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Excellence Program · S.Y.J.C. Physics.
Synopsis: H.S.C. weightage.
Topic: Electromagnetic Induction: [4 M]

* Faraday's law:
Induced e.m.f. $e = \frac{d\phi}{dt}$ [rate of change of magnetic flux associated with coil.

* Lenz's law: The direction of induced e.m.f. is such that it tries to oppose the change in magnetic flux which produce it. $e = -\frac{d\phi}{dt}$

* Coefficient of self Induction.
$L = \frac{e}{di/dt}$.
S.I unit: Henry (H)
Dimension: $[L^2 M^1 T^{-2} I^{-2}]$

* Coefficient of mutual Induction.
$M = \frac{e_s}{di_p/dt}$.
It is the phenomenon of production of an induced e.m.f. in one coil due to change of current in neighbouring coil. Unit: henry [H]
Dimension: $[L^2 M^1 T^{-2} I^{-2}]$

* Transformer:
(1) Step-up transformer.
$N_s > N_p$. also $e_s > e_p$.
(2) Step-down transformer.
$N_s < N_p$ $e_s < e_p$

(*) Transformer ratio

$$\frac{e_s}{e_p} = \frac{N_s}{N_p}.$$

(*) Coil rotating in a uniform magnetic field.

$$e = -\frac{d\phi}{dt} = -\frac{d}{dt}(NAB \cos \omega t).$$

$$e = NAB\omega \sin \omega t.$$

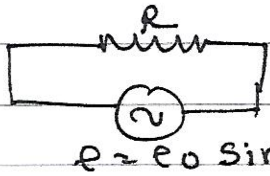
$$e = e_0 \sin \omega t.$$

$$\omega = 2\pi f. \qquad e_0 = NAB\omega.$$

(*) $$i_{r.m.s.} = \frac{i_0}{\sqrt{2}} = 0.7071\ i_0$$

$$e_{r.m.s.} = \frac{e_0}{\sqrt{2}} = (0.7071)\ e_0.$$

(*) A-C. circuit with resistor.



$e = e_0 \sin \omega t.$

$$i = \frac{e}{R} = \frac{e_0}{R} \sin \omega t.$$

$$i = i_0 \sin \omega t.$$

Phase angle $\phi = 0$.

Power factor $\cos \phi = 1$.

Instantanous power $P = ei$

$$= (e_0 \sin \omega t)(i_0 \sin \omega t)$$

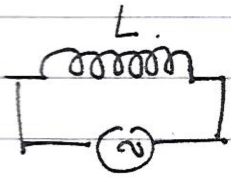
$$= e_0 i_0 \sin^2 \omega t.$$

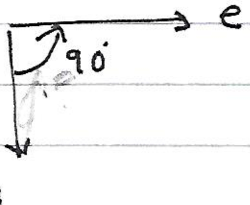
Average or mean power

$$P_{av} = i_{r.m.s} \times e_{r.m.s.}$$

$$= \frac{i_0}{\sqrt{2}} \times \frac{e_0}{\sqrt{2}} = \frac{P_0}{2} = \frac{e_0 i_0}{2}.$$

(*) Simple A.C. circuit with pure Inductance (L)





$i = i_0 \sin \omega t.$

$e_{back} = -L \frac{di}{dt} = \omega L i_0 \cos \omega t.$

$e_{max} = \omega L i_0 = e_0.$

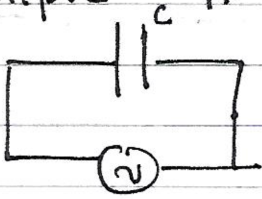
(i) $e = e_0 \cos \omega t.$

(ii) Inductive reactance $X_L = \omega L = \frac{e_{r.m.s.}}{i_{r.m.s.}}$

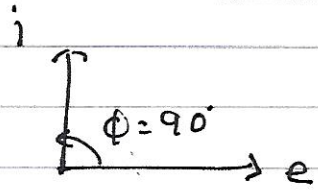
(iii) Power factor $= \cos\phi = 0.$

(iv) Phase angle : e.m.f. leads current by $\pi/2$

(*) 1 Simple A. C. circuit with pure capacitance:



$e = e_0 \sin \omega t$



$e = e_0 \sin \omega t.$

$\frac{q}{c} = e_0 \sin \omega t.$

$\frac{dq}{dt} = c\, e_0 \frac{d}{dt} (\sin \omega t)$

$i = \omega c e_0 \cos \omega t.$

(1) $i = i_0 \cos \omega t.$

$i_{max} = i_0 = \omega c e_0.$

(2) capacitive reactance $= X_c = \frac{1}{\omega c} = \frac{e_0}{i_0}$

$$= \frac{e_0/\sqrt{2}}{i_0/\sqrt{2}} = \frac{e_{r.m.s}}{i_{r.m.s}}.$$

(3) Power factor = $\cos\phi = 0$.

(4) Phase angle : e.m.f. across the capacitor lags behind the current by Phase angle of $\pi/2$

(*) An alternating current LCR series circuit:

(1) $E = i\sqrt{R^2 + (X_L - X_C)^2}$.

$e = i\,Z$.

$Z = \sqrt{R^2 + (X_L - X_C)^2}$ - Impedence (Ω).

(II) Phase angle ϕ. $\tan\phi = \frac{X_L - X_C}{R}$.

(III) Power factor = $\cos\phi = \frac{R}{Z} = \frac{\text{Resistance}}{\text{Impedence}}$.

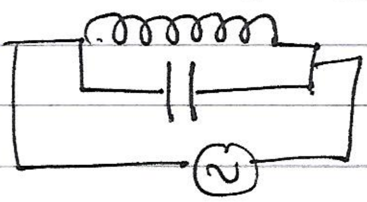
(IV) At resonance.

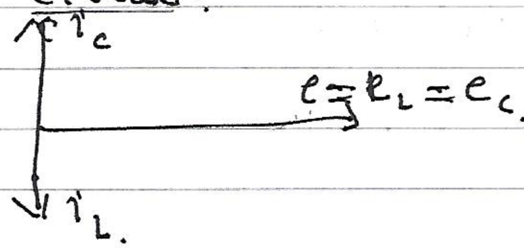
$X_L = X_C$

$\omega L = \frac{1}{\omega C}$.

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

(*) Parallel resonant circuit:





$i_L = \frac{e}{X_L}$. $i_C = \frac{e}{X_C}$.

$$i = e\left(\frac{1}{X_c} - \frac{1}{X_L}\right).$$

$$= e\left(\frac{1}{1/\omega C} - \frac{1}{\omega L}\right)$$

$$= e\left(\omega C - \frac{1}{\omega L}\right).$$

$$Z = \frac{e}{i} = \frac{1}{\left(\omega C - \frac{1}{\omega L}\right)}.$$