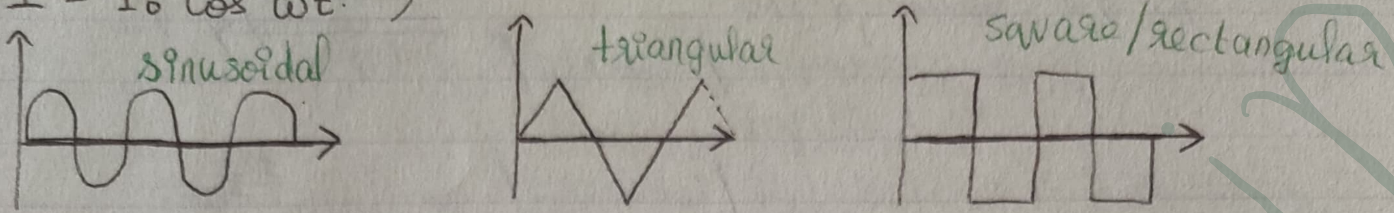
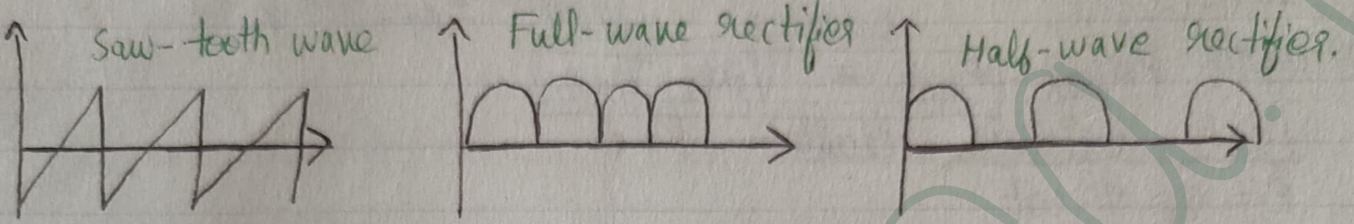
AC

1. India - 50 Hz, 220V   USA - 60 Hz, 110 V.

2. $I = I_0 \sin \omega t$, $I = I_0 \cos \omega t$ } Peak-to-peak value $= 2I_0$

3.





4. Average value of AC current = that value of DC which would send the same amount of charge through the circuit.

$$\langle f(t) \rangle = \frac{\int_{t_1}^{t_2} f(t)\,dt}{\int_{t_1}^{t_2} dt} = \frac{\text{Area under } f\text{-}t \text{ curve}}{t_2 - t_1}.$$

Avg. value of AC over -
(i) full cycle = 0
(ii) +ve half cycle = $2I_0/\pi$
(iii) -ve half cycle = $-\frac{2I_0}{\pi}$

For one time period -
$\langle \sin\theta \rangle = \langle \cos\theta \rangle = 0$
$\langle \sin 2\theta \rangle = \langle \cos 2\theta \rangle = 0$
$\langle \sin\theta \cos\theta \rangle = 0.$
$\langle \sin^2\theta \rangle = \langle \cos^2\theta \rangle = 1/2.$

Maximum value
- $I = a\sin\theta$ $I_{max} = a$
- $I = a + b\sin\theta$ $I_{max} = a + b$
- $I = a\sin\theta + b\cos\theta$ $I_{max} = \sqrt{a^2 + b^2}$
- $I = a\sin^2\theta$ $I_{max} = a.$

5. Root Mean Square [RMS] Value = that value of DC which produces the same (heat in a given resistance in a given time) as is done by AC. → average power loss.

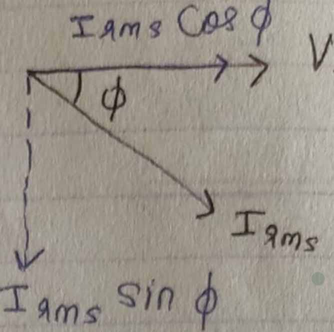
$$f_{rms} = \sqrt{\frac{\int_{t_1}^{t_2} f^2\,dt}{\int_{t_1}^{t_2} dt}}$$

$$I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{\text{Peak value}}{\sqrt{2}} = 0.707 I_0$$

always valid for sin and cos function.

(RMS value = effective value = virtual value = apparent value.)

6. $\langle P \rangle = V_{rms} I_{rms} \cos\phi = \frac{1}{2} V_0 I_0 \cos\phi$.
avg power.
$\cos\phi$ = power factor.



⇒ $I_{rms}\cos\phi$ = active part/ workful/ wattful current.
⇒ $I_{rms}\sin\phi$ = inactive part/ workless/ wattless current.

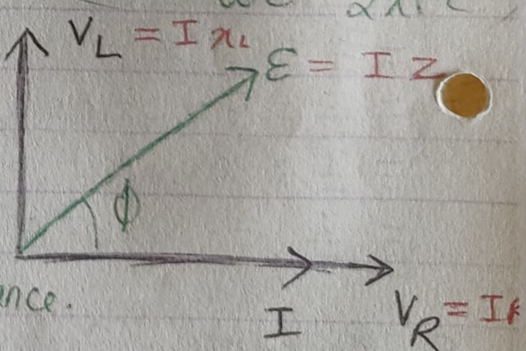
→ RMS Power - $\boxed{P_{rms} = V_{rms} I_{rms}}$

7. <u>Pure resistive circuit</u> - $\phi = 0$
$\varepsilon = \varepsilon_0 \sin\omega t$
$I = \frac{\varepsilon_0}{R}\sin\omega t = I_0 \sin\omega t$ $\left(I_0 = \frac{\varepsilon_0}{R}\right)$.

8. <u>Pure inductive circuit</u> - <u>ELI</u> $(\phi = \pi/2)$ ☆
$\varepsilon = \varepsilon_0 \sin\omega t$
$I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$ $\quad I_0 = \frac{\varepsilon_0}{x_L}$ $\quad (x_L = \omega L)$ inductive reactance
⇒ $x_L = 2\pi f L$
☆ ∴ $\langle P \rangle = 0$.

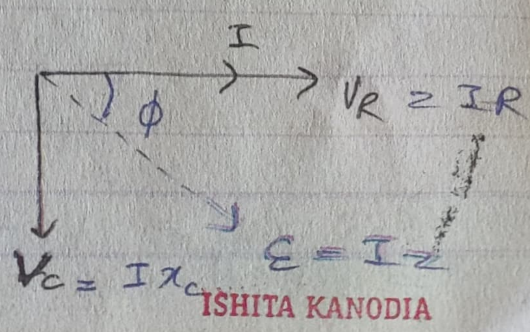
9. <u>Pure Capacitive circuit</u> - <u>ICE</u> $(\phi = \pi/2)$ ☆
$\varepsilon = \varepsilon_0 \sin\omega t$
$I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$ $\quad I_0 = \frac{\varepsilon_0}{x_C}$ $\quad \left(x_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}\right)$
☆ ∴ $\langle P \rangle = 0$.

10. <u>R-L Circuit</u>
→ $\varepsilon = \sqrt{V_R^2 + V_L^2}$
→ $I = \frac{\varepsilon}{Z_L}$ $\quad \left(Z_L = \sqrt{R^2 + x_L^2}\right)$ impedance or effective reactance.
$\left(Y_L = \text{admittance} = \frac{1}{Z_L}\right)$

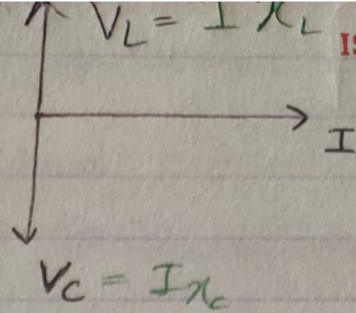


$\tan\phi = \frac{x_L}{R}$

11. <u>R-C Circuit</u>
→ $Z_C = \sqrt{x_C^2 + R^2}$.
→ $I = \frac{\varepsilon}{Z_C}$ $\quad \tan\phi = \frac{x_C}{R}$



L-C circuit

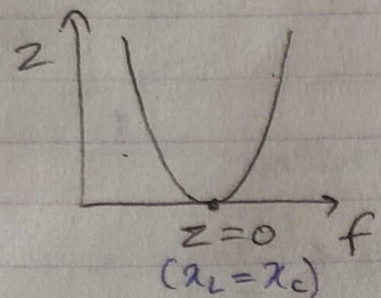


$z = |x_L - x_c|$

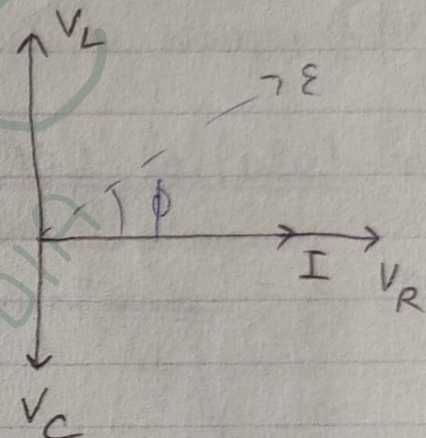
$\varepsilon = |V_L - V_c| = I z$

$= I |x_L - x_c|$.

$z = |x_L - x_c| = \left| 2\pi f L - \frac{1}{2\pi f c} \right|$ ($\therefore$ Z first decreases then increases as f ↑.)



3. LCR (series) Circuit -



→ $z = \sqrt{R^2 + (x_L - x_c)^2}$

→ $\tan \phi = \frac{|x_L - x_c|}{R}$

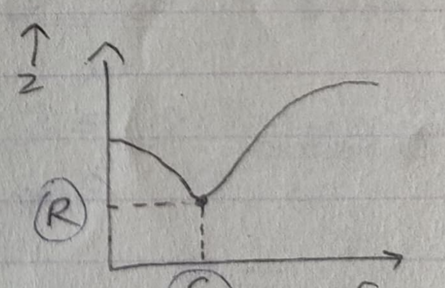
$\cos \phi = \frac{R}{z}$.

→ Resonance condition $(x_L = x_c) \Rightarrow$ $Z_{min} = R$

$\therefore I_{max} = \frac{\varepsilon_0}{z} = \frac{\varepsilon_0}{R}$.

$\Rightarrow \phi = 0$ (pure resistive circuit).

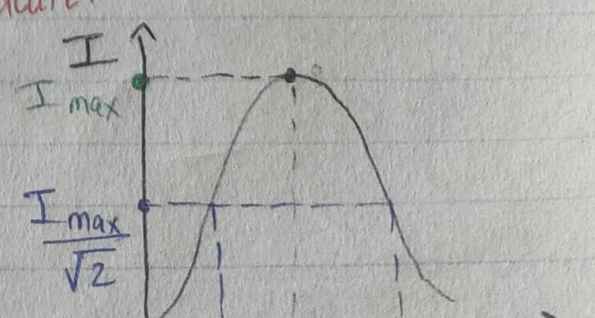
→ $\omega_r = \frac{1}{\sqrt{LC}}$. $f_r = \frac{1}{2\pi\sqrt{LC}}$.



When $f < f_r \Rightarrow$ capacitive circuit
$f > f_r \Rightarrow$ inductive circuit
$f = f_r \Rightarrow$ purely resistive circuit.

→ At resonance, $Z_{min} = R$
$\Rightarrow$ acceptor circuit.

→ resonance is applied in radio and TV tuning.



→ Half power frequency $P = \frac{1}{2} P_{max} \Rightarrow I = \frac{I_{max}}{\sqrt{2}}$

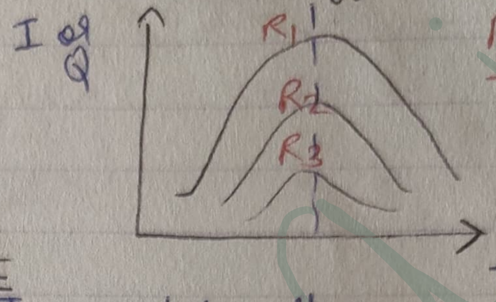
$(\because P = I^2 Z)$

$\Delta f = f_2 - f_1$ = bandwidth.

→ Q = quality factor = $2\pi \dfrac{\text{maximum energy stored per cycle}}{\text{maximum energy lost per cycle}}$

$Q = \frac{f_r}{\Delta f} = \frac{\omega_r}{\omega_2 - \omega_1}$.

$Q = \frac{X_L}{R} = \frac{X_C}{R} = \frac{1}{R}\sqrt{\frac{L}{C}}$.



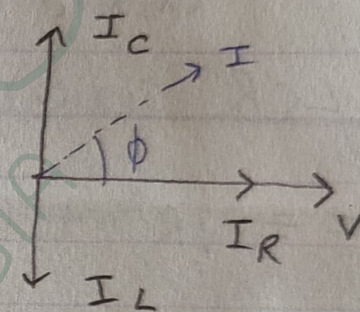
$R_1 < R_2 < R_3$

$\left(I = \frac{\varepsilon}{R}\right)$ (resonance).

→ at resonance - $V_L = V_C = Q\underbrace{E}_{\text{supplied voltage}}$

→ sharpness ∝ Quality factor ∝ magnification.

14 Parallel LCR circuit -



→ $Z = \dfrac{1}{\sqrt{\left(\frac{1}{R}\right)^2 + \left(\frac{1}{X_L} - \frac{1}{X_C}\right)^2}}$

$\left(\frac{1}{R} = G = \text{conductance}\right)\left(\frac{1}{X_L} = S_L = \text{inductive susceptance}\right)\left(\frac{1}{X_C} = S_C\right)$

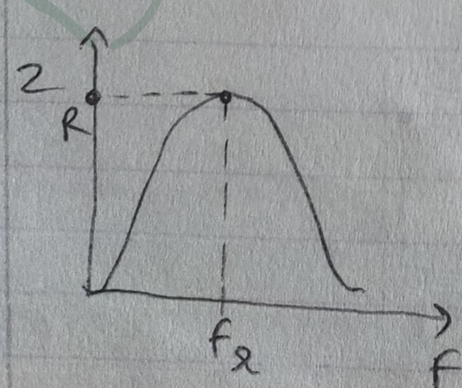
→ $Z = \dfrac{1}{\sqrt{G^2 + (S_L - S_C)^2}}$ | Y = admittance $= \frac{1}{Z} = \sqrt{G^2 + (S_L - S_C)^2}$

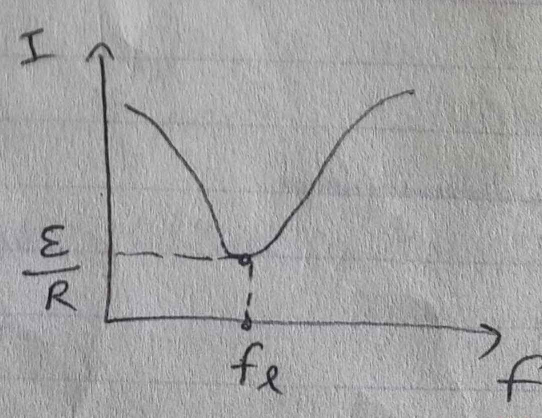
→ $\tan\phi = \dfrac{S_C - S_L}{G}$.

→ Resonance $S_L = S_C$ $(\Rightarrow X_L = X_C)$

$\Rightarrow Z_{max} = R$ $\therefore I_{min} = \frac{\varepsilon}{Z_{max}} = \frac{\varepsilon}{R}$.

$\omega_r = \frac{1}{\sqrt{LC}}$, $f = \frac{1}{2\pi\sqrt{LC}}$.





5. Choke coil - inductor used to control (reduce) the current in an AC circuit.

→ Resistance also controls current, but more heat loss occurs across resistance. Across inductor, heat loss is very small.

→ Choke coil is a copper coil wound over a soft iron laminated core. coil is put in series with circuit in which current is to be reduced. series LR circuit.

16. LC oscillations - oscillation of energy between capacitor and inductor

① Undamped oscillations -

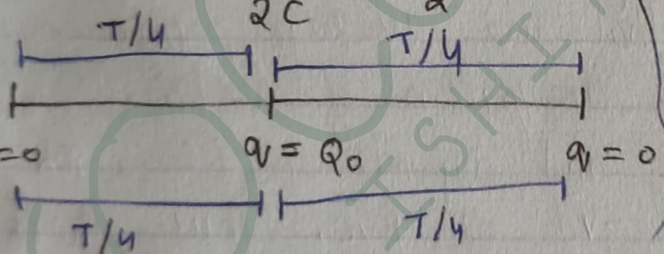
→ no resistance ∴ no energy loss.

→ oscillation produced have constant amplitude.

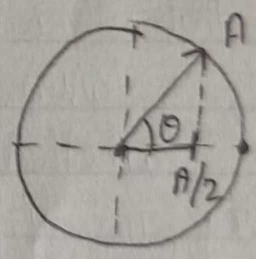
$$\frac{q^2}{2C} + \frac{1}{2}Li^2 = \frac{Q_0^2}{2C} = \frac{1}{2}LI_0^2.$$

$$\frac{d^2q}{dt^2} + \frac{q}{LC} = 0 \Rightarrow \text{equation of SHM. } (q = q_0 \cos \omega t)$$

$$U_C = U_L = \frac{Q_0^2}{2C} = \frac{1}{2}LI_0^2.$$



if $q_C = q_0$ at $t = 0$.



$2\pi \rightarrow T$

$\Rightarrow \frac{\pi}{3} \rightarrow T/6$

$A \cos\theta = A/2$

$\theta = 60° = \pi/3$

② Damped Oscillations -

→ resistance present in circuit ∴ energy loss occurs across resistance

→ amplitude of oscillations keeps decreasing.

In SHM

$$m\frac{d^2x}{dt^2} + b\frac{dx}{dt} + kx = 0$$

$$\omega' = \sqrt{\omega^2 - \left(\frac{b}{2m}\right)^2}$$

$$A = A_0 e^{-bt/2m}$$

mulberry

$K \rightarrow \frac{1}{C}$, $(m \rightarrow L,\ b \rightarrow R)$

$\omega^2 = \frac{K}{m} = \frac{1}{LC}$. $(m\omega^2 = K)$.

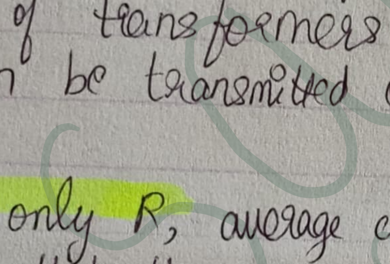
$$\omega' = \sqrt{\omega^2 - \left(\frac{b}{2m}\right)^2}$$

→ $\omega' = \sqrt{\omega^2 - \left(\frac{R}{2L}\right)^2}$, $f' = \frac{1}{2\pi}\omega'$.

→ For real oscillations- $\frac{1}{LC} > \frac{R^2}{4L^2}$.

NCERT POINTS

1. The electric mains supply in our homes and offices is alternating voltage.
2. Advantages of AC- (over DC)
   (i) AC voltages can easily converted from one voltage the other efficiently by means of transformers.
   (ii) electrical energy can be transmitted economically over long distances.
   (iii) It is cheaper.
3. In a circuit with only R, average current is zero, however, this does not mean that the average power consumed is zero and that there is no dissipation of electrical energy. Joule heating is given by i^2R and depends on i^2 which is always +ve whether i is -ve or +ve. Thus, there is Joule heating and dissipation of electrical energy when current passes through a resistor.
4. A phasor is a vector which rotates about the origin with angular speed ω.
5. Impedance diagram



6. Resonant circuits have a variety of applications, for example, in the tuning mechanism of a radio or a TV set. The antenna of a radio accepts signals from many broadcasting stations. The signals picked up in the antenna acts as a source in the tuning circuit of the radio, so the circuit can be driven at many &

☆ frequencies. But to hear one particular radio station, we tune the radio. In tuning, we vary the capacitance of a capacitor in the tuning circuit such that the resonant frequency of the circuit becomes nearly equal to the frequency of the radio signal received. When this happens, the amplitude of the current with the frequency of the signal of the particular radio station in the circuit is maximum.

7. Working of the metal detector

The metal detector works on the principle of resonance in ac circuits. When you walk through a metal detector, you in fact walk through a coil of many turns. The coil is connected to a capacitor tuned so that the circuit is in resonance. When you walk through with metal in your pocket, the impedance of the circuit changes resulting in significant change in the current in the circuit. This change in current is detected and the electronic circuitry causes a sound to be emitted as an alarm.