater number of coils than the primary (input) coil.
- In a step-up transformer the potential difference across the secondary coil is greater than the potential difference applied across the primary coil
- The ratio of the output potential difference, V_2, to input potential difference, V_1, is the ratio of the number of turns on the secondary, N_2, to the number of turns on the primary, N_1, given by :

$$(V_2 / V_1) = (N_2 / N_1)$$

The voltages , V , refer to the amplitude of the potential differences.



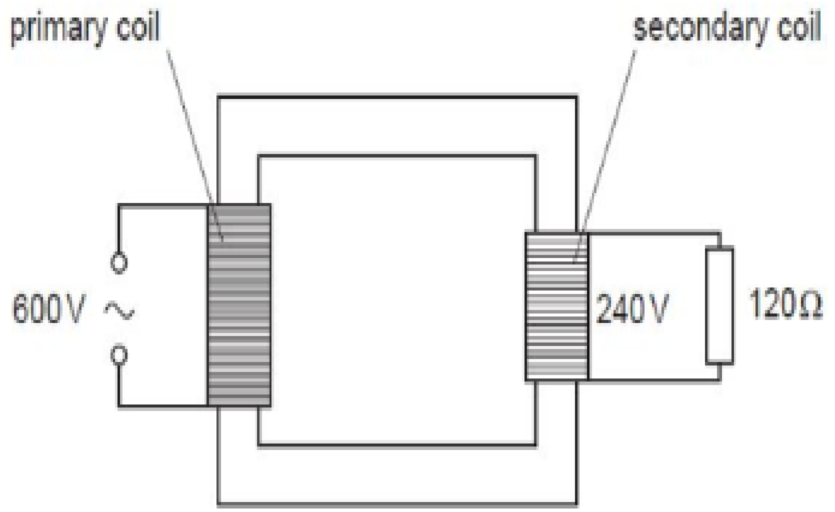
This shows a step-up transformer. The output voltage will have an amplitude of (200/40) x 12 = 60 V

Step-down transformers

- In a step-down transformer the secondary (output) coil has a fewer number of coils than the primary (input) coil.
- In a step-down transformer the potential difference across the secondary coil is smaller than the potential difference applied across the primary coil
- The ratio of the output potential difference, V_2, to input potential difference, V_1, is the ratio of the number of turns on the secondary, N_2, to the number of turns on the primary, N_1, given by :

$$(V_2 / V_1) = (N_2 / N_1)$$

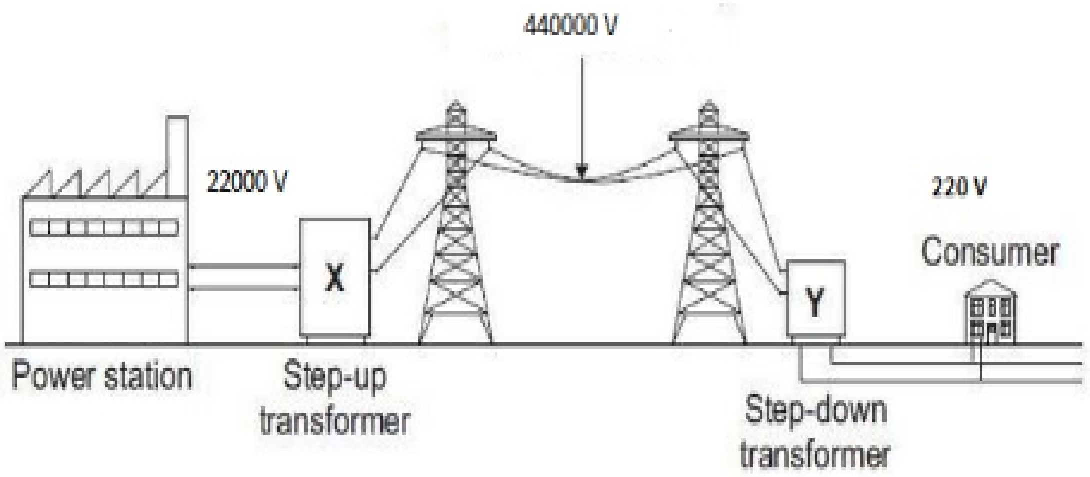
The voltages, V, refer to the amplitude of the potential differences.



This is step-down transformer. The voltage is reduced by a factor of 600/240 = 2.5 . The current is increased by a factor of 2.5, assuming a 100% efficient transformer. In this case output power = input power.

Why use step-up transformers at power stations ?

- Step-up transformers are used to increase the potential difference from power stations before transmission across the country by the national grid
- The increase of potential difference is accompanied by a decrease in the current. A reduction in current decreases the power loss along the power lines, so more power is delivered to the intended location.



Example: *A power station generated 22000 V . What would be the decrease in power loss if the voltage along the power lines is 440000 V?*

The voltage has increased by a factor of 440000/22000 = 20 (to 2 sig figs) so the current would be reduced by a factor of 20.

This , of course, assumes that the transformer is 100% efficient. Now, a factor of 20 decrease in current would result in a decrease of a factor of 400 in power loss since power loss is proportional to the square of the current! ($P = I^2 R$)

Using a step-down transformer

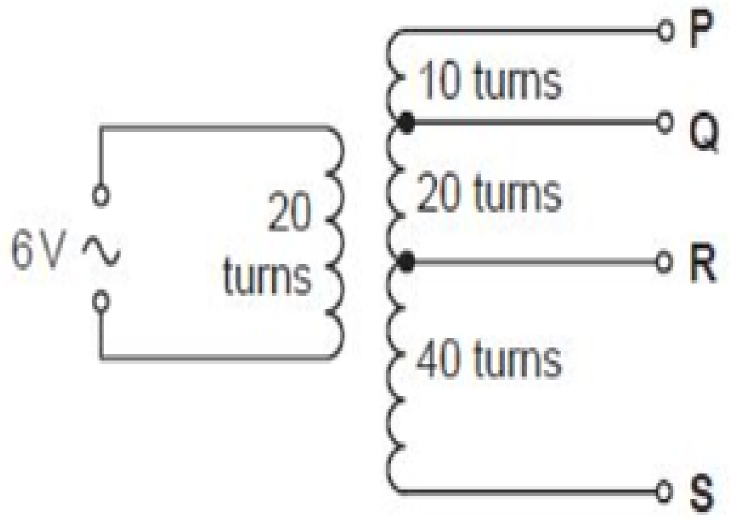
Step-down transformers are commonly used to power low voltage devices from the mains supply.

Example :

A device requires a 12V ac supply. There is a 220 V ac supply. What type of transformer would be required?

The ratio of 12/220 will give the required ratio for the secondary coils/primary coils which is 0.055 .

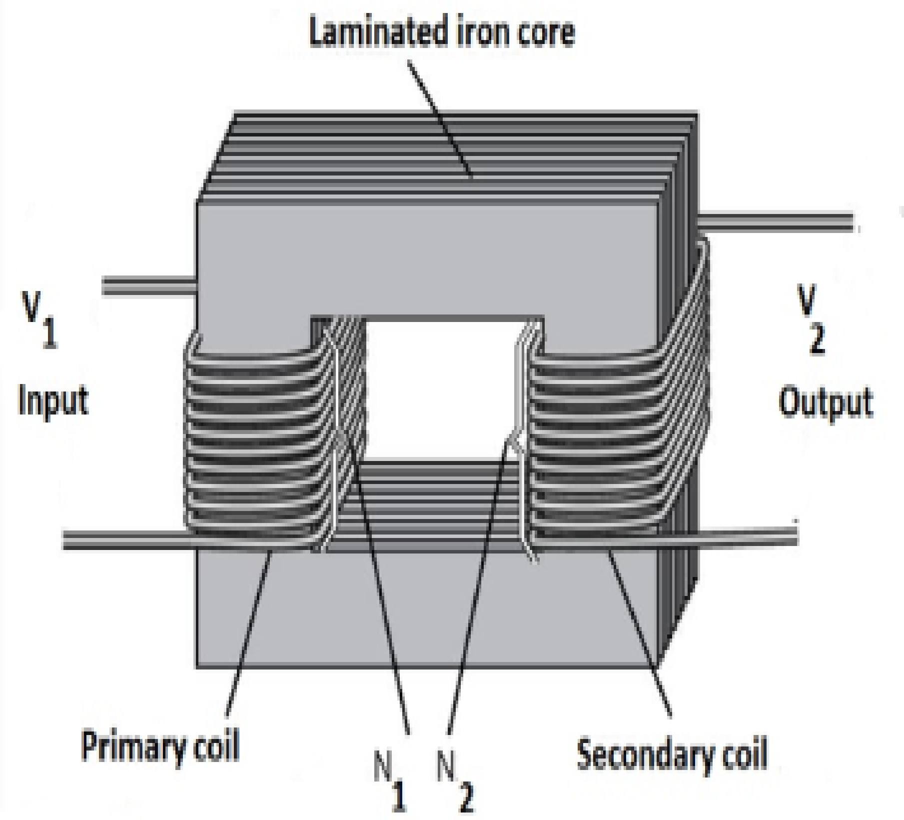
So if there are 1000 turns on the primary coil there should be 1000 x 0.055 turns on the secondary coil which gives 55 turns.



In this diagram the primary coil has 20 turns. By taking the output voltage across P and Q the voltage would be stepped down by a factor of 2. That is, output voltage = 0.5 x input voltage The output voltage would be 3 V

Why have an iron core?

- In a transformer it is essential that all the magnetic lines of force (magnetic flux) from the primary coil link the secondary coil
- The iron core concentrates the magnetic lines of force so that they all link through to the secondary coil.
- Any leakage of the magnetic lines of force would reduce the efficiency of the transformer.
- There is no current flowing through the iron core. All the iron core does it to ensure that the magnetic lines of force link generated by the primary coil link (cut) the secondary coil.



Why is the iron core laminated?

- The iron core is made of sheets of iron which are insulated from each other.
- If the iron core was sold iron an induced current would be generated across the iron core , at right angles to the change of magnetic field.
- These currents are known as 'eddy ' currents.
- Eddy currents would generate heat in the iron core
- He efficiency of the transformer would be decreased.
- Laminated iron sheets prevent the formation of eddy currents