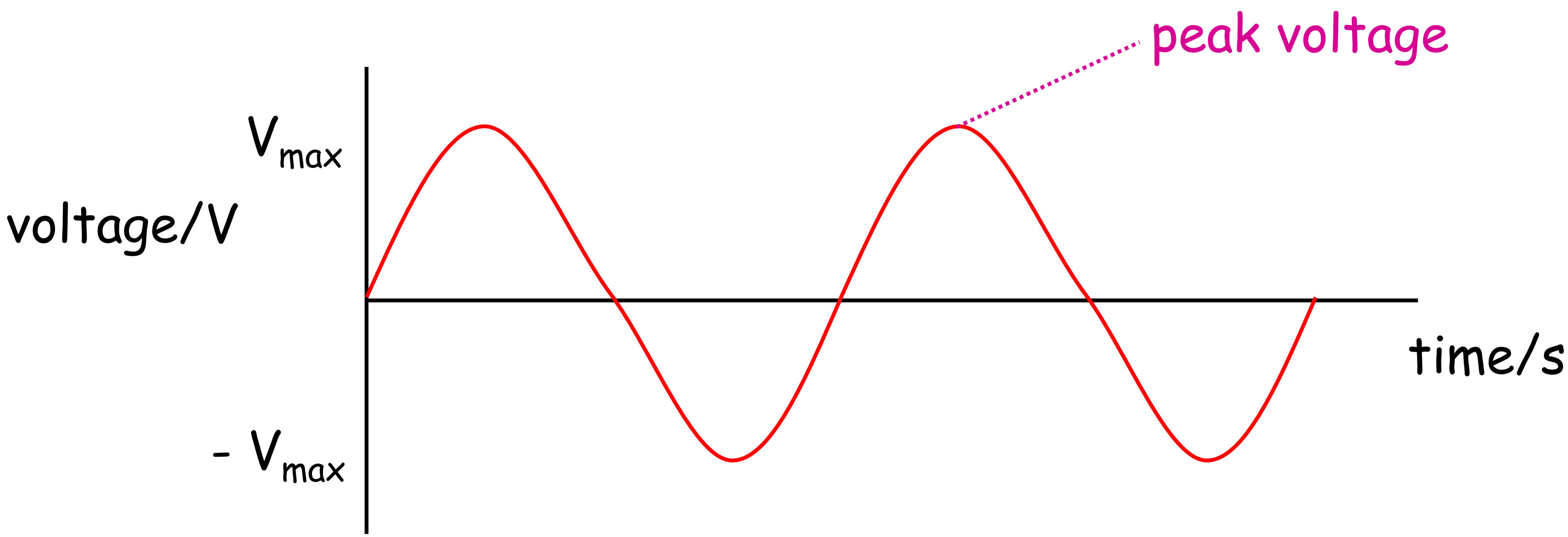
Higher Physics – Unit 2

2.2 Alternating Current and Voltage

AC Voltage Supply

The size of an AC voltage supply is constantly changing.



The maximum voltage is called the peak voltage, V_P.

Since the size of the voltage is changing, we use an **average value** when doing **calculations**.

The average value used is the "**root mean square**" or rms voltage.

It is calculated using:

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

The **rms voltage equals** the equivalent **dc voltage**.

Example 1

The rms voltage in the UK is quoted as 230 V.

Calculate the peak voltage.

$$V_{rms} = 230\text{ V}$$

$$V_p = ?$$

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

$$= \sqrt{2} \times 230$$

$$V_{peak} = 325\text{ V}$$

AC Current

An AC current also has a peak and rms value.

To calculate the rms current:

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

The **rms current equals** the equivalent **dc current**.

Components in AC circuits however, must be able to withstand the peak voltage.

AC and Ohm's Law

The peak or rms values can be applied to Ohm's Law.

$$V_{peak} = I_{peak} \times R$$

$$V_{rms} = I_{rms} \times R$$

<u>Example 1</u>

Calculate the peak current for a 100 Ω resistor connected to a mains supply.

$$V_{rms} = 230\ V$$

$$R = 100\ \Omega$$

$$I_{peak} = ?$$

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

$$= \sqrt{2} \times 230$$

$$\underline{\underline{V_{peak} = 325\ V}}$$

$$V_{peak} = I_{peak} R$$

$$I_{peak} = \frac{V_{peak}}{R}$$

$$= \frac{325}{100}$$

$$\underline{\underline{I_{peak} = 3.3\ A}}$$

Must use ALL peak values or ALL rms values.

You may need to use the following equations from standard grade:

$$V = IR$$

$$P = IV$$

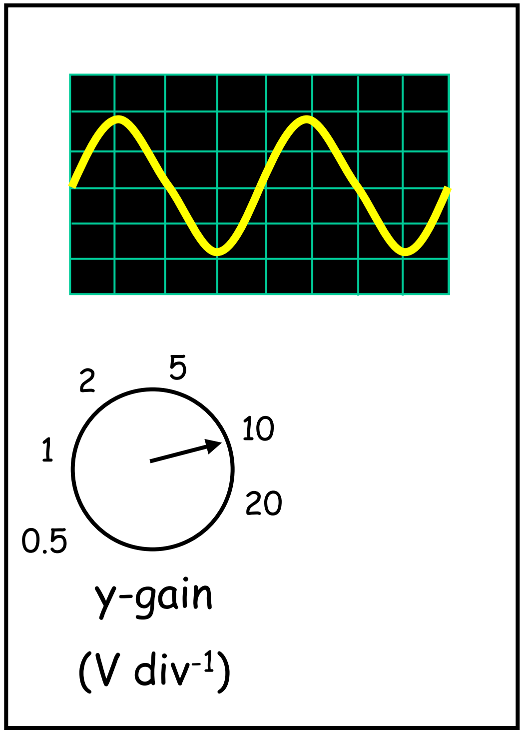
$$P = \frac{E}{t}$$

$$P = I^2 R$$

$$P = \frac{V^2}{R}$$

When asked to calculate the output power, or heat produced (energy), you must **use rms values**.

Peak Voltage on Oscilloscope



$$\text{y-gain} = 10\ \text{V per division}$$

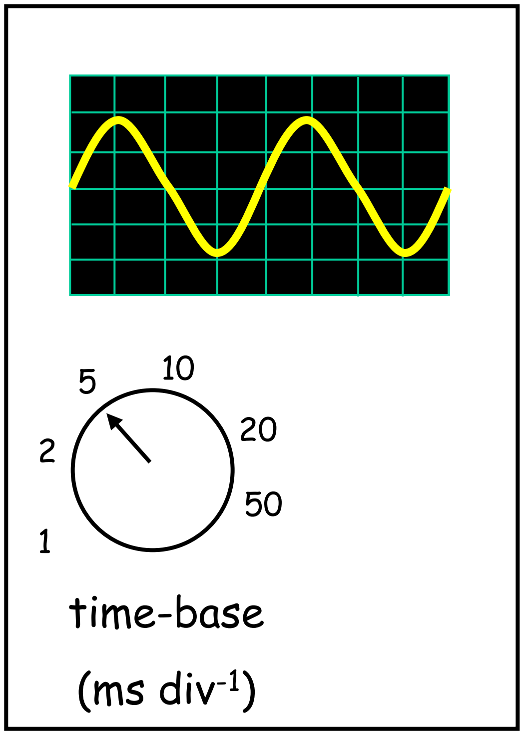
$$\text{amplitude} = 2\ \text{divisions}$$

$$\text{peak voltage} = 2 \times 10 = \underline{\underline{20\ \text{V}}}$$

Once the peak voltage is known, the rms voltage can be calculated.

$$V_{rms} = \frac{V_{peak}}{\sqrt{2}} = \frac{20}{\sqrt{2}} = \underline{\underline{14.1\ \text{V}}}$$

AC Frequency on Oscilloscope



The time-base control tells you how long it takes the spot to move 1 division along the screen.

The time taken to produce **one complete wave** is the **PERIOD**.

period (s)

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

frequency (Hz)

One wave on the oscilloscope is 4 divisions long.

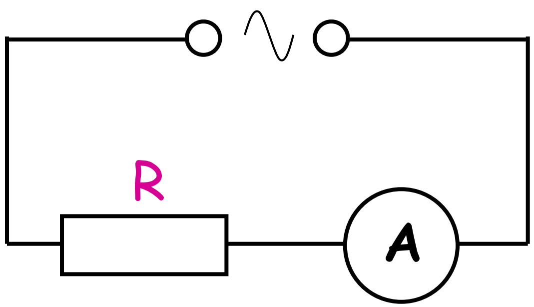
$$T = 4 \times 5\,ms$$
$$= 4 \times (5 \times 10^{-3})$$
$$T = 0.02\,s$$

The frequency is calculated to be:

$$f = \frac{1}{T}$$
$$= \frac{1}{0.02}$$
$$f = 50\,Hz$$

Resistors and AC

A resistor is connected to an AC voltage supply as shown.



As the **frequency** of the AC voltage is **increased**, the **current** in the circuit is **unchanged**.

Current is not dependent on frequency.

A graph of current against frequency in a resistor circuit is: