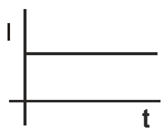
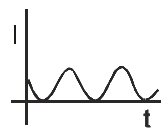
17. ALTERNATING CURRENT

1. AC AND DC CURRENT :

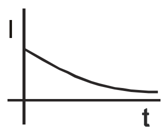
A current that changes its direction periodically is called alternating current (AC). If a current maintains its direction constant it is called direct current (DC).



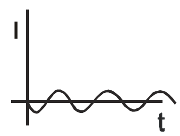
constant dc



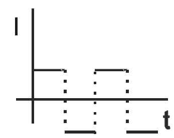
periodic dc



variable dc



ac



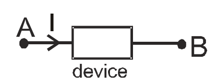
ac

3. ROOT MEAN SQUARE VALUE:

Root Mean Square Value of a function, from t_1 to t_2, is defined as $f_{rms} = \sqrt{\dfrac{\int_{t_1}^{t_2} f^2 dt}{t_2 - t_1}}$.

4. POWER CONSUMED OR SUPPLIED IN AN AC CIRCUIT:

Average power consumed in a cycle $= \dfrac{\int_0^{2\pi/\omega} P dt}{\dfrac{2\pi}{\omega}} = \dfrac{1}{2} V_m I_m \cos\phi$



$$= \frac{V_m}{\sqrt{2}} \cdot \frac{I_m}{\sqrt{2}} \cdot \cos\phi = V_{rms} I_{rms} \cos\phi.$$

Here $\cos\phi$ is called **power factor**.

5. SOME DEFINITIONS:

The factor **$\cos\phi$** is called **Power factor.**

$I_m \sin\phi$ is called **wattless current.**

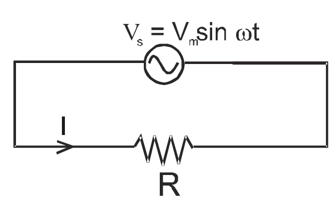
Impedance Z is defined as $Z = \dfrac{V_m}{I_m} = \dfrac{V_{rms}}{I_{rms}}$

ωL is called **inductive reactance** and is denoted by X_L

$\dfrac{1}{\omega C}$ is called **capacitive reactance** and is denoted by X_C

6. PURELY RESISTIVE CIRCUIT:

$$I = \frac{v_s}{R} = \frac{V_m \sin\omega t}{R} = I_m \sin\omega t$$

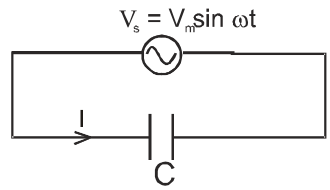


$$I_m = \frac{V_m}{R}$$

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

$$<P> = V_{rms} I_{rms} \cos\phi = \frac{V_{rms}^2}{R}$$

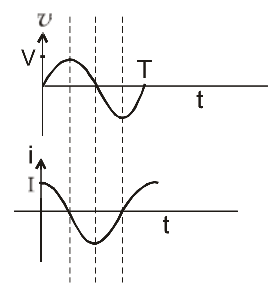
7. PURELY CAPACITIVE CIRCUIT:



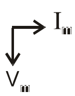
$$I = = \frac{V_m}{1/\omega C} \cos \omega t$$

$$= \frac{V_m}{X_C} \cos \omega t = I_m \cos \omega t.$$

$X_C = \frac{1}{\omega C}$ and is called capacitive reactance.



I_C leads by v_C by $\pi/2$ Diagrammatically (phasor diagram) it is represented as



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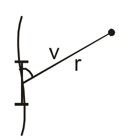
Since $\phi = 90°$, $<P> = V_{rms} I_{rms} \cos\phi = 0$

MAGNETIC EFFECT OF CURRENT & MAGNETIC FORCE ON CHARGE/CURRENT

1. Magnetic field due to a moving point charge

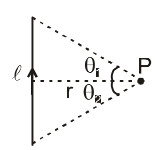
$$B = \frac{\mu_0}{4\pi} \frac{q(v \times r)}{r^3}$$

2. Biot-savart's Law



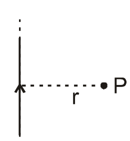
$$\vec{dB} = \frac{\mu_0 I}{4\pi} \frac{\vec{d\ell} \times \vec{r}}{r^3}$$

3. Magnetic field due to a straight wire



$$B = \frac{\mu_0}{4\pi} \frac{I}{r} (\sin\theta_1 + \sin\theta_2)$$

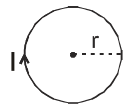
4. Magnetic field due to infinite straight wire



$$B = \frac{\mu_0}{2\pi} \frac{I}{r}$$

5. **Magnetic field due to circular loop**

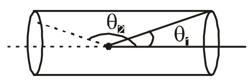
(i) At centre



$$B = \frac{\mu_0 NI}{2r}$$

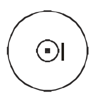
(ii) At Axis $B = \frac{\mu_0}{2} \frac{NIR^2}{(R^2 + x^2)^{3/2}}$

6. **Magnetic field on the axis of the solenoid**



$$B = \frac{\mu_0 nI}{2} (\cos\theta_1 \quad \cos\theta_2)$$

7. **Ampere's Law**

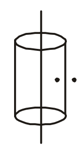


$$\circ B.d\ell = \mu_0 I$$

8. **Magnetic field due to long cylinderical shell**

$B = 0,\ r < R$

$= \frac{\mu_0}{2\pi}\frac{I}{r}, r \quad R$

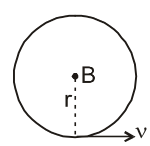


9. **Magnetic force acting on a moving point charge**

a. $F = q(\nu \quad B)$

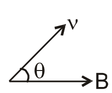
(i) $\nu \perp B$

$$r = \frac{m\nu}{qB}$$



$$T = \frac{2\pi m}{qB}$$

(ii)



$$r = \frac{m\nu\sin\theta}{qB}$$

$$T = \frac{2\pi m}{qB} \qquad \text{Pitch} = \frac{2\pi m\nu\cos\theta}{qB}$$

b. $F = q\left[(\nu \quad B) + E\right]$

10. **Magnetic force acting on a current carrying wire** $F = I(\ell \quad B)$

11. **Magnetic Moment of a current carrying loop** $M = N \cdot I \cdot A$

12. **Torque acting on a loop** $\vec{\tau} = \vec{M} \quad \vec{B}$

13. **Magnetic field due to a single pole** $B = \frac{\mu_0}{4\pi} \cdot \frac{m}{r^2}$

14. **Magnetic field on the axis of magnet** $B = \frac{\mu_0}{4\pi} \cdot \frac{2M}{r^3}$

15. **Magnetic field on the equatorial axis of the magnet** $B = \frac{\mu_0}{4\pi} \cdot \frac{M}{r^3}$

16. **Magnetic field at point P due to magnet** $B = \frac{\mu_0}{4\pi} \frac{M}{r^3} \sqrt{1 + 3\cos^2\theta}$