**Electrical Science and Principles - Workbook 2**

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| **Name:** |  | **Group:** |  |

The purpose of the last block of learning which included Workbook 1, was to try to get you grounded in the basics, so that you should be capable to progress with the rest of the unit 08.

As you progressed through the set tasks you will have been introduced to the term **REACTANCE**, and it is this that you will now study further and be able to understand and to explain this electrical property.

This sheet contains a study plan with **Step**s that must be followed in the order laid out; skipping steps or undertaking them in the wrong order **will not help at all**.

References for study including **Text** and YouTube video links, are shown below each answer box.

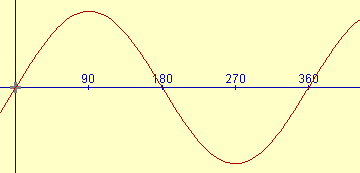
**Step 1**

Based on what you learnt in the last block of learning, explain **why the current in an a.c. circuit is continuously changing (i) in magnitude AND (ii) in direction of flow**.

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| **References:**   * **Text Book B Chapter ELTK 08 pages 304 – 305** * **YouTube videos:** [ac fundamentals](https://www.youtube.com/watch?v=F6q8nXIXGow)[ac generator](https://www.youtube.com/watch?v=gQyamjPrw-U) |

**Step 2**

The following graph (***normally referred to as a Sine Wave***), is showing 1 cycle of an a.c. generator.



**Step 2 (continued)**

The following five questions relate to this single-phase ac generator as used in the UK:

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| 1. How many degrees does a coil have to rotate in an a.c. generator to complete **1 cycle**? |
| 1. In the UK how many cycles does the a.c. generator complete in **1 second**? |
| 1. How would the number of **cycles per second** be indicated on an ac generator (number and unit)? |
| 1. What **speed in RPM (**revolutions per minute) would the generator be rotating at? |
| 1. What is the **peak voltage** produced from an a.c. generator at the 90**O** and 270**O** sine wave points? |
| **References:**   * **Text Book B Chapter ELTK 08 pages 312 - 314** * **YouTube videos:** [Understanding RMS and PEAK](https://www.youtube.com/watch?v=o_t2RdCCxro) |

**Step 3**

Heating elements are often referred to as **Purely Resistive** loads (cookers, heater, showers, etc)

Consider the following immersion heating element connected to a **240 V** supply.

Explain, if any, what would be the difference if the heating element was connected to a 240V **d.c.** supply than if it was connected to a 240V **a.c.** supply?

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| **References:**   * **Text Book B Chapter ELTK 08 page 314** * **YouTube videos:** [ac V dc](https://www.youtube.com/watch?v=BcIDRet787k) [Difference](https://www.youtube.com/watch?v=vN9aR2wKv0U) [rms ac](https://www.youtube.com/watch?v=ERIToctYUcQ) [ac vs dc](https://www.youtube.com/watch?v=dJf6pp4aqp4) |

**Step 4**

Coils of conductor are often referred to as **Inductors** or **Inductive** loads (transformers, motors, chokes, etc), and they do something quite extra ordinary when connected to only an a.c. supply.

1. Explain what happens inside an inductor (coil) when a voltage to it is first switched on, and then what happens inside the inductor when the voltage is switched off.

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| **References:**   * **Text Book B Chapter ELTK 08 page 317** * **YouTube videos:** [Inductors explained](https://www.youtube.com/watch?v=KSylo01n5FY) |

1. What type of electricity supply has the voltage ‘switching’ on and off continuously?

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**Step 4 (continued)**

The following questions are based on a single transformer coil (**as in the video below**) which has a natural resistance of 53 Ohm. Be clear, this **53 Ω** of resistance cannot change, as it is based on the material (copper), its length, and its cross-sectional area.

1. Calculate the current that will flow in to the transformer coil when it is connected to a **53V d.c.** supply.

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| **Show all your working out**. |
| **References:**   * **Text Book B Chapter ELTK 08 pages 317 – 319** * **YouTube videos:** [Inductive reactance explained](https://www.youtube.com/watch?v=gzlZ84--JrQ) |

**Step 4 (continued)**

1. When the open transformer coil is then connected to a **53V a.c.** supply, what current flows.

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1. By applying Ohm’s Law to the **a.c. current** in 4d) above, calculate what the Ohms value of the circuit must be when connected to the a.c. voltage.

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| **Show all your working out**. |

1. Does the current through the transformer coil increase or decrease when connected to an a.c. supply?

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1. In **YOUR OWN WORDS**, but including the following six terms, explain why the current changes in the way you answered it in f) above:

Inductor Inductive reactance Inducing moving magnetic field

opposing (bucking) counter electromotive force

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**Step 4 (continued)**

1. Show the formula that allows you to calculate the extra OHMs that an inductor will produce when connected to an a.c. supply, and provide details of all the units in the formula.

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| **References:**   * **Text Book B Chapter ELTK 08 pages 318** * **YouTube videos:** [Inductive reactance explained](https://www.youtube.com/watch?v=gzlZ84--JrQ) |

1. A coil of 0.25 Henry is connected across a 230 V 50 Hz supply. Calculate the inductive reactance produced by the coil

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| **Show all your working out**. |
| **References:**   * **Text Book B Chapter ELTK 08 page 323** * **YouTube videos:** [Inductive reactance formula](https://www.youtube.com/watch?v=J_ZwTp1E-CU) |

1. For the question above, which of the following electrical quantities **DO NOT** make any difference whatsoever to the inductive reactance produced by the coil?

Inductance (0.25 H) Voltage (230 V) Frequency (50 Hz)

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1. A coil of 150 mH is connected across a 110 V 50 Hz supply. Calculate the inductive reactance produced by the coil

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| **Show all your working out**. |

**Step 4 (continued)**

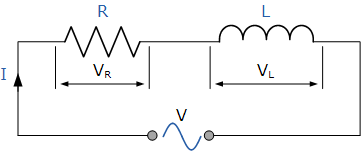
1. In the symbol **X*L***

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| **What does the X stand for?** |
| **What does the *L* stand for?** |

**Step 5**

When the length of copper conductor is wound in to produce the transformer coil (as in the video demonstration) the conductor doesn’t suddenly lose it’s 53 Ω of resistance, **it can’t suddenly disappear**. What happens is that, when it is connected to an a.c. supply, some additional ‘*resistance*’ appears as a reaction to the a.c. supply.

In order to show both the natural resistance and the created reactance in a diagram, the coil is often drawn like:



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| Note: | Fixed resistor » Resistor Guide | is now used rather than the older symbol | Resistor Schematic Symbol with White Background - Wisc-Online OER |

1. What does the symbol R represent of the coil, and what are the units measured in?

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| **References:**   * **Text Book B Chapter ELTK 08 pages 323 - 324** |

1. What does the symbol L represent of the coil, and what are the units measured in?

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| **References:**   * **Text Book B Chapter ELTK 08 pages 323 - 324** |

**Step 5 (continued)**

1. A **132.6 mH** transformer winding has a resistance of **120 Ω** and is designed to be connected to a single-phase **240 V 50 Hz** supply.

Produce a diagram like the one at the beginning of **Step 5**, and label it with the following:

**R L Vs  *f* 120 Ω 132.6 mH 240 V 50 Hz**

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| **References:**   * **Text Book B Chapter ELTK 08 pages 323 - 325** * **YouTube videos:** [Calculate Inductive Reactance & Impedance](https://www.youtube.com/watch?v=Ld8dIzfRUrI) |

1. Calculate the inductive reactance produce by the transformer winding.

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| **Show all your working out.** |
| **References:**   * **Text Chapter ELTK 08 pages 323 - 325** * **YouTube videos:** [Calculate Inductive Reactance & Impedance](https://www.youtube.com/watch?v=Ld8dIzfRUrI) |

1. Explain why you cannot just add the Inductive Reactance (XL) OHMs to the Resistance (R) OHMs to get the overall Impedance (Z) OHMs in other words **Z = R + XL**

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| **References:**   * **Text Book B Chapter ELTK 08 pages 323 - 324** |

**Step 5 (continued)**

1. Combine the inductive reactance and resistance to calculate the Impedance of the transformer winding when connected to a single-phase 240 V 50 Hz supply.

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| **Show all your working out.** |
| **References:**   * **Text Chapter ELTK 08 pages 323 - 325** * **YouTube videos:** [Calculate Inductive Reactance & Impedance](https://www.youtube.com/watch?v=Ld8dIzfRUrI) |

1. Produce an Impedance triangle that shows the Impedance, Reactance, Resistance of this circuit.

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| **References:**   * **Text Chapter ELTK 08 pages 323 - 325** * **YouTube videos:** [Calculate Inductive Reactance & Impedance](https://www.youtube.com/watch?v=Ld8dIzfRUrI) |

**Step 5 (continued)**

1. Calculate the current that would flow through the transformer winding when it is connected to a single-phase 240 V 50 Hz supply.

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| **Show all your working out.** |
| **References:**   * **Text Chapter ELTK 08 pages 323 - 325** * **YouTube videos:** [Calculate Inductive Reactance & Impedance](https://www.youtube.com/watch?v=Ld8dIzfRUrI) |

1. Calculate the voltage that would be across the Resistive part of the circuit (**VR**)

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| **Show all your working out.** |
| **References:**   * **Text Chapter ELTK 08 pages 323 - 325** * **YouTube videos:** [Calculate Inductive Reactance & Impedance](https://www.youtube.com/watch?v=Ld8dIzfRUrI) |

1. Calculate the voltage that would be across the Reactive part of the circuit (**VL**)

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| **Show all your working out.** |
| **References:**   * **Text Chapter ELTK 08 pages 323 - 325** * **YouTube videos:** [Calculate Inductive Reactance & Impedance](https://www.youtube.com/watch?v=Ld8dIzfRUrI) |

**Step 5 (continued)**

1. Explain why the voltage across the resistive part (**VR**) and the voltage across the reactive part (**VL**) do not add up to the supply voltage (**VS**) in other words **VS = VR + VL**

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| **References:**   * **Text Chapter ELTK 08 pages 323 - 325** * **YouTube videos:** [Calculate Inductive Reactance & Impedance](https://www.youtube.com/watch?v=Ld8dIzfRUrI) |

1. When this transformer is connected to a 240 V 50 Hz supply, explain what is meant by its power factor (pf)

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| **References:**   * **Text Chapter ELTK 08 pages 317 - 319** * **YouTube videos:** [Calculate Inductive Reactance & Impedance](https://www.youtube.com/watch?v=Ld8dIzfRUrI) |

1. Calculate the power factor of the circuit (**p.f.**)

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| **Show all your working out.** |
| **References:**   * **Text Chapter ELTK 08 pages 323 - 325** * **YouTube videos:** [Calculate Inductive Reactance & Impedance](https://www.youtube.com/watch?v=Ld8dIzfRUrI) |

**Step 6**

Now that you have worked through an example of an inductor impedance calculation, the following is aimed at seeing if you can undertake the same again, but for a different coil.

The following questions are based on the main winding of a single-phase induction motor.

The motor nameplate details include: -

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Electric Motor Winding Service, Electrical Motor Winding Services ... | **Nameplate details:**   |  |  | | --- | --- | | **Voltage** | **230 Volt** | | **Frequency** | **50 Hz** | | **Coil resistance** | **12 Ohm** | | **Coil inductance** | **20mH** | |

For this motor winding calculate:

1. The Inductive Reactance
2. The Impedance
3. The current
4. The voltage across the resistance
5. The voltage across the reactance
6. The power factor

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| **Show all your working out.** |

**Step 6 (continued)**

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| **Show all your working out.** |