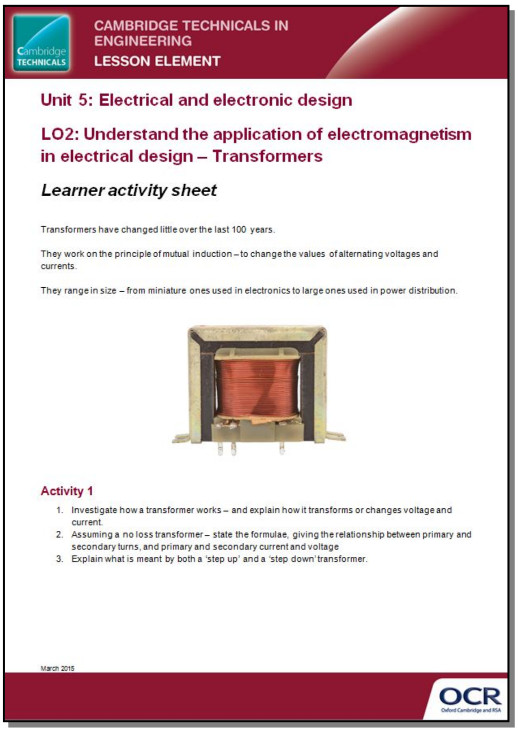
# Unit 5: Electrical and electronic design

# LO2: Understand the application of electromagnetism in electrical design – Transformers

## *Instructions and answers for teachers*

***These instructions should accompany the OCR resource 'Understand the application of electromagnetism in electrical design – Transformers'** activity which supports Cambridge Technicals in Engineering Level 3.*


CAMBRIDGE TECHNICALS IN ENGINEERING
LESSON ELEMENT

Unit 5: Electrical and electronic design

LO2: Understand the application of electromagnetism in electrical design – Transformers

*Learner activity sheet*

Transformers have changed little over the last 100 years.

They work on the principle of mutual induction – to change the values of alternating voltages and currents.

They range in size – from miniature ones used in electronics to large ones used in power distribution.

Activity 1

1. Investigate how a transformer works – and explain how it transforms or changes voltage and current.
2. Assuming a no loss transformer – state the formulae, giving the relationship between primary and secondary turns, and primary and secondary current and voltage
3. Explain what is meant by both a 'step up' and a 'step down' transformer.

March 2015

**The Activity:**

In this task the students are tasked with familiarising themselves with transformers.

*This activity offers an opportunity for English skills development.*

*This activity offers an opportunity for maths skills development.*

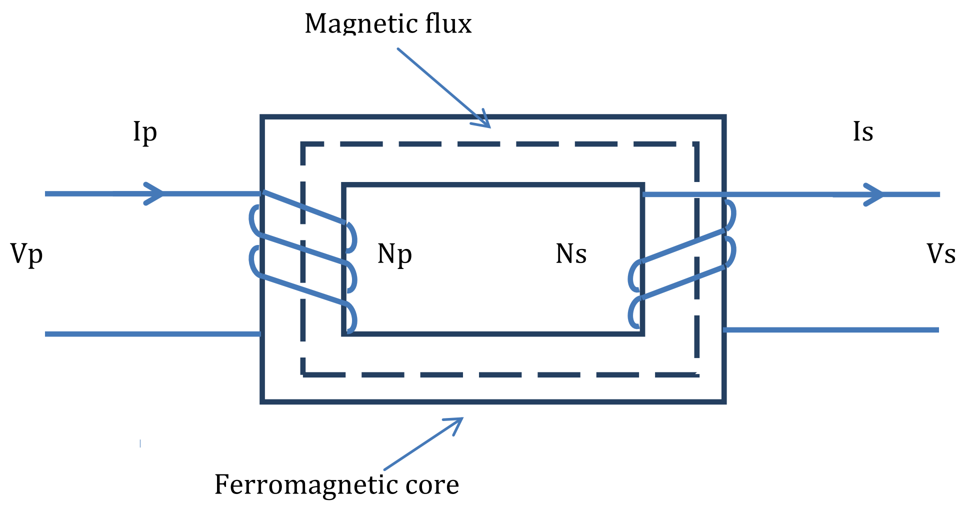
**Suggested timings:**

2 hours

## Activity 1

1. Learners might research how a transformer works – presenting their findings in a suitable format (e.g. short report, presentation or poster).

   Learners might include diagrams and sketches in their explanation e.g.




   Their findings should include:

   - The transformer is a device that works on the principle of mutual induction.
   - It consists of a ferromagnetic core and two windings – termed the primary and secondary winding.
   - A voltage is applied to the primary winding, and a load to the secondary winding.
   - When a voltage is applied to the primary winding a magnetic field is generated within the core that links with the secondary winding.
   - The magnetic field induces an EMF (electromotive force) in the secondary winding by mutual induction.
   - The induced EMF (E) is described by the formula:

     $$E = - N\,(d\Phi/dt)$$

     Where E is the EMF in the coil, N is the number of turns, and $d\Phi/dt$ is the rate of change of magnetic flux.
   - This follows both Faraday's and Lenz's Laws.  Learners may have already covered this as part of the unit.

2. The relationship between primary and secondary turns, and primary and secondary voltage and current is:

   - Assuming no losses in the transformer (an ideal transformer) then $\mathrm{Ep} = \mathrm{Vp}$ and $\mathrm{Es} = \mathrm{Vs}$ (primary and secondary voltages are the same as induced EMF).
   - Hence: $\mathbf{Np/Ns = Vp/Vs}$ (where $\mathrm{V}$ is voltage, $\mathrm{N}$ is number of turns and $\mathrm{p}$ and $\mathrm{s}$ are primary and secondary respectively)
   - When a load is connected to the secondary winding of a transformer a current flows.
   - For the ideal transformer: input power = output power
     So: $\mathrm{Vp\ Ip} = \mathrm{Vs\ Is}$ and so $\mathbf{Vp/Vs} = \mathbf{Np/Ns = Is/Ip}$

   Learners will require these formulae when solving transformer problems.

3. In a transformer $\mathrm{Np} / \mathrm{Ns}$ is called the voltage ratio.

   If $\mathrm{Ns}$ is less than $\mathrm{Np}$ then $\mathrm{Vs}$ is less than $\mathrm{Vp}$. This is called a **step-down** transformer as the voltage is reduced.

   If $\mathrm{Ns}$ is greater than $\mathrm{Np}$ then $\mathrm{Vs}$ is greater than $\mathrm{Vp}$. The voltage from primary to secondary increases and this is called a **step-up** transformer.

## Activity 2

1. $\mathrm{Vp} = 240\ \mathrm{V}$ and $\mathrm{Vs} = 12\ \mathrm{V}$

   Current $\mathrm{Is}$ (from the Power Law) = $\mathrm{P} / \mathrm{Vs} = 150 / 12 = 12.5\ \mathrm{A}$

   Using the formula to calculate turns ratio:

   $\mathbf{Vp/Vs} = \mathbf{Np/Ns} = 240 / 12 = \mathbf{20}$

   The turns ratio is 20.

   Calculate primary (supply) current using:

   $\mathbf{Vp/Vs = Is/Ip}$

   $240 / 12 = 12.5 / \mathrm{Ip}$

   Rearranging for $\mathrm{Ip}$ :

   $\mathrm{Ip} = 12.5\ (12 / 240) = \mathbf{0.625\ A}$

2. Use the formula:

   $$Vp/Vs = Np/Ns$$

   $$240 / Vs = 500 / 2000$$

   Rearrange for $Vs$:

   $$Vs = 240\ (2000 / 500) = \mathbf{960\ V}$$

   This is an example of a step-up transformer.

Learners could solve similar transformer problems.