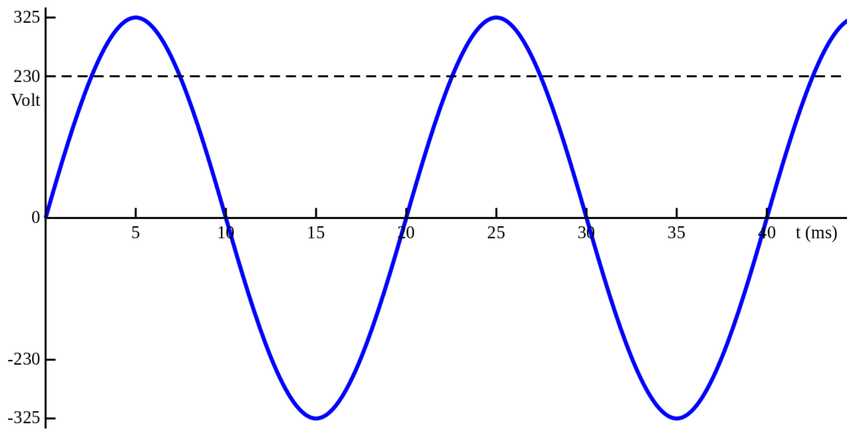
FLIPPED around PHYSICS

# 7.15 Alternating current

Mains electricity is alternating current (a.c.). When we plug in a device to the mains supply, an alternating voltage is applied to the live wire, whilst the neutral wire is held around zero. This means that there is a potential difference across the device that alternates between positive and negative. The causes a current to flow backwards and forwards through the device (an alternating current).

videos

The following diagram shows how the voltage of the live wire varies with time.




*(1)✐What is the peak voltage?*

*(2)✐What is the period of oscillation?*

*(3)✐What is the frequency?*

*(4)✐At what time would the maximum current flow, in the forward direction?*

*(5)✐At what time would the maximum current flow, in the reverse direction?*

From GCSE, we know that mains voltage is given as 230V. This is the value that we use in our calculations (e.g. $current = \frac{power}{voltage}$). As the voltage varies with time, 230V is the 'root mean square' voltage $V_{rms}$. To obtain $V_{rms}$, the time varying voltages are squared, a mean is taken of the squared values, and then this is square-rooted.

*(6)✐Work out the root-mean-square value for the following voltages: -220V, +45V, -135V, +300V.*

The voltage varies as a sinusoidal function (i.e. sine or cosine). The root mean square value ($V_{rms}$) for this function is found to be:

$$V_{rms} = \frac{V_{peak}}{\sqrt{2}}$$

*where $V_{peak}$ = peak voltage.*

*(7) Using the peak voltage for the mains supply, show that $V_{rms} = 230V$.*

For a device with a fixed resistance, the current ($I$) will vary proportionally to voltage. Therefore:

$$I_{rms} = \frac{I_{peak}}{\sqrt{2}}$$

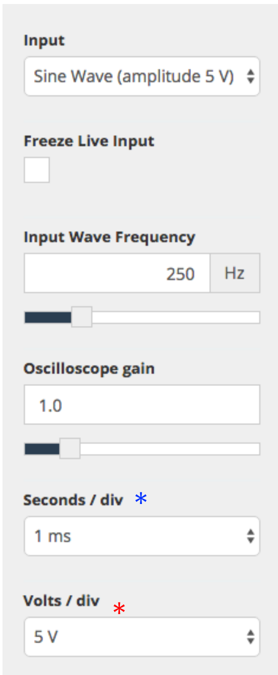
*where $I_{peak}$ = peak current.*

**The Cathode Ray Oscilloscope (CRO)**

We can analyse time-varying voltages using a CRO. The CRO essentially creates a graph of voltage against time. We can scale the time axis and the voltage axis and read off values from the screen.

Run the following simulation:
[https://academo.org/demos/virtual-oscilloscope/](https://academo.org/demos/virtual-oscilloscope/)

and set the following parameters, right:




The peak voltage can be calculated by reading off the amplitude (from the centre line) of the waveform. With these settings, the amplitude is 1 division. If you look at the scaling for the voltage axis (*), you will see that it is set to 5V per division. This means that the peak voltage is 5V.

To work out the period ($T$) of the waveform, you need to measure the time interval from one peak to the next. For this setting, you should see that this is 4 divisions. If you look at the scaling for the time axis (*), you will see that it is set to 1ms (millisecond) per division. This means that the period is 4ms.

To work out the frequency ($f$) of this signal:

$$f = \frac{1}{T}$$

*(8) Show that the frequency for this signal is 250Hz.*

Now try changing the 'timebase' – time scaling.

*(9)✏What happens to the waveform when you decrease the time scaling?*

Now try changing the voltage scaling.

*(10)✏What happens to the waveform when you decrease the voltage scaling?*

*(11)✏Work out the peak voltage and frequency for the following two signals: (Show working)*