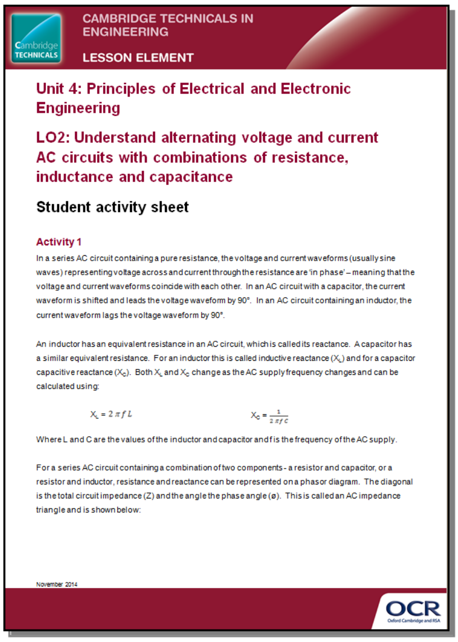
Unit 4: Principles of Electrical and Electronic Engineering

LO2: Understand alternating voltage and current – AC circuits with combinations of resistance, inductance and capacitance

Instructions and answers for teachers

These instructions should accompany the OCR resource 'Understanding alternating voltage and current – AC circuits with combinations of resistance, inductance and capacitance' *activity which supports Cambridge Technicals in Engineering Level 3.*



CAMBRIDGE TECHNICALS IN ENGINEERING
LESSON ELEMENT

Unit 4: Principles of Electrical and Electronic Engineering

LO2: Understand alternating voltage and current AC circuits with combinations of resistance, inductance and capacitance

Student activity sheet

Activity 1

In a series AC circuit containing a pure resistance, the voltage and current waveforms (usually sine waves) representing voltage across and current through the resistance are 'in phase' – meaning that the voltage and current waveforms coincide with each other. In an AC circuit with a capacitor, the current waveform is shifted and leads the voltage waveform by 90°. In an AC circuit containing an inductor, the current waveform lags the voltage waveform by 90°.

An inductor has an equivalent resistance in an AC circuit, which is called its reactance. A capacitor has a similar equivalent resistance. For an inductor this is called inductive reactance (X_L) and for a capacitor capacitive reactance (X_C). Both X_L and X_C change as the AC supply frequency changes and can be calculated using:

$$X_L = 2\pi f L \qquad X_C = \frac{1}{2\pi f C}$$

Where L and C are the values of the inductor and capacitor and f is the frequency of the AC supply.

For a series AC circuit containing a combination of two components - a resistor and capacitor, or a resistor and inductor, resistance and reactance can be represented on a phasor diagram. The diagonal is the total circuit impedance (Z) and the angle the phase angle (ø). This is called an AC impedance triangle and is shown below:

November 2014

The Activity:

In this task the students are tasked with finding the total impedance and phase angles for a selection of series AC circuits.

This activity offers an opportunity for English skills development.

This activity offers an opportunity for maths skills development.

Suggested timings:

1 hour

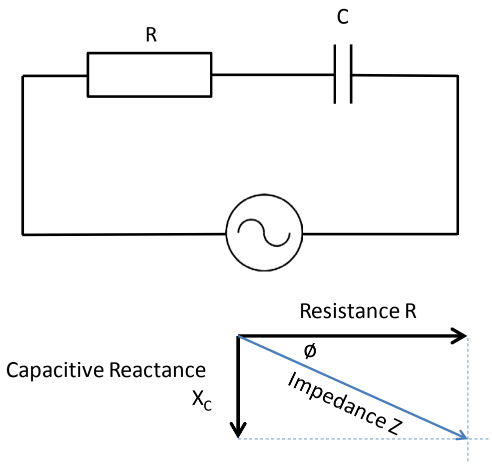
Activity 1

For this activity learners are tasked to determine the total impedance (Z) and phase angle (ø) for series AC circuits. Problems 1 to 4 are series circuits containing two components, while problem 5 has three components.

Teachers might begin by introducing learners to the appropriate theory relating to the behaviour of resistors, inductors and capacitors in series AC circuits including the terms reactance, impedance and phase angle.

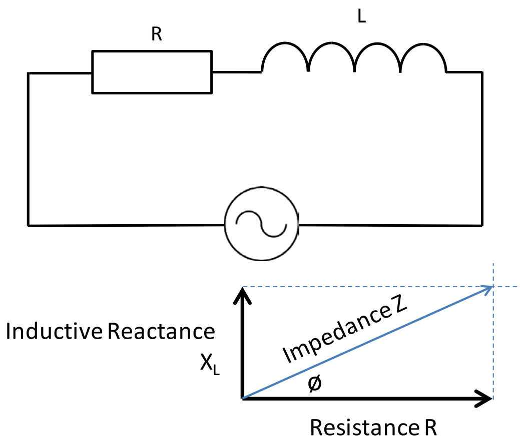
Learners will also need to be able to determine inductive reactance and capacitive reactance using the defining equations, and also understand how to construct phasor diagrams for series AC circuits:

Series RC Circuit



$$X_C = \frac{1}{2\pi f C}$$

Series RL Circuit



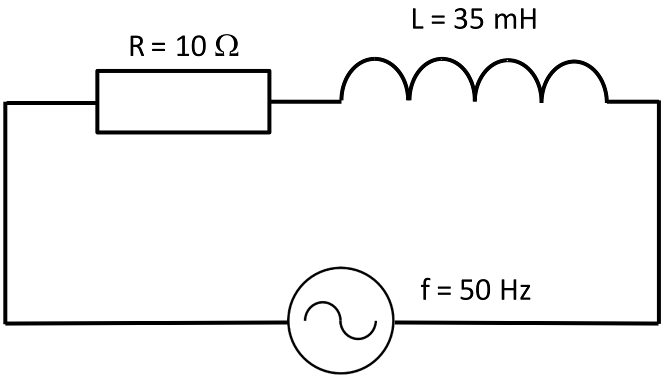
$$X_L = 2\pi f L$$

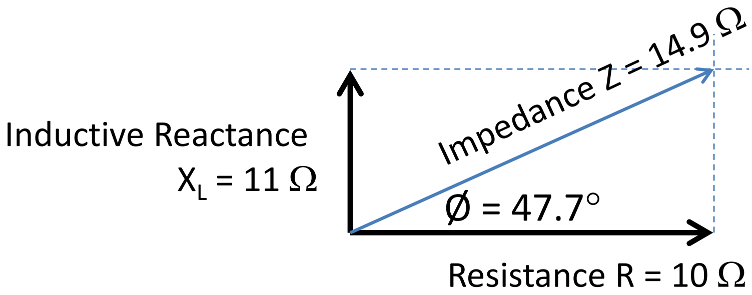
For the problems given, learners will also need to be able to manipulate terms involving scientific notation i.e. milli (m) being 10^{-3} and micro (μ) being 10^{-6}.

Learners might determine impedance (Z) and phase angle (ø) for the given problems both using scale drawings and also mathematically using Pythagoras' Theorem (to determine the length of the hypotenuse) and the cosine rule (to determine the angle).

Solutions to the problems are given over the page.

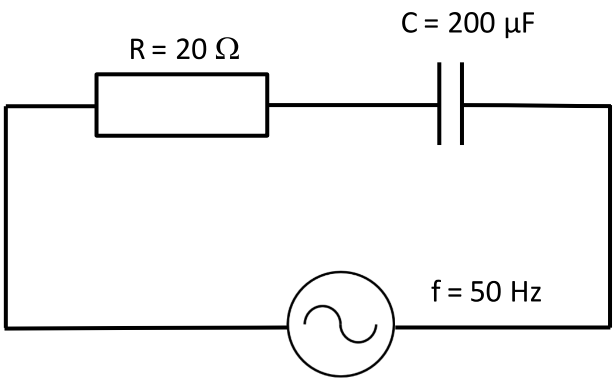
Solution to Problem 1

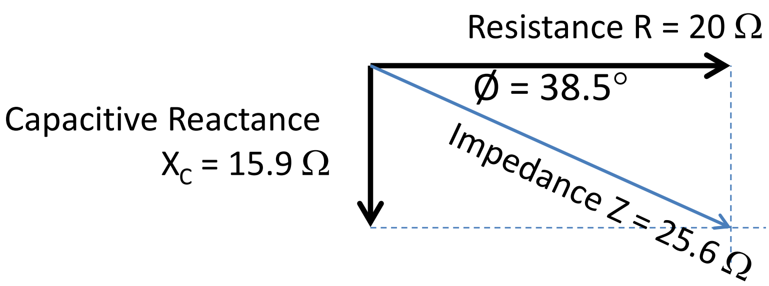




R:	10Ω
$X_{L:}$	11Ω
Z:	14.9Ω
Phase Angle:	47.7°

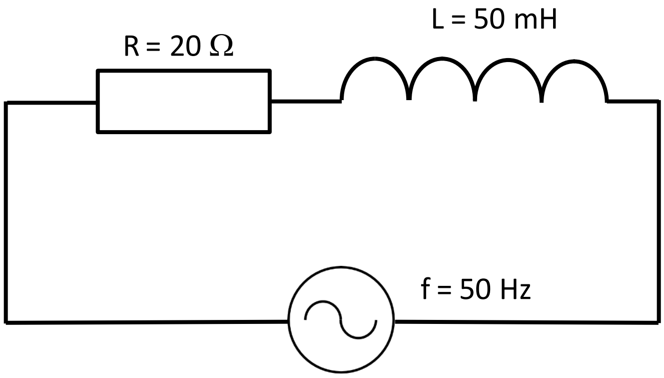
Solution to Problem 2

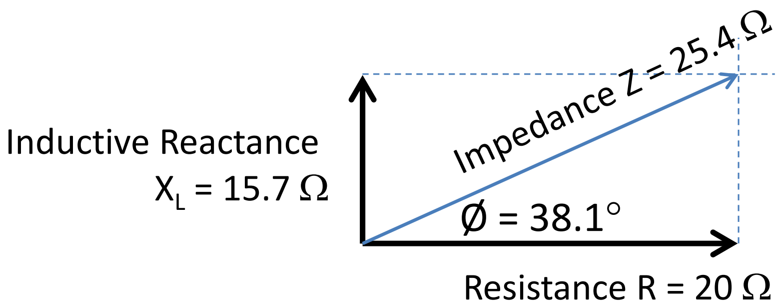




R:	20Ω
X_C	15.9Ω
Z:	25.6Ω
Phase Angle:	38.5°

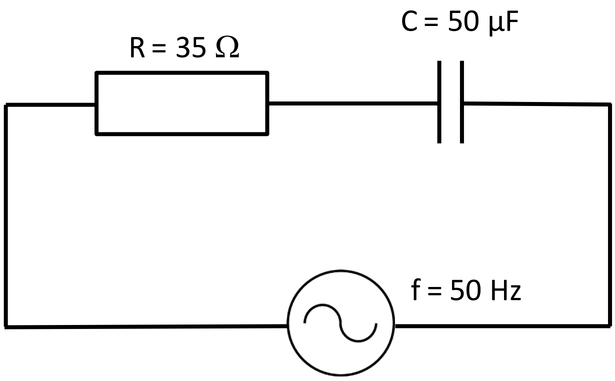
Solution to Problem 3

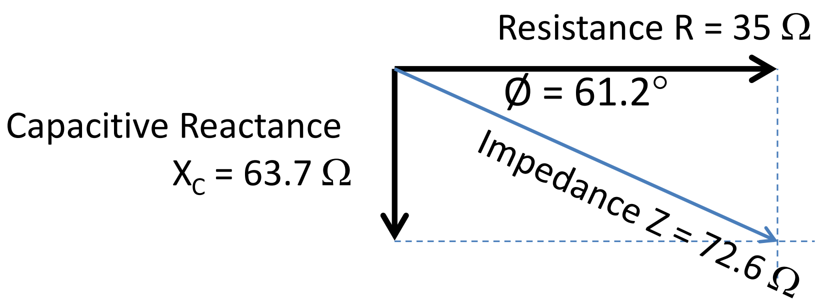




R:	20Ω
X_L:	15.7Ω
Z:	25.4Ω
Phase Angle:	38.1°

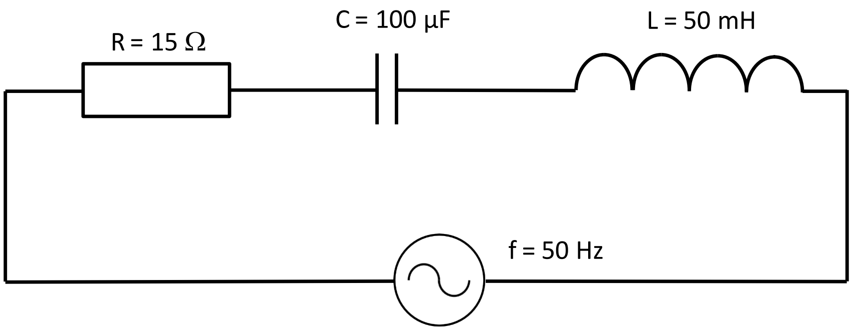
Solution to Problem 4

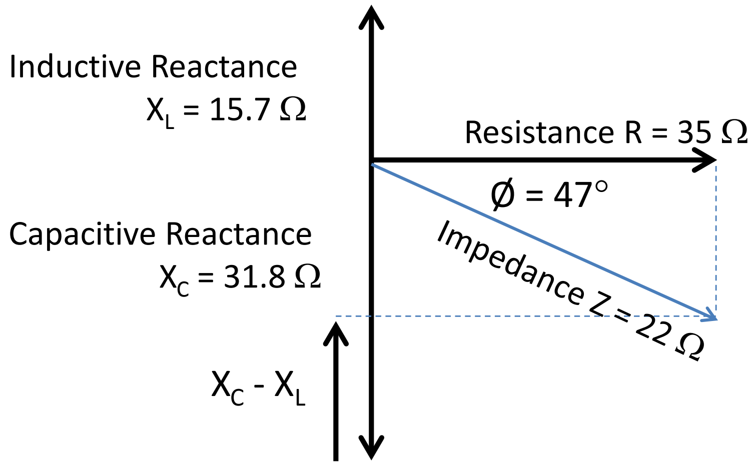




R:	35Ω
X_C:	63.7Ω
Z:	72.6Ω
Phase Angle:	61.2°

Solution to Problem 5





R:	35Ω
X_C:	31.8 Ω
X_L:	15.7Ω
Z:	22.0Ω
Phase Angle:	47.0°

Note: For problem 5, as $X_C > X_L$ then the resulting vertical phasor is given by $X_C - X_L$

Teachers could extend this activity by providing learners with a value for the AC voltage in each example (eg 100 V) and tasking them to calculate the circuit current (using $I = V/Z$), voltage across the inductor (from $V_L = I X_L$) and voltage across the capacitor (from $V_C = I X_C$). These could similarly be represented on phasor diagrams showing voltage and current.