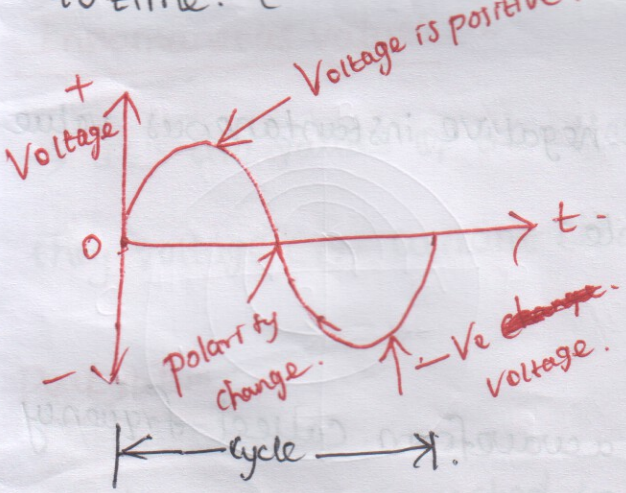
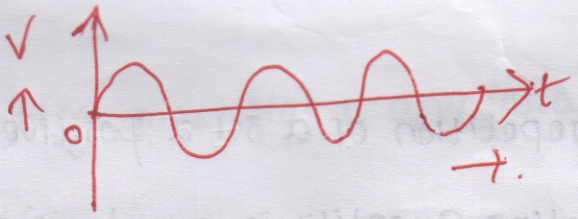
AC Circuits fundamentals

Alternating Quantity:

→ Required AC voltage is generated by AC generator → Alternator.

→ Alternating quantity has varying magnitude and angle with respect to time. (Time varying in Nature)





Generation of AC Voltage:-

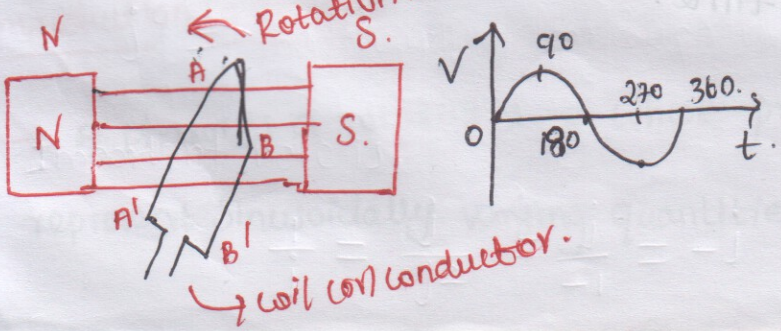
At 0, 360°, 180° ⇒ Flux linked with coil is maximum. (↑)

Rate of change of flux Minimum (e=0). $e = N\frac{d\phi}{dt}$

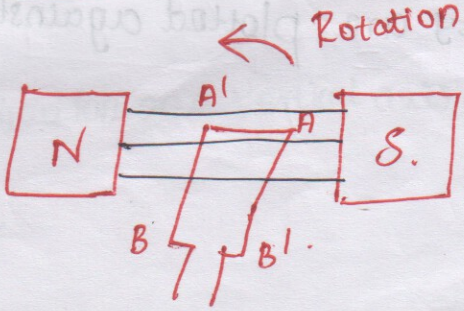
At 90°, 270° ⇒ Flux linked with coil is minimum (↓).

Rate of change of flux Maximum (↑) [e=90°].

At 0, 360°, 180



At 90°, 270.



Basic Terminology :-

Alternating Current (AC):

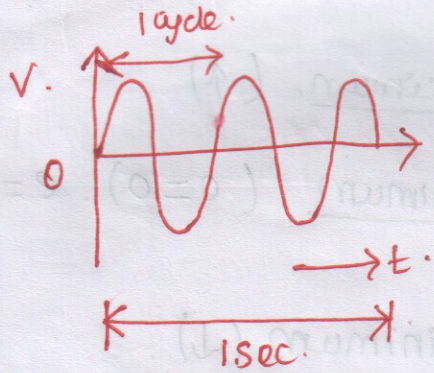
→ A current, which changes both in magnitude and direction with respect to time is called alternating current.

Cycle:-

→ Each repetition of a set a positive & negative instantaneous value of alternating quantity is called one cycle.

frequency:-

→ The number of cycles per second of a waveform called frequency denoted as 'f'. Unit is hertz (Hz). Supply frequency is 50Hz (or) 60Hz



$$f = \frac{1}{T} \text{ (Hz)}$$

Waveform :-

→ A waveform is a graph in which the instantaneous values of any quantity are plotted against time.

Period (T) :-

→ The time taken by an alternating quantity to complete one full cycle is called time period. Inverse of frequency - unit is Seconds (S).

$$T = \frac{1}{f} \quad (S)$$

Instantaneous values :-

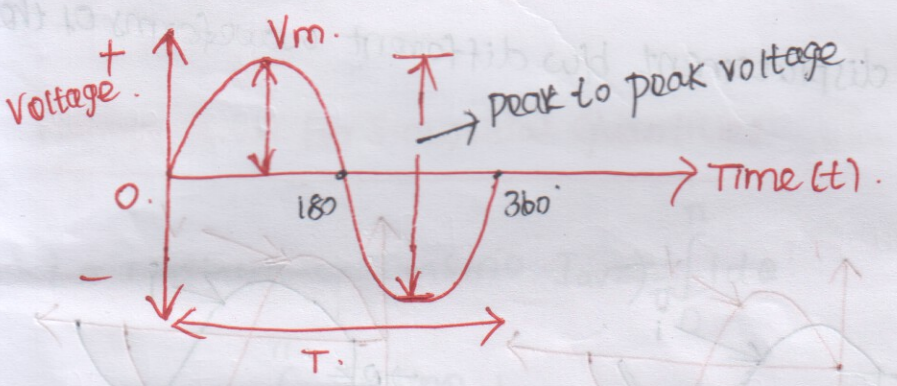
→ It's are values of the alternating quantities at any instant of time. they voltage (V), current (i), etc.

Peak value :-

→ Largest value reached in a half cycle is called peak value (or) maximum Value (or) Crest value (or) amplitude of the waveform.

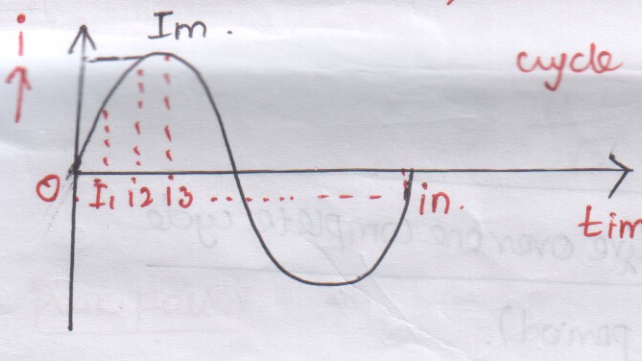
→ Denoted as Vm, Im.

→ Peak to peak value is measured minimum & maximum peaks.



Average Value :-

→ Average (or) mean value of symmetrical alternating quantity, is the average value measured over a half cycle, since over a complete cycle the avg. value is zero.



→ Arithmetic avg. of all alternating quantities over a cycle i.e,

$$I_{av} = \frac{i_1+i_3+i_3+\cdots+i_n}{n}$$

$$I_{av} = \frac{\text{Area under the curve over one complete cycle}}{\text{Base (period)}}$$

Average value for Sinusoidal Quantities.

$i = I_m \sin\omega t \Rightarrow I_m \sin\theta$ $I_{av} \Rightarrow \frac{1}{\pi}\int_0^{\pi} i\,d\theta$.

$$I_{av} = \int_0^{\pi} \frac{I_m \sin\theta}{\pi}\,d\theta$$

$$= \frac{I_m}{\pi}\int_0^{\pi} \sin\theta.d\theta \Rightarrow \frac{I_m}{\pi}(-\cos\theta)_0^{\pi} \Rightarrow \frac{I_m}{\pi}\left[-\cos\pi+\cos 0\right]$$

$I_{av} = \frac{2I_m}{\pi} \Rightarrow 0.6371 I_m$. Similarly $V_{av} = 0.6371 V_m$.

Root Mean Square (RMS) Value (or) Effective Value :-

→ RMS value of an alternating current is that value of steady DC current which produces the same heat as produced by the alternating current, when passed through the ckt for the same time

→ If i_1, i_2, i_3 are instantaneous values, then $i_1^2, i_2^2, i_3^2, i_4^2 \cdots i_n^2$ are instantaneous values of squared value.

→ Take their mean value & square root it to get rms values,

$$I_{RMS} = \sqrt{\frac{i_1^2 + i_2^2 + \cdots + i_n^2}{n}}$$

$$I_{RMS} = \sqrt{\frac{1}{T}\int_0^T i^2(t)\,dt}.$$

$$I_{RMS} = \sqrt{\frac{\text{Area under squared curve over one complete cycle.}}{\text{Base (period).}}}$$

Rms value of a sine quantity :-

$$i = I_m \sin\theta,$$

$$I_{RMS} = \sqrt{\frac{\text{Area under squared curve}}{\text{period}}}, \quad \text{Time period } 2\pi.$$

$$= \sqrt{\frac{1}{2\pi}\int_0^{2\pi} (I_m \sin^2\theta)\,d\theta} = \frac{I_m^2}{2\pi}\int_0^{2\pi} \sin^2\theta\,d\theta.$$

$$= \frac{I_m^2}{2\pi}\int_0^{2\pi} \left(\frac{1-\cos 2\theta}{2}\right) d\theta.$$

$$= \frac{Im^2}{2\pi \times 2}\left[0 - \frac{\sin 2\theta}{2}\right]_0^{2\pi} \Rightarrow \frac{Im^2}{4\pi^2}[2\pi - 0]$$

$$= \frac{Im}{\sqrt{2}} \Rightarrow 0.707\, Im.$$

Form factor:-

→ Ratio of RMS value to Average value.

RMS value $= \frac{1}{\sqrt{2}}$ maximum value, Avg. value $= \frac{2}{\pi}$ Maximum Valu

$$\text{Form factor} = \frac{\text{RMS value}}{\text{Avg. value}} \Rightarrow \frac{\text{Max. value}\ (Im)}{\sqrt{2}} \times \frac{\pi}{2 \times \text{max/va}\ (Im)}$$

$$\Rightarrow \frac{\pi}{2\sqrt{2}} \Rightarrow 1.11$$

Peak Factor:-

→ Ratio of maximum (or) peak value of any AC Quantity to its RMS value of Sine wave.

$$\text{Peak factor} = \frac{\text{Max. value}}{\text{RMS value}} \Rightarrow \frac{\text{Max. value}}{\text{Max. value}/\sqrt{2}} = \sqrt{2}$$

Peak factor = 1.414.