UNIT 2

MODULE 2: A.C. THEORY AND ELECTRONICS

Alternating Currents (Pg 674: A-Level Physics; Pg486: Understanding Physics)

An alternating current (a.c.) or voltage is one whose amplitude is not constant, but varies with time about some mean position (value). Some examples of a.c. variations are shown below.

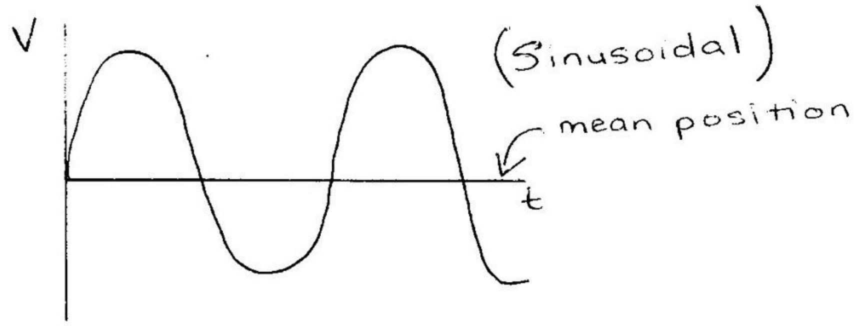

Fig. 1

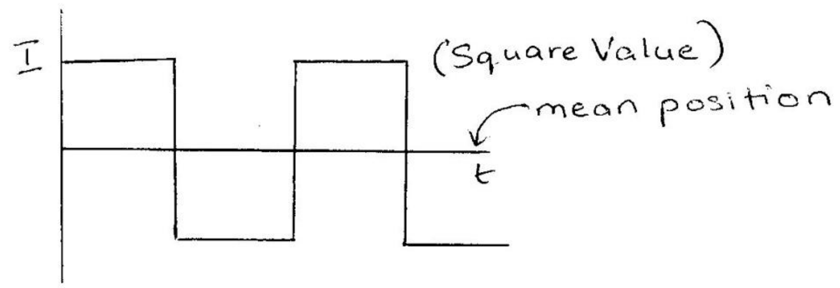

Fig. 2

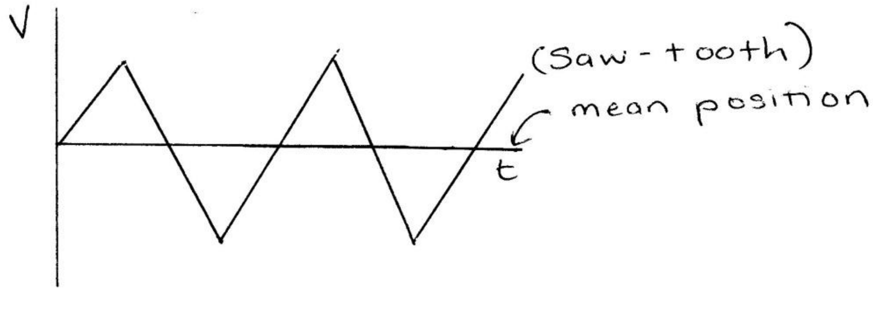

Fig. 3

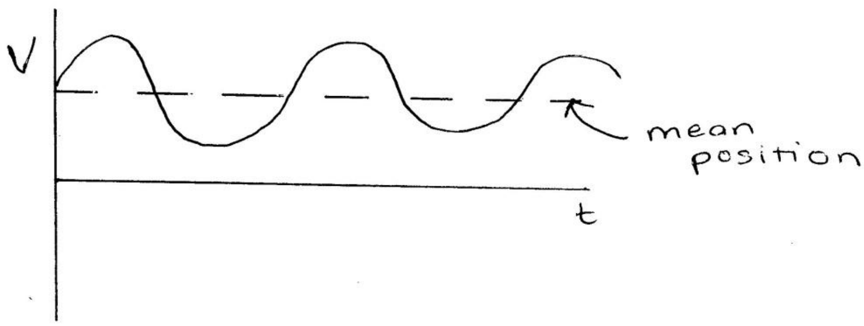

Fig. 4

Definitions

Period: The time taken for a complete cycle or oscillation.

Symbol: T
Unit: Second (s)

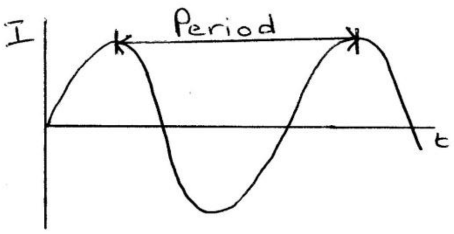

Fig. 5

Frequency: The number of cycles in one second

Symbol: f
Unit: Hertz (Hz)

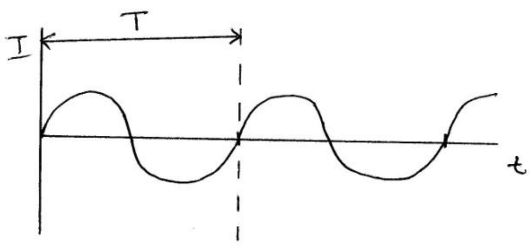

Fig. 6

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

Amplitude (peak value): The maximum value of the a.c. variation or the distance between a crest or trough and the mean position.

Symbol: A

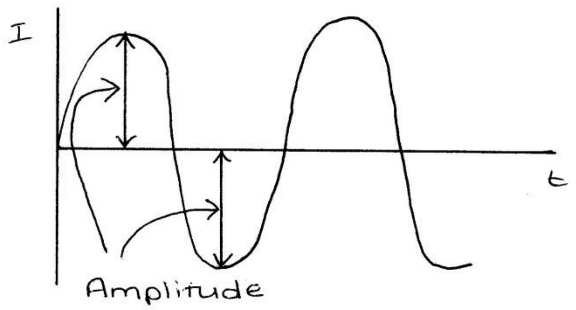

Fig. 7

Mean Value: The value of the variation for which as much of the curve lies above as below.

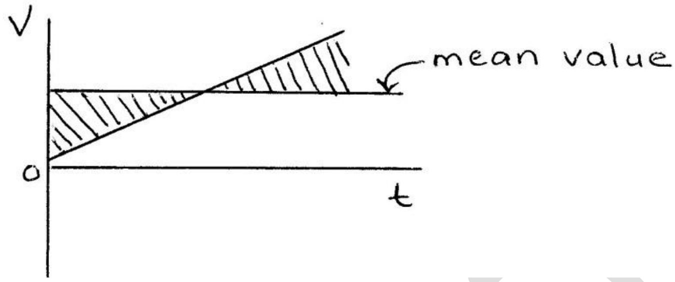

Fig. 8

Root Mean Square (R.M.S): The square root of the mean of the squares of the values of the variation.

Calculation of R.M.S values

E.g. Calculate the R.M.S of the numbers given

1, 2, 3, 4, 5

Step1: Square the values

$1^2, 2^2, 3^2, 4^2, 5^2 = 1, 4, 9, 16, 25$

Step2: Sum the squares

$1 + 4 + 9 + 16 + 25 = 55$

Step3: Find the Mean

$\frac{55}{5} = 11$

Step4: Square root the mean

$\sqrt{11} = 3.3$

R.M.S for a Sinusoidal Function

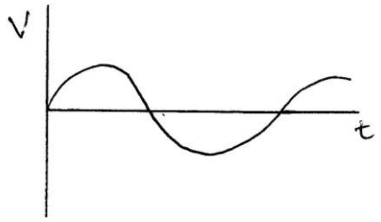

Fig. 9

The equation which describes the sinusoidal variation such as the graph shown would be of the form

$$V = V_0 \sin \omega t$$

where

$V =$ the voltage at time t

$V_0 =$ the peak value of the voltage

$\omega =$ the angular frequency of the supply ($rad\ s^{-1}$)
(**NB**: $\omega = 2\pi f$ where f is the frequency of the supply in Hertz.)

Step1: Square the values

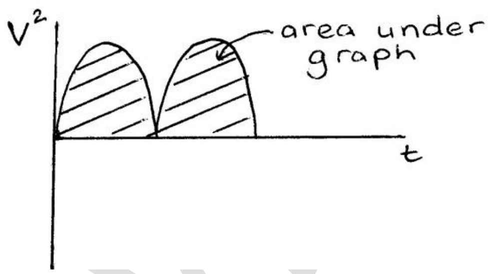

Fig. 10

Step2: Sum the squares- find the area under the graph

Step3: Find the mean of the squares

$$Mean\ of\ squares = \frac{area\ under\ the\ graph}{one\ period}$$

Step4: Find the square root of the mean

$$\sqrt{\frac{area\ under\ graph}{one\ period}}$$

Note that the R.M.S. value of a sinusoidal variation is always equal to

$$0.707 \times Peak\ value$$

i.e

$0.707 \times V_0$ **or** $0.707 \times I_0$

Note:

$$0.707 = \frac{1}{\sqrt{7}}$$

The R.M.S. value of an alternating current is the value of that steady direct current (d.c.) which produces energy in a resistor at the same rate as the ac supply.

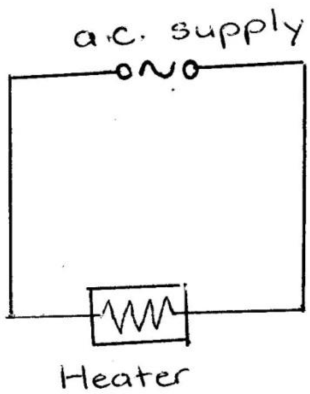

Fig. 11: Circuit 1

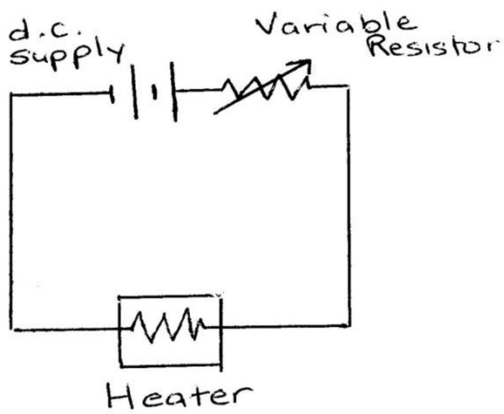

Fig. 12: Circuit 2

1. Measure the rate at which heat is produced in circuit 1.

$$E = mc\Delta\theta$$

$$Rate\ of\ heating = \frac{mc\Delta\theta}{\Delta t}$$

2. Adjust the variable resistor in circuit 2 until the rate of energy produced is the same as in circuit 1.
3. The current which produces heat in circuit 2, at the same rate as in circuit 1, is the R.M.S supply of the a.c. supply of circuit 1.

E.g. Calculate the R.M.S. value for the variation shown.

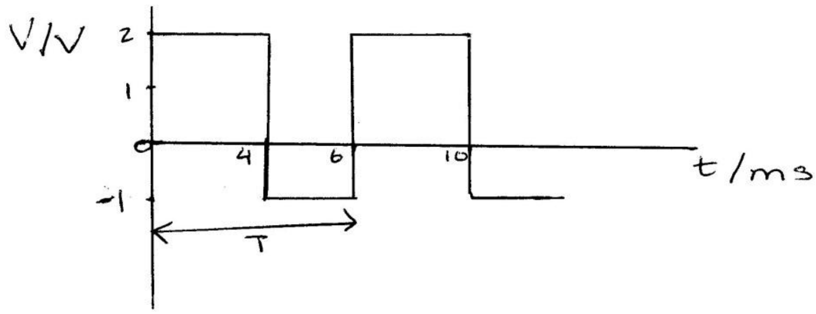

Fig. 13

$$Sum\ of\ Squares\ =\ Area\ under\ the\ graph$$

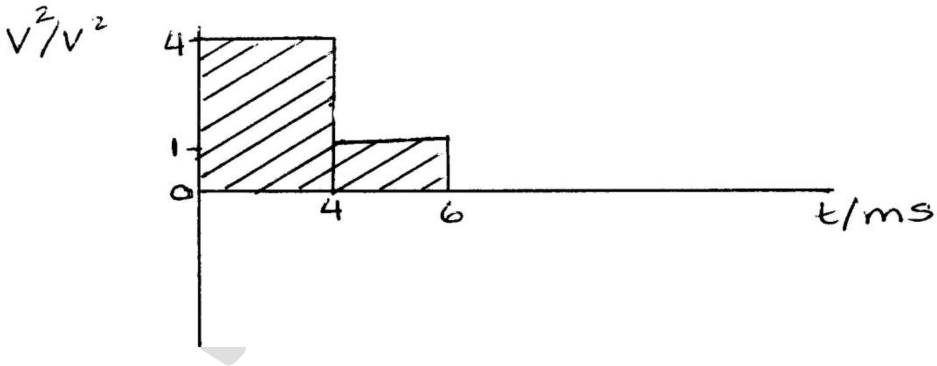

Fig. 14

$$4 \times 10^{-3} \times 4 + 2 \times 10^{-3} \times 1 = 18 \times 10^{-3}$$

$$Mean = \frac{Area\ under\ the\ graph}{one\ period}$$

$$Mean = \frac{18 \times 10^{-3}}{6 \times 10^{-3}}\ \frac{V^2 s}{s}$$

$$Mean = 3V^2$$

$\therefore R.M.S\ value = \sqrt{3} = 1.7V$

E.g. A sinusoidal a.c. supply has a peak value of 3.0A.

a.) What is the R.M.S. value of the current?

b.) How much heat is produced, each second, in a 2Ω resistor?

E.g. An a.c. voltage produces 60J of heat energy every second in a 10Ω resistor. What is the peak value of the voltage?

E.g. An alternating voltage with a frequency 50Hz has a peak value of 110V. Calculate the time when the voltage reaches -80V. Use the equation

$$v = v_0 \sin \omega t$$