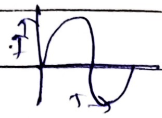
Alternating current

$X_C = \frac{1}{\omega C}$

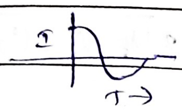
$X_L = \omega L$

① AC types

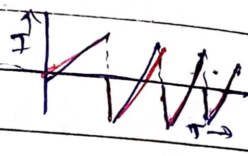
a) sine function $I = I_0 \sin(\omega t)$



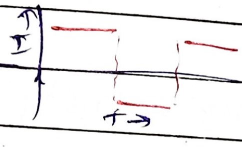
b) cosine function $I = I_0 \cos(\omega t)$



c) saw-tooth



d) Rectangular



$I_{rms} = \sqrt{\overline{I^2}}$ → square of Av. current and then square root

Value of functions

Av. value	half cycle	full cycle
$\sin \omega t$	$2/\pi$	0
$\cos \omega t$	0	0
$\sin^2\omega t = \cos^2\omega t$	$1/2$	$1/2$

Av. of square root of current ($\overline{I^2}$)

	Half cycle	full cycle
① $I = I_0\sin(\omega t)$	$I_0^2/2$	$I_0^2/2$
② $I = I_0\cos(\omega t)$	$I_0^2/2$	$I_0^2/2$
③ saw tooth	$I_0^2/3$	$I_0^2/3$
④ Rectangular	I_0^2	I_0^2

② $\overline{P} = I_{rms} \cdot E_{rms} \cdot \cos(\phi)$

($\phi = 90°$) $\overline{P} = 0$ (wattless current)

circuits

① L-R circuit and C-R circuit

⇒ $V_N = \sqrt{V_R^2 + V_L^2}$ | $Z = \sqrt{R^2 + X_L^2}$

⇒ $\tan \Delta\phi = \frac{V_L}{V_R}$ | $\cos\phi = \frac{R}{Z}$

⇒ $V_{rms} = I_{rms} \cdot Z$

$P = \left(\frac{V_{rms}}{Z}\right)^2 R$ ★★

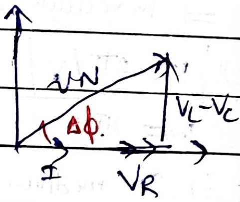
- for C.R. circuit replace X_L by X_C.

ⓑ L-C-R circuit

a) $V_L > V_C$

⇒ $V_N = \sqrt{V_R^2 + (V_L - V_C)^2}$

$= I\sqrt{R^2 + (X_L - X_C)^2}$



$V_N = IZ$ ★

$\tan\Delta\phi = \frac{V_L - V_C}{V_R}$ | $\cos\phi = R/Z = \frac{V_R}{V_N}$

$\overline{P} = \left(\frac{V_{rms}}{Z}\right)^2 R$

★ Resonance circuit

$f_0 = \frac{1}{2\pi\sqrt{LC}}$

$V_N = V_R$, when $V_L = V_C = 0$

Q-factor

$Q\text{ factor} = \frac{1}{R}\sqrt{\frac{L}{C}}$

★ Inductor property in LCR or LR circuit

DC battery	AC battery
$t = 0$, open branch	~~open branch~~ ~~close~~ wire
t_∞ = wire	t_∞ = open branch

$\mu_r = \frac{\mu}{\mu_0}$

E.M wave

① $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$

ε_0 = permittivity of vacuum
μ_0 = permeability — " —.

② $C_{medium} = \frac{c}{\mu}$ or $v = \frac{1}{\sqrt{\mu \varepsilon}}$

(μ → refractive index.)

No Phase diff. b/w E.field & M. field

③ E.field : $E_y = E_0 \sin(\omega t - kx)$

④ B.field : $B_z = B_0 \sin(\omega t - kx)$

⇒ in vaccum ligh wave propagates, then

$k = 2\pi/\lambda$

$\omega = 2\pi f$

$\frac{E}{B} = \frac{E_0}{B_0} = \frac{\omega}{k} = c$

⇒ In medium light wave Propagates, then

$\frac{\omega}{k} = \frac{c}{\mu_0}$ $\frac{c}{\mu_0} = v$

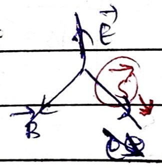
- max. E.force on charge particle

$F_{max} = qE_0$ $E = E_0 \sin(\omega t - kx)$

- max. magnetic force on moving charge

$F_{max} = qvB_0 \sin\theta$

⑤ $\vec{S} = \frac{\vec{E} \times \vec{B}}{\mu_0}$ (S → energy flux; → electromagnetic flux)



S ⇒ pointing vector.

→ its directn gives propagation of light wave

→ Its magnitude gives intensity.

unit = $\frac{watt}{Area}$ = W/m^2

Energy density

① $E.F = \frac{1}{2}\varepsilon_0 E^2$ ② $M.F = \frac{B^2}{2\mu_0}$

⇒ Total Energy

$U = U_E + U_B$ or $\frac{1}{2}\varepsilon_0 E^2 + \frac{B^2}{2\mu_0}$

Average Energy density

① $\bar{U}_E = \frac{1}{4}\varepsilon_0 E^2$

② $\bar{U}_B = \frac{B_0^2}{4\mu_0}$

Total Energy density. $2\bar{U}_E$ or $2\bar{U}_B$

$\bar{U}_E = \bar{U}_B$

∴ $\bar{U}_{Total\ average} = \frac{1}{2}\varepsilon_0 E^2 = \frac{B_0^2}{2\mu_0}$

Average Intensity

$I = \bar{U} \times c$ ⇒ $\frac{U}{A \times t}$ → $\frac{1}{2}\varepsilon_0 E_0^2 c$

concept of Displacement current

⇒ Modified Ampere's law.

$\oint \vec{B} \cdot d\vec{l} = \mu_0 (I_C + I_D)$

⇒ Displacement current

$I_D = \varepsilon_0 \frac{d\phi_E}{dt}$

$I_D = \frac{(E.A)\varepsilon_0}{dt} = \frac{d\phi \cdot \varepsilon_0}{dt}$

$I_c = I_d$, always same value.

: Refractive index ⇒ $n = \sqrt{\mu_r \varepsilon_r}$

	EMW	wavelength
1 Mev	① Gamma	$< 10^{-3}$ nm
1 keV	② X rays	10^{-3} nm – 1 nm
10 –100eV	③ U.V. rays	1nm – 400nm
1eV – 2eV	④ Visible (VIBGYOR)	400 nm – 700 nm
1 meV	⑤ Infra red. (Heat waves)	700nm – 1mm
1 μeV	⑥ M.W	1 mm – 0.1 m
	⑦ R.W	> 0.1 m