Physics Notes

BY

Er. Lalit Sharma
B.Tech (Electrical)
Ex. Lecturer Govt. Engg. College Bathinda
Physics Faculty Ranker's Point, Bathinda

Arun Garg
M.Sc. Physics
Gold Medalist
Physics Faculty Ranker's Point, Bathinda

Class:10+2
Unit: IV

Topic: Electromagnetic Induction & Alternating Currents

<u>*SYLLABUS*</u>: UNIT-IV-*B*

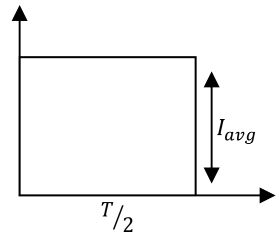
Electromagnetic induction; Faraday's law, induced emf and current; Lenz's Law; Eddy currents, Self and mutual inductance.
Need for displacement current.
Alternating current, peak and rms value of alternating current/voltage; reactance and impedance; LC oscillations (Qualitative treatment only), LCR series circuit, resonance; power in AC circuits, wattles current.
AC generator and transformer.

Q.No.	Topic/Question	Page No.
	Unit-IV-B	
1.	Derive an expression for "*Average value*" of alternating current (sine wave) a) Half wave b) Full wave.	1
2.	Derive an expression for "*RMS*" value of alternating current (sine wave) a) Half wave b) Full wave.	3
3.	Find magnitude and phase of current in pure resistive (*R*) circuit when sine voltage is applied across it?	5
4.	Find magnitude and phase of current in pure induction (*L*) circuit when sine voltage is applied across it.	7
5.	Find magnitude and phase of current in pure capacitor circuit when sine voltage is applied across it.	9
6.	Find magnitude and phase of current in R-L series circuit when sine voltage is applied across it.	11
7.	Find magnitude and phase of current in R-C series circuit when sine voltage is applied across it.	15
8.	Find magnitude and phase of current in R-L-C series circuit when sine voltage is applied across it.	17
9.	What is "Resonance" in R-L-C circuit? Derive expression for resonant frequency?	19
10.	a) Prove Energy stored in an inductor is $\frac{1}{2}.L.I^2$? b) Prove Energy density in magnetic field is $\frac{1}{2}.\mu.H^2$?	21
11.	Find Power associated with a "*Resistor*" in a.c. ?	23
12.	Find Power associated with an "*Inductor*" in a.c.?	25
13.	Find Power associated with a "*Capacitor*" in a.c. ?	27
14.	Prove P = V_{rms} I_{rms} cos ϕ, where ϕ is phase difference between voltage and current?	29
15.	What is an L-C oscillator? Derive expression for resonant frequency of L-C oscillator?	31
16.	What do you mean by Quantity factor of a circuit? Explain.	31
17.	Discuss Construction, Working and Efficiency of a transformer.	33
18.	Discuss Construction, Working of A.C. Generator.	35

Q.1. Derive an expression for "*Average value*" of alternating current (sine wave)

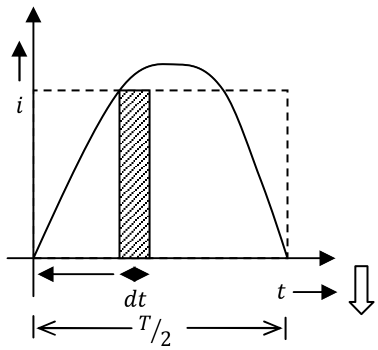
a) Half wave

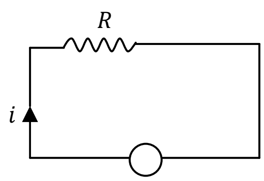
b) Full wave.

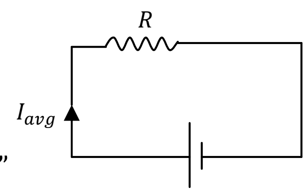


$$\boxed{I_{avg} = \frac{2}{\pi} I_{max}}$$

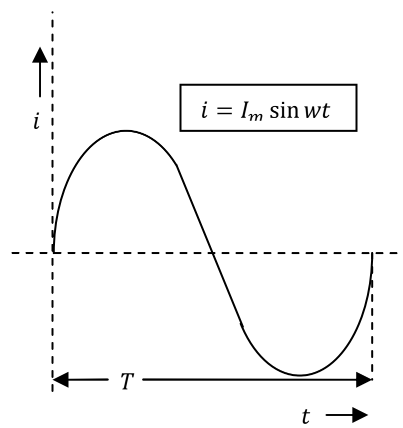
Ans.a) **<u>Half wave</u>**







- Average value of current is defined on the basis of "Charge" flowing in a circuit.
- Average flowing value of current in a circuit is that a.c which when flowing in a circuit allow same charge to flow as is flowing in a.c. current.ω



$$\int_0^{T/2} i\,dt = I_{avg}\left(\frac{T}{2}\right)$$

$$\int_0^{T/2} I_m \text{sinwt dt} = I_{avg}\left(\frac{T}{2}\right)$$

$$I_m \left|-\frac{\cos wt}{\omega}\right|_{t=0}^{t=\frac{T}{2}} = I_{avg}\left(\frac{T}{2}\right) \qquad \left[\omega = \frac{2\pi}{T}\right]$$

$$\frac{I_m}{\omega}\left[-\frac{\cos 2\pi}{\omega} \text{x} \frac{T}{2} - (-\cos 0)\right] = I_{avg}\left(\frac{T}{2}\right)$$

$$\frac{I_m}{\omega}(2) = I_{avg}\left(\frac{T}{2}\right)$$

$$\boxed{I_{avg} = \frac{2}{\pi} I_{max}}$$

$$I_{avg} = 0.64\, I_{max}$$

b) **Full wave**: I_{avg} . T

$$= \int_0^{T} I_m \text{sinwt dt} = 0\,.\,\text{so,} \qquad \boxed{I_{avg} = 0}$$

Q2. Derive an expression for "*RMS*" value of alternating current (sine wave)

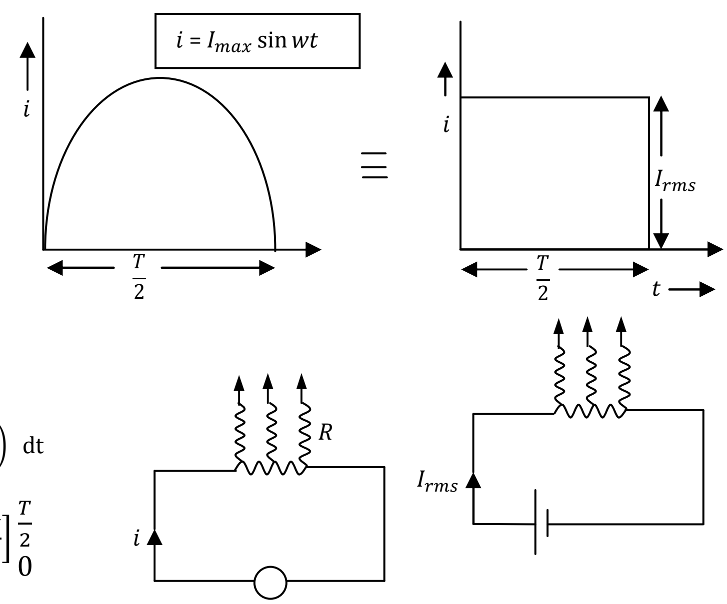
a) Half wave

b) Full wave.

Ans.

- RMS value is defined on the basis of "Heating effect".

  RMS value is that *dc* current which when flowing in a resistance gives same heating effect as given by alternating current.



$$I_{rms}^2 . R . \frac{T}{2} = \int_0^{T/2} i^2 \, R . dt$$

$$I_{rms}^2 . 1 . \frac{T}{2} = \int_0^{T/2} i^2 \, dt$$

$$= \int_0^{T/2} I_{max}^2 \sin^2 \omega t \, dt$$

$$= \int_0^{T/2} I_{max}^2 \left(\frac{1 - \cos 2\,\omega t}{2}\right) dt$$

$$= I_{max}^2 \cdot \frac{1}{2}\left[t - \frac{\sin 2\,\omega t}{2\omega}\right]_0^{\frac{T}{2}}$$

$$= I_{max}^2 \cdot \frac{1}{2}\left[\frac{T}{2} - \frac{\sin 2\left(\frac{2\pi}{T}\right) x \frac{T}{2}}{2\omega}\right] - [0 - sin0]$$

$$= I_{max}^2 \cdot \frac{1}{2}\left[\frac{T}{2} - 0\right]$$

$$I_{rms}^2 . 1 . \frac{T}{2} = \frac{I_{max}^2}{2} . \frac{T}{2}$$

$$\boxed{I_{rms} = \frac{I_{max}}{\sqrt{2}}}$$

FORM FACTOR:

$$= \frac{I_{rms}}{I_{avg}}$$ (Ratio of r.m.s value to avg. value)

$$= \frac{\frac{I_{max}}{\sqrt{2}}}{\frac{2}{\pi} I_{max}}$$

$$= \frac{\pi}{2.\sqrt{2}}$$

$$= 1.11$$

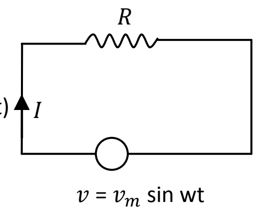
Q3. Find magnitude and phase of current in pure resistive (R) circuit when sine voltage is applied across it?

Ans.

<u>Step 1</u>:-

Draw 2 figures i.e. (Fig. I, II)

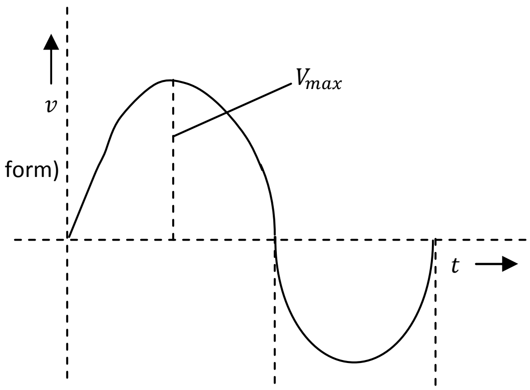
Fig. I
(Circuit)



<u>Step 2</u>:-

Write relationship between *i* and *v*

Fig. II
(Voltage wave form)



$$v = R\, i$$

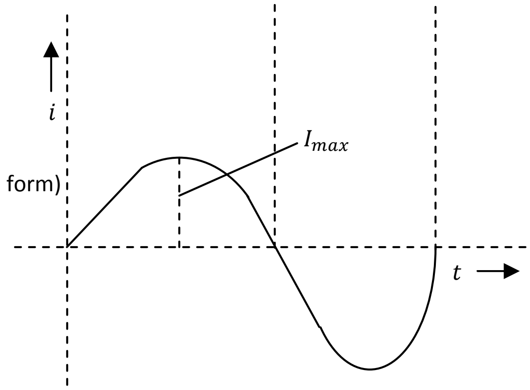
$$i = \frac{V}{R}$$

$$i = \left(\frac{V_m}{R}\right) \sin \omega t$$

$$\boxed{i = I_{max} \sin \omega t}$$

$V_{max} = 220\sqrt{2}$ domestic

Fig. III
(Current wave form)



where $I_{max} = \frac{V_m}{R}$

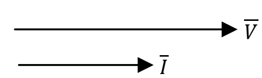
Draw current wave form

<u>Step 3</u>:-

After analyzing voltage and current wave form, Draw "*Phasor*" diagram.

$\overline{V}$ and $\overline{I}$ are in phase.

Fig. IV
(Phasor diagram)



Q4. Find magnitude and phase of current in pure induction (*L*) circuit when sine voltage is applied across it.

Ans.

<u>Step 1</u>:-

Draw 2 figures i.e. (Fig. I, II)

$$v = V_m.\sin \omega t$$

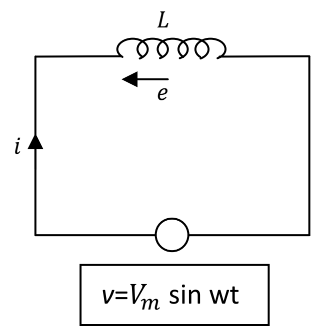


Fig. I
Circuit

<u>Step 2</u>:-

Write relationship between *i* and *v*

$$v = -e$$

$$v = -\left(-L\frac{di}{dt}\right)$$

$$v = L\frac{di}{dt}$$

$$di = \frac{v}{L}dt$$

Integrating both sides

$$\int di = \int\left(\frac{V_m}{L}\sin \omega t\right)dt$$

$$i = \frac{V_m}{L}\left(-\frac{\cos wt}{w}\right)$$

$$i = \frac{V_m}{L\omega}\left[sin\left(wt - \frac{\pi}{2}\right)\right]$$

$$\boxed{i = I_{max}\sin\left(wt - \frac{\pi}{2}\right)}$$

$$\left\{\text{where } I_{max} = \frac{V_m}{L\omega} = \frac{V_m}{X_L}\right\}$$

(X_L: Inductive reactance)

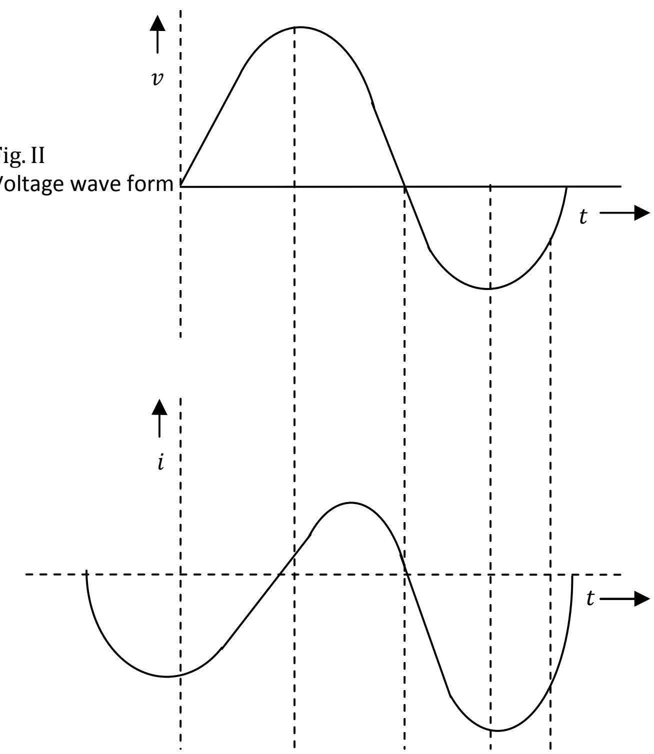
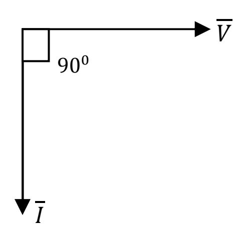


Fig. II
Voltage wave form

<u>Step 3</u>:-

Phasor diagram



Current lags voltage by $\frac{\pi}{2}$

Q5. Find magnitude and phase of current in pure capacitor circuit when sine voltage is applied across it.

Current leads by $\frac{\pi}{2}$ in a pure capacitor.

Ans.

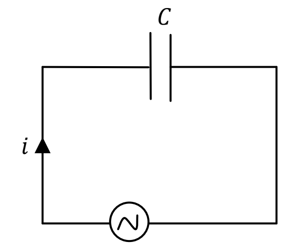
<u>Step 1</u>:-

Draw 2 figures i.e. (Fig. I, II)

$$v = V_m \sin \omega t$$

The above voltage is applied across a capacitor.

Fig. I
Circuit



$v = V_m \sin \omega t$

<u>Step 2</u>:-

Write relationship between i and v

$$i = \frac{dq}{dt}$$

$$i = \frac{d\,(Cv)}{dt}$$

$$i = C\frac{dv}{dt} = C\frac{d\,(V_m \sin \omega t)}{dt}$$

$$i = C\, V_m\, (\cos \omega t).\, \omega$$

$$= (C\, V_m.\, \omega) \cos \omega t$$

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

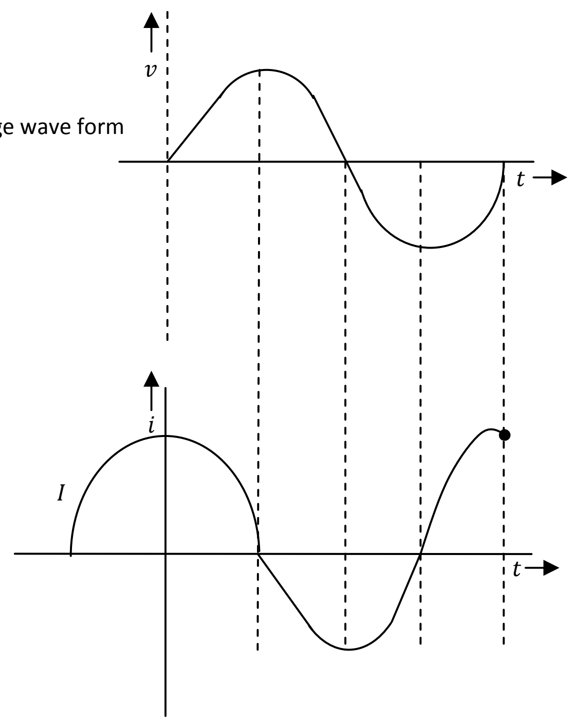
$$= \frac{V_m}{X_C}.\cos \omega t$$

i	$= I_m \cos wt$

$$= I_m \left[\sin\left(wt + \frac{\pi}{2}\right)\right]$$

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

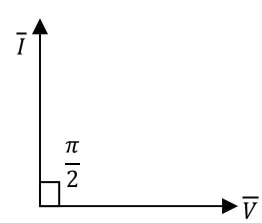
Fig. II
Voltage wave form



<u>Step 3</u>:-

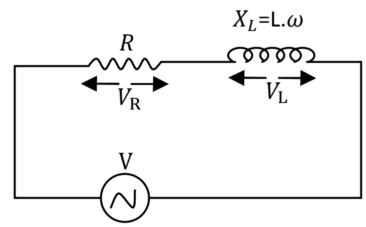
$$v = V_m \sin \omega t$$

$$i = I_m \sin\left(\omega t + \frac{\pi}{2}\right)$$



Q6. Find magnitude and phase of current in R-L series circuit when sine voltage is applied across it.

Fig. I



Ans.

Step 1:-

Draw circuit diagram

Step 2:-

Mark voltages, currents in circuit diagram.

Step 3:-

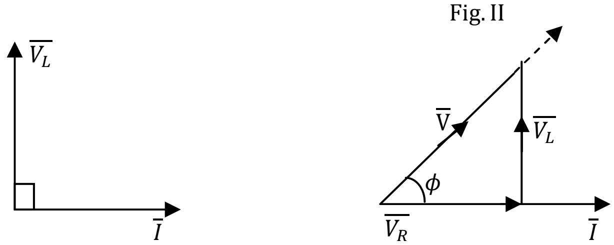
Draw phasor diagram for voltages

V $= \overline{V_R} + \overline{V_L}$

→ $\bar{I}$

→ $\overline{V_R}$

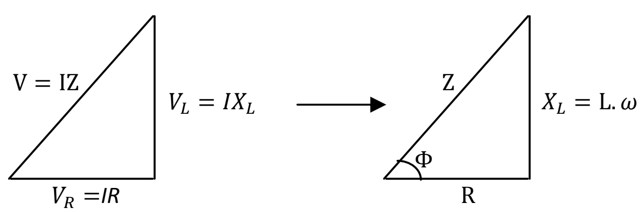
Fig. II



Step 4:-

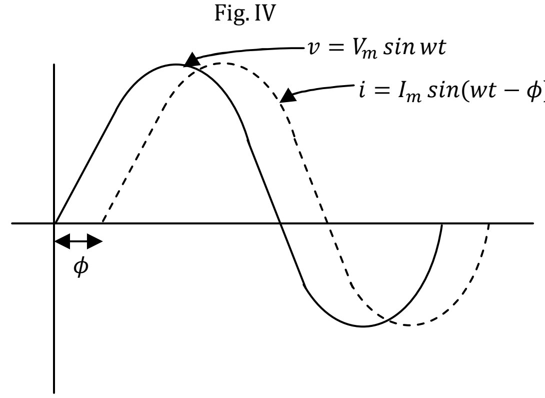
Draw Impedance triangle

Fig. III



Impedance, $Z = \sqrt{R^2 + X_L^2}$

Fig. IV



Step 5:-

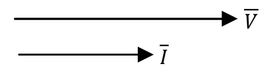
Draw voltage and current wave form

Current lags voltage by Φ

I $= \frac{V}{Z}$

Discussion for Q.6

1. If L = 0, Z $= \sqrt{R^2 + (LW)^2}$



$= \sqrt{R^2 + 0}$

$= \sqrt{R^2}$

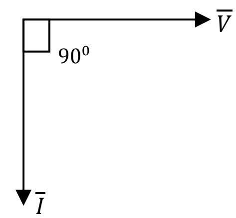
Z	= R

Pure resistive network

Φ = 0

$\overline{V}$ and $\overline{I}$ are in phase

2. If R = 0, Z $= \sqrt{R^2 + (L\omega)^2}$



$= \sqrt{0 + (L\omega)^2}$

Z	= Lω

Z $= X_L$ $[X_L = L\omega]$

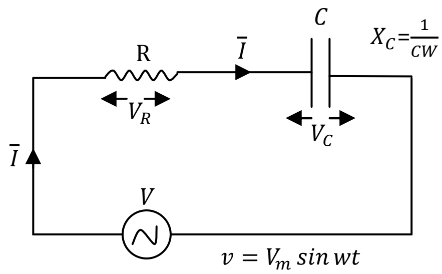
Pure inductive network

Φ = 90^0

Current lags voltage by $\frac{\pi}{2}$.

Q7. Find magnitude and phase of current in R-C series circuit when sine voltage is applied across it.

Fig. I



Ans.

<u>Step 1</u>:-

Draw circuit diagram

<u>Step 2</u>:-

Mark voltages, currents in circuit diagram.

<u>Step 3</u>:-

Draw phasor diagram for voltages

$\overline{V} = \overline{V_R} + \overline{V_C}$

⟶ $\bar{I}$ and

⟶ $\overline{V_R}$

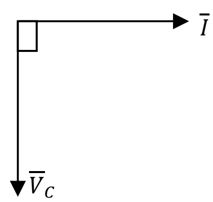
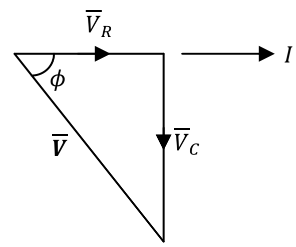
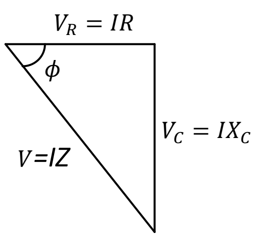


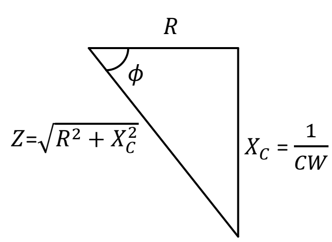
Fig. II



<u>Step 4</u>:-

Draw Impedance triangle





$$\text{Impedance, } Z = \sqrt{R^2 + X_C^2}$$

<u>Step 5</u>:-

Draw voltage and current wave form

Current leads voltage by Φ

$$I = \frac{V}{Z}$$

<u>Case I</u> $X_C = 0$

$Z = R$

Pure resistive

⟶ I

⟶ V

<u>Case II</u> $R = 0$

$Z = X_C$

Pure capacitive

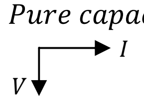
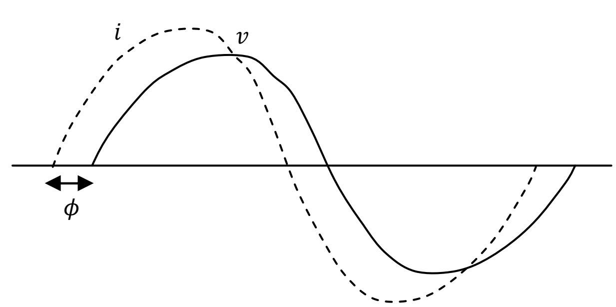


Fig. IV



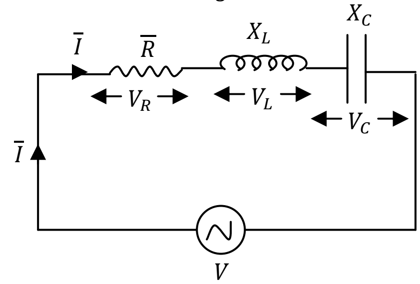
Q8. Find magnitude and phase of current in R-L-C series circuit when sine voltage is applied across it.

Ans.

Step 1:-

Draw circuit diagram

$Fig. I$



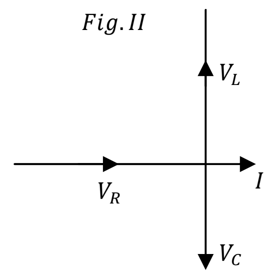
Step 2:-

Mark voltages, currents in circuit diagram.

Step 3:-

Draw phasor diagram for voltages

$Fig. II$

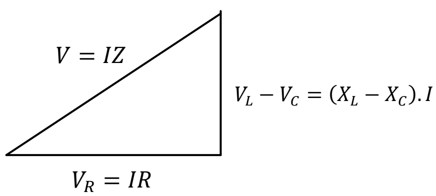


$$\bar{V} = \bar{V}_R + \bar{V}_C + \bar{V}_L$$

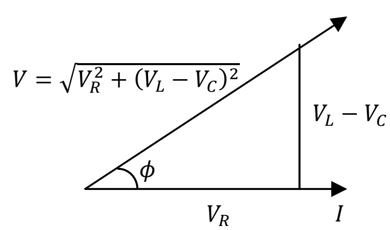
Inductive effect is more than capacitive effect. (Assumption)

Step 4:-

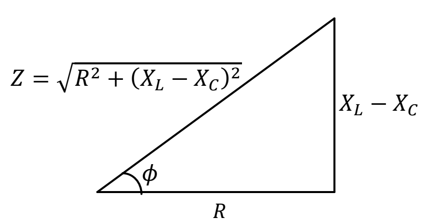
Draw Impedance triangle



$Fig. III$



Impedance, Z	$= \sqrt{R^2 + (X_L - X_C)^2}$

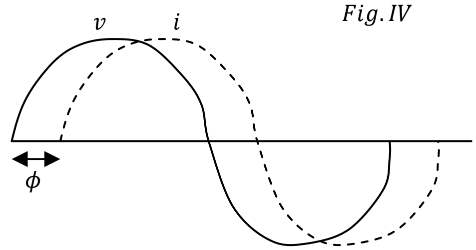


Step 5:-

Draw voltage and current wave form

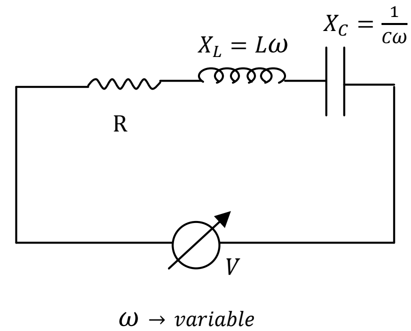
I	$= \frac{V}{Z}$

$Fig. IV$



Current lags voltage by Φ

Q9. What is "Resonance" in R-L-C circuit? Derive expression for resonant frequency?



Ans.

a) Resonance in R-L-C circuit means condition when current is optimum.
That is for series R-L-C circuit, current is maximum.

b-1) As ω changes, X_L = Lω and $X_C = \frac{1}{C\omega}$ change

$$Z = \sqrt{R^2 + \left(L\omega - \frac{1}{C\omega}\right)^2}$$

$$Z_{min} = R$$

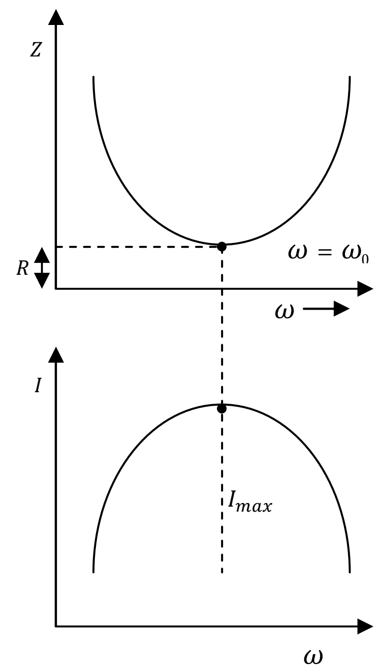
When $L\omega_0 = \frac{1}{C\omega_0}$

$$\omega_0^2 = \frac{1}{LC}$$

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

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

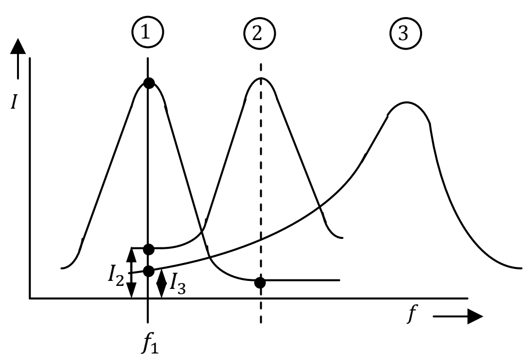
$$\boxed{f_0 = \frac{1}{2\pi\sqrt{LC}}}$$



b-2) When $f_0 = \frac{1}{2\pi\sqrt{LC}}$

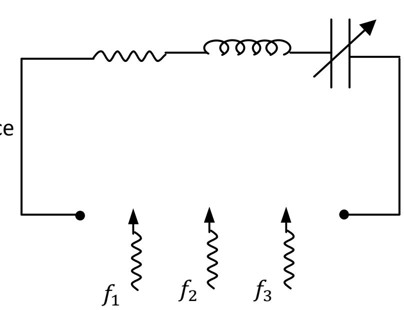
current is maximum.

b-3) Three station frequency is fed in transistor circuit.
Sharpness of resonance curve should be high



I_2 and I_3 are currents due to station 2 and 3 when station 1 is tuned at frequency f_1

Sharpness of resonance curve should be high



Q10. a) Prove Energy stored in an inductor is $\frac{1}{2}.L.I^2$?

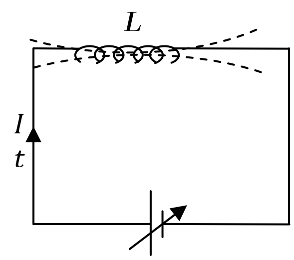
b) Prove Energy density in magnetic field is $\frac{1}{2}.\mu.H^2$?

Ans.a) Energy is stored in an inductor in form of magnetic field.

When current increases from I to I + dI, flux linking increase.

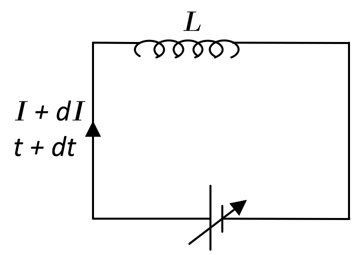
Rate of change of flux causes an emf e as shown in diagram.

Battery does work against e and energy supplied by battery gets stored in inductor in form of magnetic field.



$$dw = e\,dq$$
$$= e\,Idt$$
$$w = \int e\,I\,dt$$
$$= \int L\,\frac{dI}{dt}.\,I.\,dt$$
$$= L\int I\,dI$$
$$= L\left|\frac{I^2}{2}\right|_0^{I_0}$$

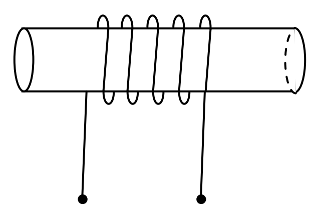
$|e| = L\,\frac{dI}{dt}$



Energy stored $= \frac{L}{2}I_0^2$

Energy stored $= \frac{1}{2}LI_0^2$

b) Energy Density:



$$\text{Energy Density} = \frac{Energy}{Volume}$$
$$= \frac{\frac{1}{2}.L.I^2}{A.l}$$
$$= \frac{1}{2}.\frac{\frac{N^2}{R_e}.\,I^2}{A.l}$$

(Where $R_e = \frac{l}{\mu.A}$ is reluctance of magnetic material)

$$= \frac{1}{2}.\frac{N^2}{R_e}.\frac{I^2}{A.l}$$
$$= \frac{1}{2}.\frac{N^2}{\frac{l}{\mu.A}}.\frac{I^2}{A.l}$$
$$= \frac{1}{2}.\mu.\left(\frac{N.I}{l}\right)^2$$

Energy Density	$= \frac{1}{2}.\mu.H^2$
OR	$\frac{1}{2}.\frac{B^2}{\mu}$

Q11. Find Power associated with a "*Resistor*" in a.c. ?

Ans. dE $= vi.dt$

E $= \int vi.dt$

$= \int V_m \sin wt \,.\, I_m \sin wt \; dt$

$= V_m I_m \int sin^2\, wt.dt$

$= V_m I_m \int \frac{1-\cos 2wt}{2}.dt$

$= \frac{V_m I_m}{2}\left[t - \frac{sin2\,wt}{2w}\right]_{t=o}^{t=T}$

$= \frac{V_m I_m}{2}\left[\left(T - \frac{sin2\,wT}{2W}\right) - \left(0 - \frac{sin2\,w(0)}{2w}\right)\right]$

$= \frac{V_m I_m}{2}\left[\left(T - \frac{sin2\frac{(2\pi)}{T}(T)}{2\frac{(2\pi)}{T}}\right)\right]$

$= \frac{V_m I_m}{2}\left[\left(T - \frac{sin\,4\pi}{\frac{4\pi}{T}}\right)\right]$

E $= \frac{V_m I_m}{2}$ T

P $= \frac{E}{T}$ $= \frac{V_m I_m \cancel{T}}{2\cancel{T}}$ $= \frac{V_m}{\sqrt{2}} \cdot \frac{I_m}{\sqrt{2}}$

P	$= V_{rms}\, I_{rms}$

Fig. I
(Circuit)

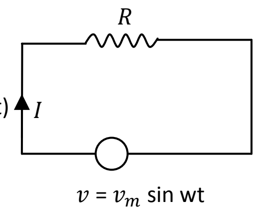


Fig. II
(Voltage wave form)

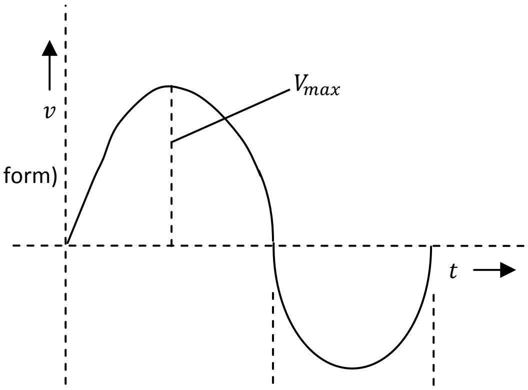
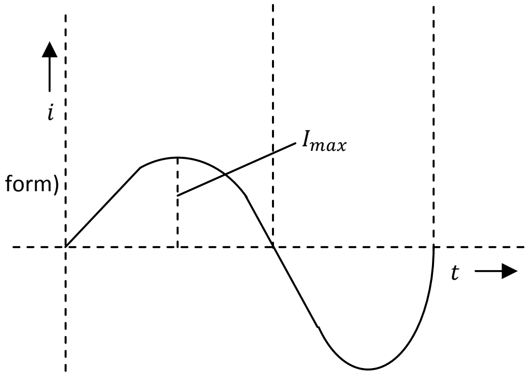


Fig. III
(Current wave form)



Problem: A voltage of 220 volt (A.C) is applied across a resister of value 100Ω. Find reading of watt meter connected in the circuit.

Q12. Find Power associated with an "*Inductor*" in a.c.?

Ans.

$$dE = vi.dt$$

$$E = \int vi.dt$$

$$= \int V_m \sin wt . I_m \sin\left(wt - \frac{\pi}{2}\right) dt$$

$$= V_m I_m \int \sin wt \sin\left(wt - \frac{\pi}{2}\right) dt$$

$$= V_m I_m \int -\sin wt \cos wt . dt$$

$$= \frac{V_m I_m}{2} \int_0^T -\sin 2wt. dt$$

$$= \frac{V_m I_m}{2} \left[\frac{\cos 2wt}{2w}\right]_{t=o}^{t=T}$$

$$= \frac{V_m I_m}{2} \left[\left(\frac{\cos 2wt}{2w}\right) - \left(\frac{\cos 2w(0)}{2w}\right)\right]$$

$$= \frac{V_m I_m}{2} \left[\left(\frac{\cos 2\frac{(2\pi)}{T}(T)}{2\frac{(2\pi)}{T}} - \frac{\cos 0}{\frac{2.2\pi}{T}}\right)\right]$$

$$= \frac{V_m I_m}{2} \left[\left(\frac{\cos 4\pi}{\frac{4\pi}{T}} - 1\right)\right]$$

$$E = \frac{V_m I_m}{2} \left[\frac{1}{\frac{4\pi}{T}} - \frac{1}{\frac{4\pi}{T}}\right]$$

$$= 0$$

$$E = 0$$

$$\boxed{P = 0}$$

Fig. I Circuit

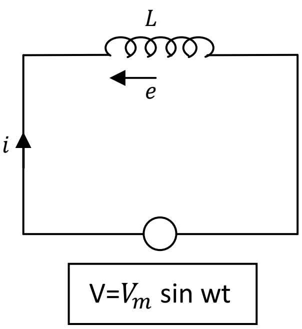
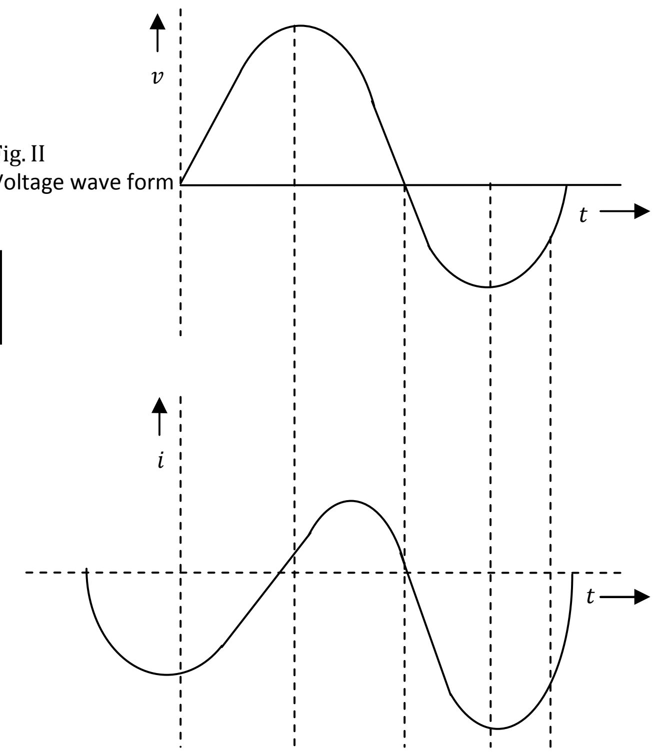
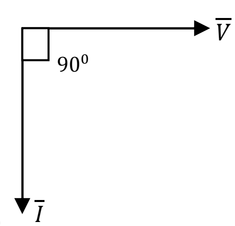


Fig. II Voltage wave form





<u>Problem</u>: A voltage of 220 volt (A.C) is applied across an inductor of value 5mH. Find reading of watt meter connected in the circuit.

Q13. Find Power associated with a "*Capacitor*" in a.c. ?

Ans.

$$dE = vi.dt$$

$$E = \int vi.dt$$

$$= \int V_m \sin wt \,.\, I_m \sin\left(wt + \frac{\pi}{2}\right) dt$$

$$= V_m I_m \int sin\ wt \,.\cos wt \,.dt$$

$$= \frac{V_m I_m}{2} \int_0^T sin\ 2wt.\ dt$$

$$= \frac{V_m I_m}{2} \left[\frac{cos2\ wt}{2w}\right]_o^T$$

$$= \frac{V_m I_m}{2} \left[\left(\frac{cos2\ wt}{2w}\right) - \left(\frac{cos2\ w(0)}{2w}\right)\right]$$

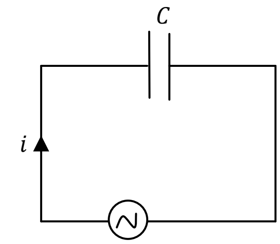
$$= \frac{V_m I_m}{2} \left[\left(\frac{cos2\ \frac{(2\pi)}{T}(T)}{2w} - \frac{cos0}{2w}\right)\right]$$

$$= 0$$

$$E = 0$$

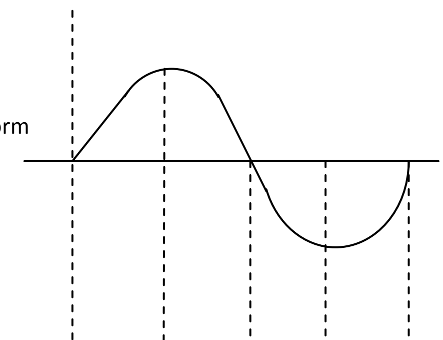
P	= 0

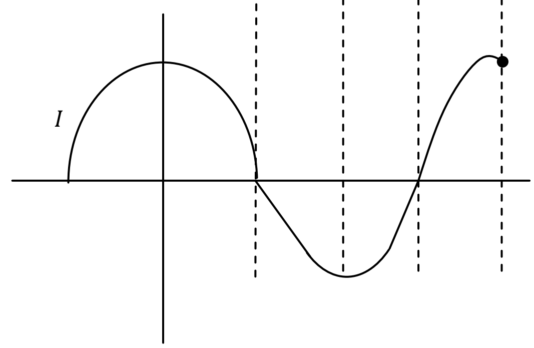
Fig. I
Circuit

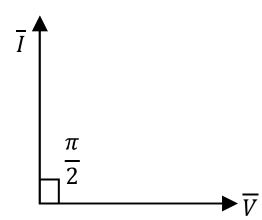


$v = V_m \sin \omega t$

Fig. II
Voltage wave form



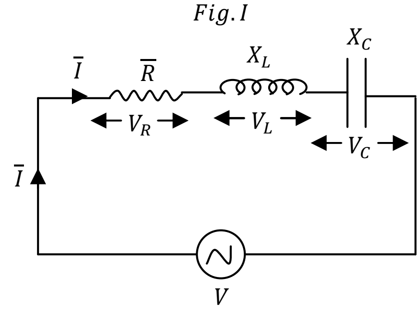




<u>Problem</u>: A voltage of 220 volt (A.C) is applied across a capacitor of value $12\mu F$. Find reading of watt meter connected in the circuit.

Q14. Prove P = V_{rms} I_{rms} cos ϕ, where ϕ is phase difference between voltage and current?

Fig. I



Ans. dE $= vi.dt$

E $= \int vi.dt$

$= \int V_m \sin wt \,.\, I_m \sin(wt - \Phi).dt$

$= V_m\, I_m \int \sin wt \,.\, \sin(wt - \Phi).dt$

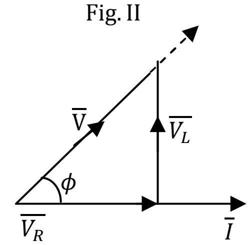
$= V_m\, I_m\, [(\sin wt)\,.\, \sin(wt - \Phi).dt]$

$= V_m\, I_m\, [(\sin wt)\,.\,(\sin wt\, cos\Phi - \cos wt\, sin\Phi]\text{dt}$

$= V_m\, I_m\, [sin^2 wt\, cos\Phi\, dt - sinwt\, costwt\, sin\Phi]$

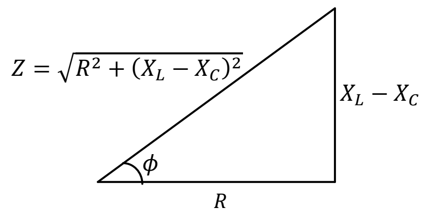
$= V_m\, I_m \left[(cos\Phi).\ \frac{T}{2} - 0\right]$

Fig. II



$E/_T$ $= V_m\, I_m \left[cos\Phi\ \frac{1}{2}\right]$

$= \frac{V_m}{\sqrt{2}} . \frac{I_m}{\sqrt{2}} [cos\Phi\,]$



P	**$= V_{rms}\, I_{rms}\, cos\Phi$**

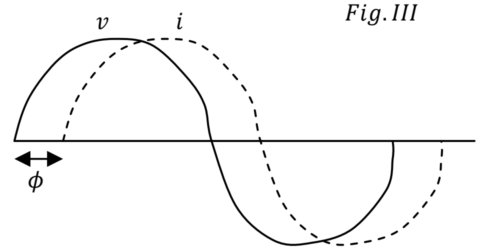
- Power factor of an A.C circuit

Power factor $= \frac{true\ power}{average\ power}$

$= cos\Phi$

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

Fig. III



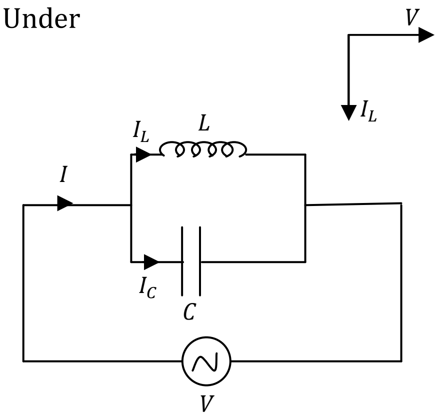
Power factor $= cos\Phi$

$= \frac{R}{Z} = \frac{Resistance}{Impedance}$

Therefore, current through pure L or pure C, which consumes no power for its maintenance in the circuit is called idle current or wattles current.

Q15. What is an L-C oscillator? Derive expression for resonant frequency of L-C oscillator?

Ans. L-C Oscillator is a parallel combination of L and C as shown in the Fig. Energy is stored in L in form of magnetic field. Energy is stored in C in form of Electric Field. Energy keeps on oscillating from magnetic to electric and vice versa. Under resonant conditions I is zero and $|\bar{I}_L| = |\bar{I}_C|$.



When $|\bar{I}_L| = |\bar{I}_C|$

$\bar{I} = \bar{I}_L + \bar{I}_C$

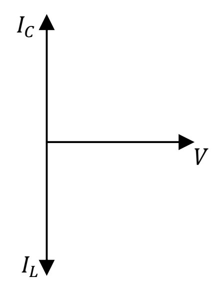
$= 0$

$$\bar{I} = \bar{I}_L + \bar{I}_C$$

$|I_L| = |I_C|$

$X_L = X_C$

Phasor diagram



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

$\omega^2 = \frac{1}{LC}$

$\omega = \frac{1}{\sqrt{LC}}$

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

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

Q16. What do you mean by Quantity factor of a circuit? Explain.

Ans. The characteristic of series resonant circuit is determined by the Q factor or quality factor of the circuit. It defines the sharpness of tuning at resonance.

$$Q = \frac{voltage\ across\ L\ or\ C}{applied\ voltage\ (voltage\ across\ R)}$$

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

The difference w_2 - w_1 = $2\Delta w$ is called the band width of the circuit. It defines sharpness of tuning at resonance.

The values of Q usually vary from 10 to 100.

Q17. Discuss Construction, Working and Efficiency of a transformer.

Ans. Transformer is a device used to change A.c. voltage level/current.

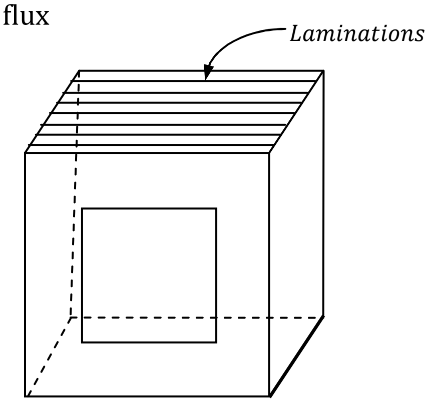
Core is made up of soft iron laminations.

μ_r = 1000 or more

Core is in form of laminations to decrease eddy current losses/heating. Input is given to primary winding. Load is connected across secondary winding.

Number of turns of primary (N_1) can be less than, equal to, greater than number of turns of secondary (N_2).

Thickness of wires depends on current to be carried Primary and Secondary are co-axial for practical purpose, i.e. flux linking is max.



Core diagram

Working

(i) $\frac{emf}{turn} = \frac{d(flux)}{dt}$ is same for all turns.

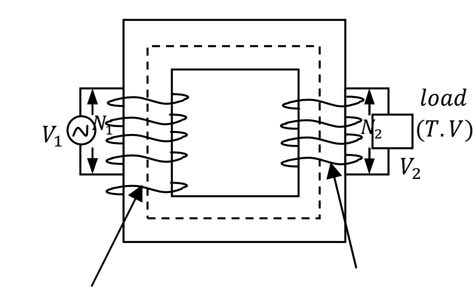
$$\boxed{\frac{V_1}{N_1} = \frac{V_2}{N_2}} \quad \text{———} (1)$$

(2) Law of conservation of energy (Assumption): No losses in transformer

Input Energy = Output Energy

$$V_1 . I_1 = V_2 . I_2$$

$$\boxed{\frac{V_1}{V_2} = \frac{I_2}{I_1}} \quad \text{———} (2)$$



From (1) and (2)

$$\boxed{\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}}$$

(3) Efficiency, $\eta = \frac{output}{input} = \frac{V_2 . I_2}{V_1 . I_1}$

(Output = Input - Losses)

Q18. Discuss Construction, Working of A.C. Generator.

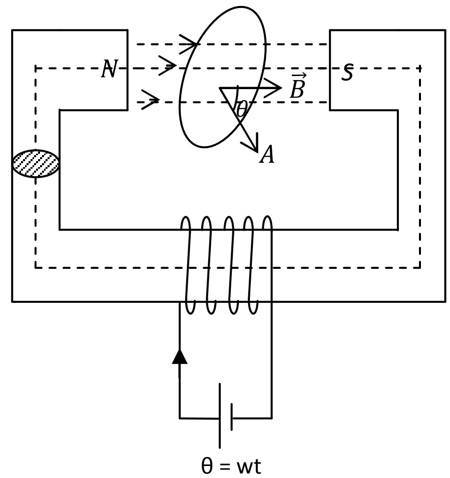
Ans. $\phi = BA\cos\theta$

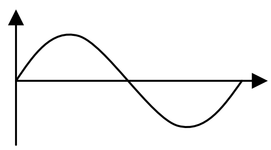
$|e| = \frac{d\phi}{dt} = \frac{d}{dt}(BA\cos\theta)$

$= BA\frac{d}{dt}(\cos\theta) \quad (\theta = w.t.)$

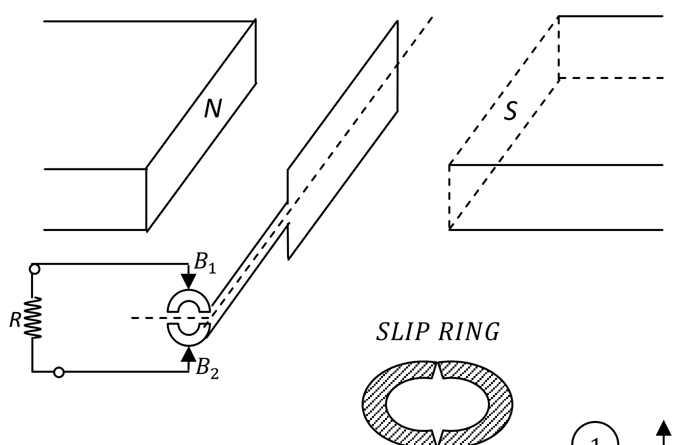
$= (BA\,W)\sin wt$

$$\boxed{e = e_{max}\sin wt}$$





DC Generator



2-D view