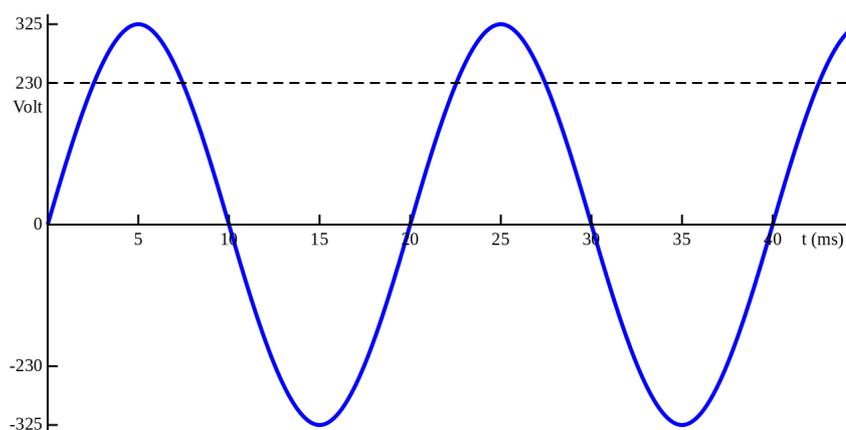


## 7.15 Alternating current

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. This causes a current to flow backwards and forwards through the device (an alternating current).



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/>

and set the following parameters, right:

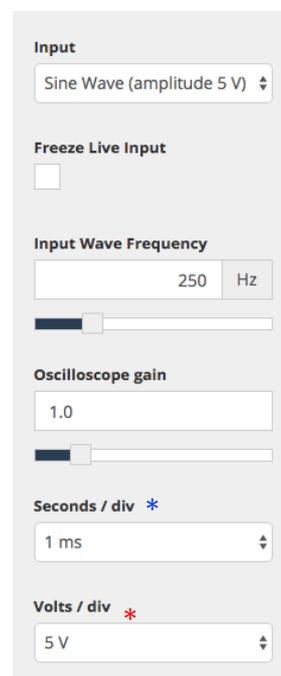
The peak voltage can be calculated by reading off the amplitude (from the centre line) of the waveform. With these settings, the amplitude is 1 division. If you look at the scaling for the voltage axis (\*), you will see that it is set to 5V per division. This means that the peak voltage is 5V.

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.



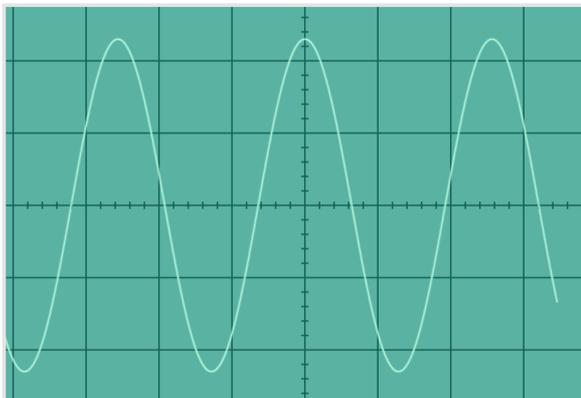
Now try changing the 'timebase' – time scaling.

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

Now try changing the voltage scaling.

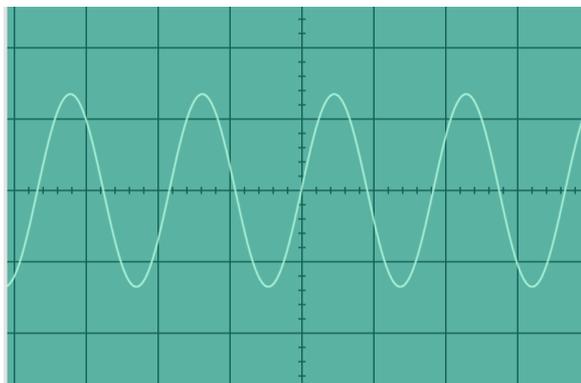
(10) *What happens to the waveform when you decrease the voltage scaling?*

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



Seconds / div  
500  $\mu$ s

Volts / div  
5 V



Seconds / div  
5 ms

Volts / div  
10 V