Ohms Law

21.8.18

This law gives relationship betn potential diff (V), ct (I) & resistance (R) of a d.c. ckt. In 1827 Dr Ohm has invented this relation, which is called as Ohm's Law.

" The ct flowing through an elect. ckt is directly proportional to p.d. a/c the ckt & inversely proportional to resistance of the ckt".

Mathematically, $I \propto \frac{V}{R}$, $I = \frac{V}{R}$

Ohm's law can be applied either to the entire ckt or to the part of the ckt.

Limitations —

1) It is not applicable to non linear devices such as diodes, zener diode, vg regulators etc

2) It is not applicable to non-metallic conductors ie semiconductors such as SiC.

Series & Parallel ckts

Characteristics of each,

Comparison

Ex ① Resistance of two wires is 25Ω when connected in series & 6Ω when connected in parallel. Calculate the resistance of two wires.

Sol^n Let R_1 & R_2 be the two unknown resistances

Then, when in series $R_1 + R_2 = 25$ —(1) or $R_2 = 25 - R_1$

& when in parallel $1/R_1 + 1/R_2 = 1/6$ or $6 = R_1R_2/(R_1+R_2)$ —(2)

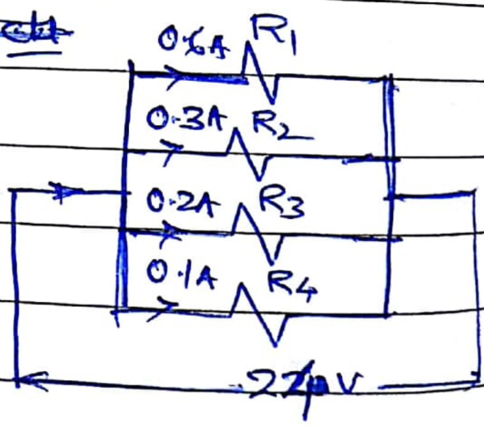
Substituting the value of R_2 in eq^2 R_1, we have

$$6 = \frac{R_1 \times (25 - R_1)}{\cancel{R_1} + 25 - \cancel{R_1}} \implies R_1^2 - 25R_1 + 150 = 0$$

or $(R_1 - 15)(R_1 - 10) = 0$.

∴ If $R_1 = 15\Omega$ then $R_2 = 10\Omega$ or $R_1 = 10\Omega$, $R_2 = 15\Omega$.

Ex ② The equivalent resistance of four resistors joined in parallel is 20Ω. The cts flowing through them are 0.6, 0.3, 0.2 & 0.1 A. Find the value of each resistor ~~when 220V is applied to the ckt~~



Sol^n Total current in the ckt is

$I_1 = 0.6 + 0.3 + 0.2 + 0.1$

$= 1.2\,A$

Voltage applied a/c the resistors

$= 20 \times 1.2 = 24\,V$.

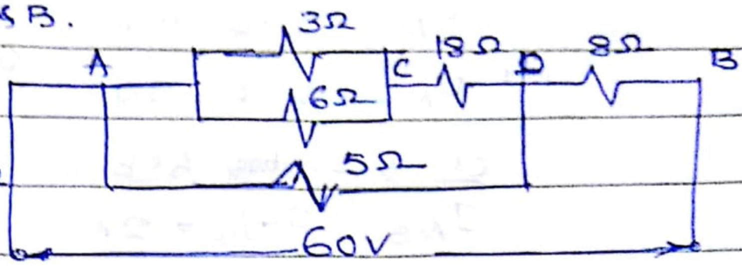
∴ $R_1 = 24/0.6 = 40\Omega$

$R_2 = 24/0.3 = 80\Omega$

$R_3 = 24/0.2 = 120\Omega$

$R_4 = 24/0.1 = 240\Omega$

Ex (3) Calculate the effective resistance of the combination of resistances shown & the vg. drop a/c each resistance when a p.d. of 60V is applied between points A & B.



Sol^n : Resistance bet^n A & C

$$R_{AC} = \frac{3\times6}{3+6} = \frac{18}{9} = 2\Omega$$

Resistance bet^n A & D

~~$R_{AD} = 2+18 = 20\Omega$~~

$$R_{AD} = \frac{20\times5}{20+5} = \frac{100}{25} = 4\Omega$$

∴ Resistance bet^n A & B

$$R_{AB} = 4+8 = 12\Omega$$

Now, Total ckt ct $= I = \frac{60}{12} = 5A$

ct through 5Ω $I_{5\Omega} = 5 \times 20/25 = 4A$

∴ ct through AD Branch $= 5-4 = 1A$

Now ct through 3Ω $= I_{3\Omega} = 1 \times 6/9 = 0.67A$

∴ — " — 6Ω $= I_{6\Omega} = 0.33A$

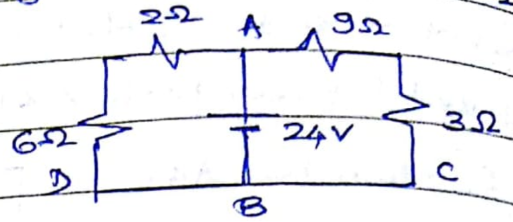
Now vg a/c 3Ω $= 3\times0.67 = 2V$ = vg a/c 6Ω resistor.

vg a/c 18Ω $V_{18} = 18\times1 = 18V$

vg a/c 5Ω $V_5 = 5\times4 = 20V$

vg a/c 8Ω $V_8 = 8\times5 = 40V$.

Assgn
Ex (4) In the ckt shown, find the vg a/c & ct in each resistor



Soln: 9Ω & 3Ω are in series

$\therefore R_{ACB} = 9+3 = 12\Omega$

lly $R_{ADB} = 2+6 = 8\Omega$

$\therefore$ Ct in section ACB is

$I_{ACB} = 24/12 = 2A$

& ct in section ADB is

$I_{ADB} = 24/8 = 3A$

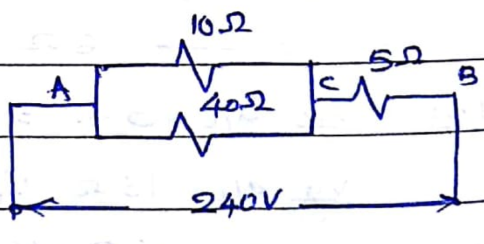
$\therefore$ vg a/c 9Ω $V_9 = 9\times2 = 18V$ $\quad V_2 = 2\times3 = 6V$

lly $V_3 = 3\times2 = 6V$ $\quad V_6 = 6\times3 = 18V$

Assignments:

1) Two resistances of 10 Ω & 40Ω respectively are connected in parallel. A third resistance of 5Ω is connected in series with the combination & a dc supply of 240V is applied to the ends of the complete ckt. Calculate (i) Ct in each resistance, (ii) what power would be spent in a fourth resistor of 20Ω connected in parallel with the 5Ω resistance.

Soln: $R_{AC} = \frac{10\times40}{50} = 8\Omega$



$R_{AB} = 8+5 = 13\Omega$

Total ct in the ckt $I = \frac{240}{13} = 18.46A$

Ct in 10Ω resistor $I_{10} = 18.46\times 40/50 = 14.77A$

$\therefore$ Ct in 40Ω — " — $I_{40} = 18.46 - 14.77 = 3.7A$

— " — 5Ω — " — $I_5 = 18.46A$.

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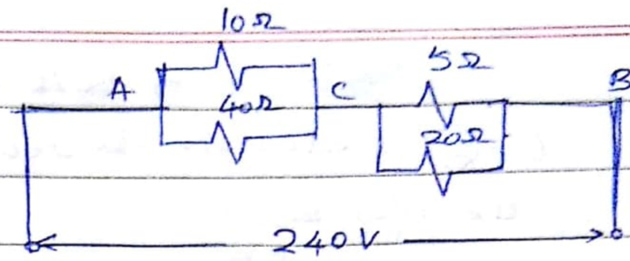

$R_{AC} = 8\Omega$

$R_{CB} = \frac{5 \times 20}{25} = 4\Omega$

$\therefore R_{AB} = 12\Omega$

$I_T = \frac{240}{12} = 20A$

$I_{10} = \overset{4}{\cancel{20}} \times \frac{4\cancel{0}}{5\cancel{0}} = 16A \quad \therefore I_{40} = 4A$

$I_{20} = 20 \times \frac{5}{25} = 4A \quad \therefore P = I^2R = 16 \times 20 = \underline{320W}$

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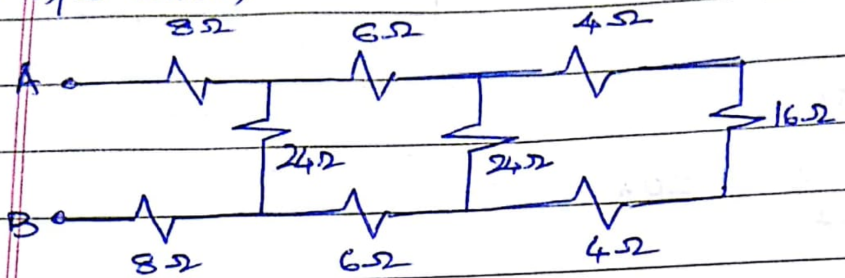
Problems on KVL :

Ex (6) Calculate the equivalant resistance a/c the ~~supply~~ terminals in the n/w shown



Soln : Resistances 4Ω, 16Ω & 4Ω are in series ∴

$\therefore R_{1eq} = 4+16+4 = 24\Omega$

R_{1eq} is in parallel with 24Ω resistor

$\therefore R_{2eq} = \frac{24\times24}{48} = 12\Omega$

Now R_{2eq}, 6Ω & 6Ω are in series

$\therefore R_{3eq} = 6+12+6 = 24\Omega$

R_{3eq} & 24Ω are in parallel

$\therefore R_{4eq} = \frac{24\times24}{48} = 12\Omega$

Now R_{4eq}, 8Ω & 8Ω are in series

$\therefore R_{eq} = 8+12+8 = 28\Omega$

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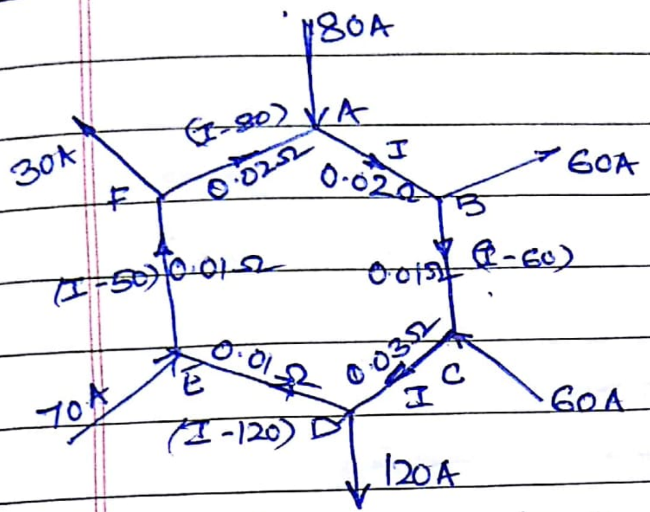
Problems on KVL :

Ex ① Find the ct in all the branches of the n/w shown



Let ct through AB be I Amps.
Applying KCL at various nodes, we can calculate branch cts

Applying KVL to the loop ABCDEFA

$-I \times 0.02 - (I-60)\times 0.01 - I \times 0.03 - (I-120)\times 0.01 - (I-50)\times 0.01 - (I-80)0.02 = 0$

$-0.02I - 0.01I + 0.6 - 0.03I - 0.01I + 1.2 - 0.01I + 0.5 - 0.02I + 1.6 = 0$

$0.1I = 3.9$

$\therefore I = 39A$

Now various branch cts are

AB	39 A
BC	−21 A
CD	39 A
DE	−81 A
EF	−11 A
FA	−41 A

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Power & Energy —

Power (P) is the rate of doing work or work done per unit time $P = \frac{VIt}{t} = V \times I$ watts $= V^2/R$ or I^2R.

One watt may be defined as the rate of doing one joule/sec

Practical units of Power $KW = 10^3 W$ or $MW = 10^6 W$.

Energy —

Total work done over a time is energy

$$E = P \times t = V \times I \times t \text{ W-sec}$$

Practical unit is kWh.

$$1 \text{ Wh} = 1 \text{ J/s} \times 3600 \text{ s} = 3600 \text{ J}$$

$$1 \text{ kWh} = 3600 \times 1000 = 36 \times 10^5 \text{ J}$$

Electricity bill is based on the no of kWh consumed.

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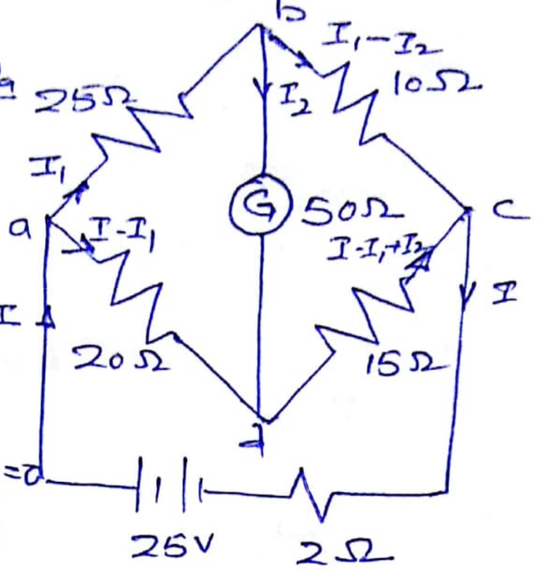
Problems on KVL 26.8.18

Ex: Using Kirchhoff's laws, find the ct flowing through the galvanometer G in the Wheatstone bridge n/w shown



Sol^n Applying KVL to loop abda

$$-25I_1 - 50I_2 + 20(I - I_1) = 0$$

$$-45I_1 - 50I_2 + 20I = 0 \quad -(1)$$

bcdb

$$-10(I_1 - I_2) + 15(I - I_1 + I_2) + 50I_2 = 0$$

$$-25I_1 + 75I_2 + 15I = 0 \quad -(2)$$

adca

$$-20(I - I_1) - 15(I - I_1 + I_2) - 2I + 25 = 0$$

$$+35I_1 - 15I_2 - 37I + 25 = 0 \quad -(3)$$

or $35I_1 - 15I_2 - 37I = -25 \quad -(3)$

Applying Cramers rule

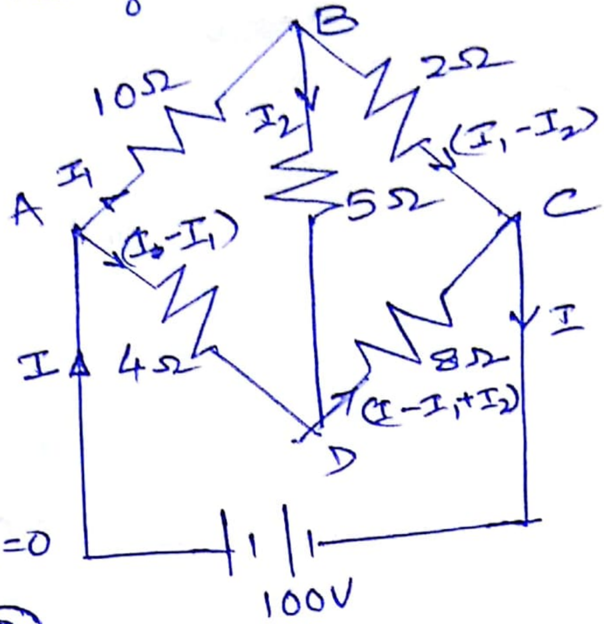
$$D = \begin{vmatrix} -45 & -50 & 20 \\ -25 & 75 & 15 \\ 35 & -15 & -37 \end{vmatrix} = \cancel{1,14750} \; 89750$$

Now we want ct through galvanometer ie I_2, so calculate D_2 only as I_2 is 2nd variable in the eq^ns.

$$D_2 = \begin{vmatrix} -45 & 0 & 20 \\ -25 & 0 & 15 \\ 35 & -25 & -37 \end{vmatrix} = \cancel{-16875} \; -4375$$

$$\therefore I_2 = \frac{D_2}{D} = \cancel{-0.1884} \; -0.0487A$$

Ex: A Wheatstone bridge ABCD is arranged as follows: Resistances bet^n AB, BC, CD, DA & BD are 10, 2, 8, 4 & 5 Ω resp. A 100V supply is connected bet^n terminals A & C. Det. cts in branches AB & AD of the ckt & total ct taken from the supply.



Sol^n Applying KVL to

ABDA

$$-10I_1 - 5I_2 + 4(I-I_1) = 0$$

$$-14I_1 - 5I_2 + 4I = 0 \quad -(1)$$

BCDB

$$-2(I_1 - I_2) + 8(I - I_1 + I_2) + 5I_2 = 0$$

$$-10I_1 + 15I_2 + 8I = 0 \quad -(2)$$

ADCA

$$-4(I - I_1) - 8(I - I_1 + I_2) + 100 = 0$$

$$12I_1 - 8I_2 - 12I = -100 \quad -(3)$$

$$D = \begin{vmatrix} -14 & -5 & 4 \\ -10 & 15 & 8 \\ 12 & -8 & -12 \end{vmatrix} = 1624 + 120 - 400 = 1344$$

$$D_1 = \begin{vmatrix} 0 & -5 & 4 \\ 0 & 15 & 8 \\ -100 & -8 & -12 \end{vmatrix} = 4000 + 6000 = 10,000$$

$$I_1 = \frac{D_1}{D} = \cancel{0.1344} \; 7.44\,A$$

$$D_2 = \begin{vmatrix} -14 & 0 & 4 \\ -10 & 0 & 8 \\ 12 & -100 & -12 \end{vmatrix} = -11200 + 4000 = \cancel{80} -7200$$

$$\therefore I_2 = D_2/D = \cancel{0.6A} \; -5.35\,A$$

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Total ct

$$D_3 = \begin{vmatrix} -14 & -5 & 0 \\ -10 & 15 & 0 \\ 12 & -8 & -100 \end{vmatrix} = 21{,}000 + \cancel{Z25}5000$$

$$= \cancel{20500}\ 26000$$

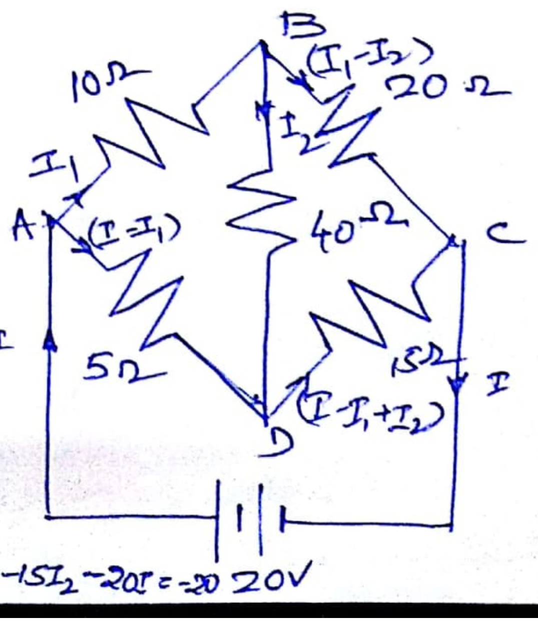
$$\therefore I = \frac{D_3}{D} = \cancel{15.08A}\ 19.34A$$

$\therefore$

Branch	Current
AB	$I_1 = 7.44A$
BC	$I_1 - I_2 = 12.79A$
CD	$I - I_1 + I_2 = 6.55A$
DA	$I - I_1 = 11.9A$
CA	$I = 19.34A$
BD	$I_2 = -5.35A$

Assign

① A Wheatstone bridge is arranged as follows: resistances between AB, BC, CD, DA & BD are 10, 20, 15, 5 & 40Ω resp. A 20V battery of negligible ~~battery~~ internal resistance is connected bet^n A & C. Determine ct in each resistor.



Sol^n Applying KVL to

ABDA

$-10I_1 - 40I_2 + 5(I - I_1) = 0$

$-15I_1 - 40I_2 + 5I = 0$ —①

BCDB

$-20(I_1 - I_2) + 15(I - I_1 + I_2) + 40I_2 = 0$

$-35I_1 + 75I_2 + 15I = 0$ —②

ADCA

$-5(I - I_1) - 15(I - I_1 + I_2) + 20 = 0$ / $20I_1 - 15I_2 - 20I = -20$

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+19125

$\cancel{4125}$ $\quad$ -4875

$\cancel{25875} + 16,000 - \cancel{1025}$

$$D = \begin{vmatrix} -15 & -40 & 5 \\ -35 & 75 & 15 \\ 20 & -15 & -20 \end{vmatrix} = \cancel{31750}\ \cancel{18250}\ 30250$$

$$D_1 = \begin{vmatrix} 0 & -40 & 5 \\ 0 & 75 & 15 \\ -20 & -15 & -20 \end{vmatrix} = +12,000 + 7500$$

$$= 19.500 \qquad I_1 = \frac{D_1}{D} = 0.644\ A$$

$$D_2 = \begin{vmatrix} -15 & 0 & 5 \\ -35 & 0 & 15 \\ 20 & -20 & -20 \end{vmatrix} = -4500 + \cancel{2000}\ 3500$$

$$= -\cancel{2500}\ 1000$$

$$\therefore I_2 = \cancel{0.078}\ -0.033\ A$$

$$D_3 = \begin{vmatrix} -15 & -40 & 0 \\ -35 & 75 & 0 \\ 20 & -15 & -20 \end{vmatrix} = 22500 + 28000 = 50,500$$

$$I = \frac{D_3}{D} = 1.67\ A$$

Branch	Current
AB	$I_1 = 0.644\ A$
BC	$I_1 - I_2 = 0.677\ A$
CD	$I - I_1 + I_2 = 1.06\ A$
DA	$I - I_1 = 1.026\ A$
BD	$I_2 = -0.033\ A$

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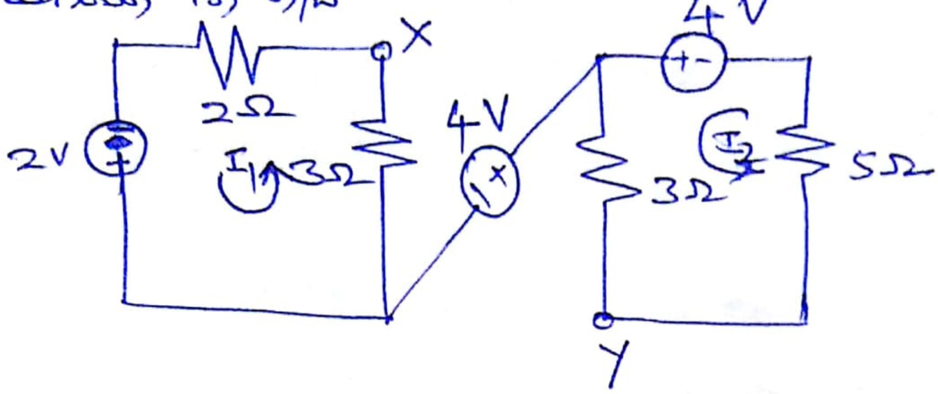
Ex Apply Kirchhoff's Laws to find p.d. betn x & y shown in fig



Soln $I_1 = 2/5 = 0.4\,A$

$I_2 = 4/8 = 0.5\,A$

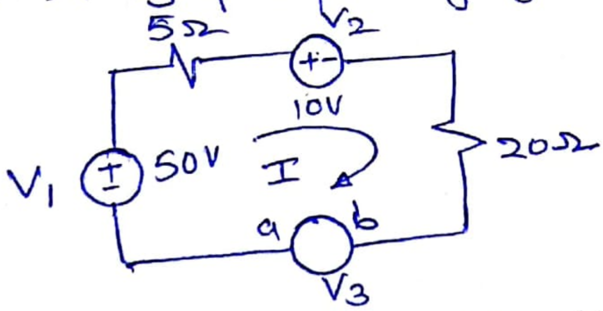
$V_4 = 1.2\,V \qquad V_3 = 1.5\,V$

0.000266
0.000004

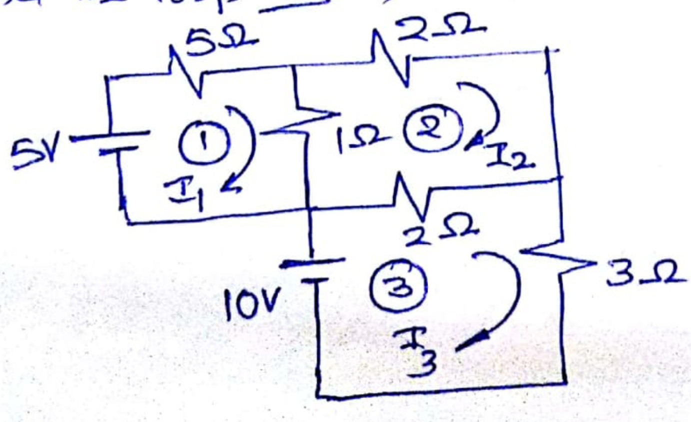
$V_{xy} = 1.2V + 4V - 1.5V$
$= 3.7V$

Assignment –

1) Find V_3 & its polarity if the ct I in the ckt shown is 0.4A



2) Find the loop cts in the ckt shown in fig.



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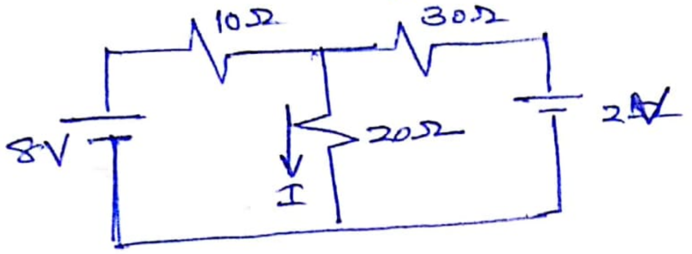
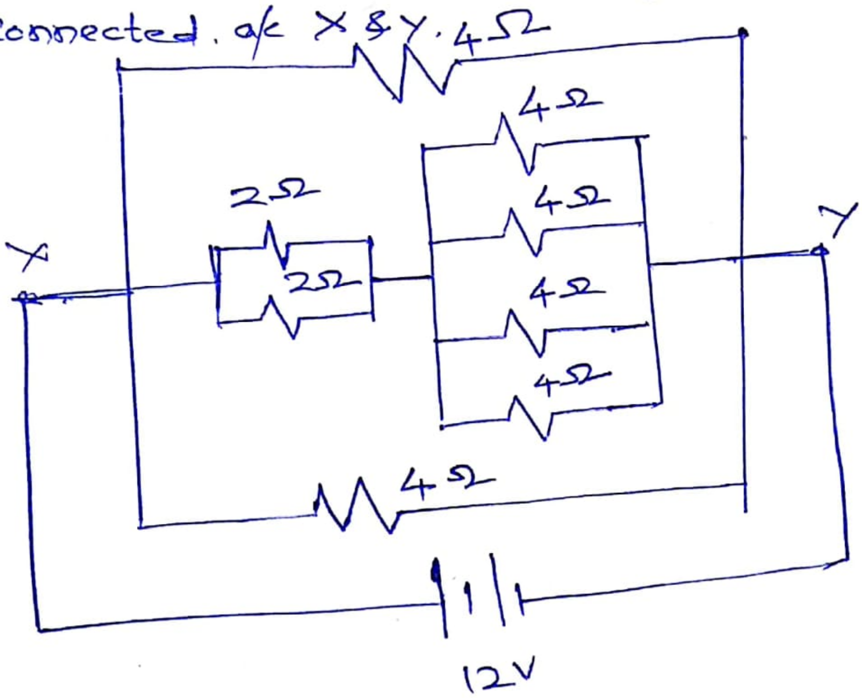
③ Find the ct through 20Ω in the ckt shown



$I = 0.249A$

④ Find the total resistance of the ckt a/c the terminals X & Y Also find the power consumed by the ckt if a 12V battery is connected a/c X & Y.



$R_{xy} = 1\Omega$

$I = 12A$

$P = 144W$

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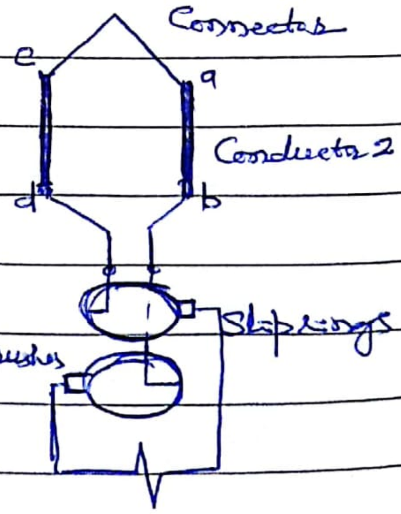
A C Fundamentals

Adv :- 1) The vg can be raised or lowered with the help of a device called transformer. In dc s/m, raising or lowering a vg is not so easy.
2) As the vg can be raised, electrical power trans^n at higher vg is possible. Now, higher the vg, lower is the ct flowing through the transmission line. Hence, losses are less & lesser conducting material is req. This makes ac trans^n economical & efficient.
3) AC motors are simple in construction, very robust, cheaper & require less or no maintenance.
4) Whenever required AC can be easily converted into DC.

Generation of AC Voltage -

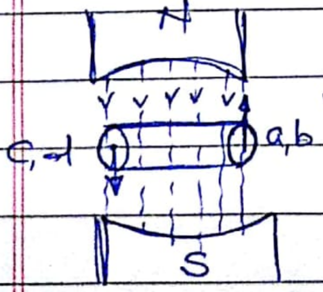
The m/cs which are used to generate elect. vgs are called generators. The generators which are used to generate ac vg are called as 'Alternators'.

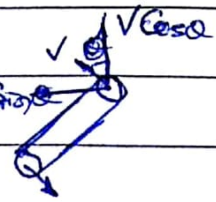
The basic principle of operation of an alternator is 'Electro-magnetic Induction'. It says, 'whenever there is a relative motion bet^n the conductor & magnetic field in which it is kept, an emf is induced in the conductor.'



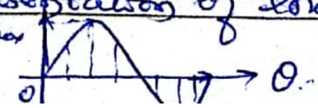
Construction :

Working -





Graphical Representation of Induced EMF



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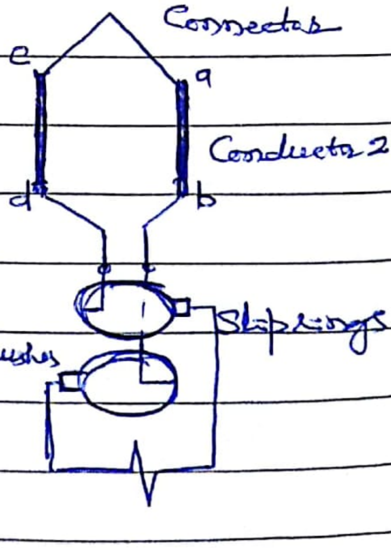
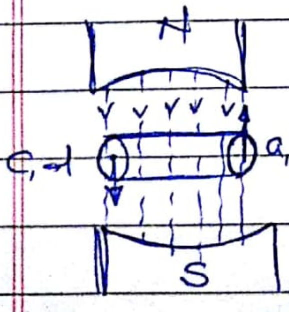
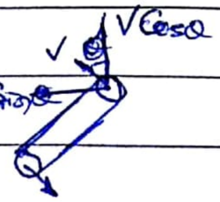


Construction :

Working –





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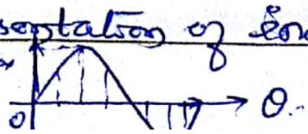

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Cycle – It is defined as a set of positive & negative instantaneous values of the alternating quantity.

Time period (T) — It is the time taken by an alternating quantity to complete its one cycle. Denoted by T & measured in secs.

Frequency – (f) — The no of cycles completed by an alternating quantity per sec is its freq. Denoted by f, & measured in cycles/sec or Hz

Equation of Generated EMF –

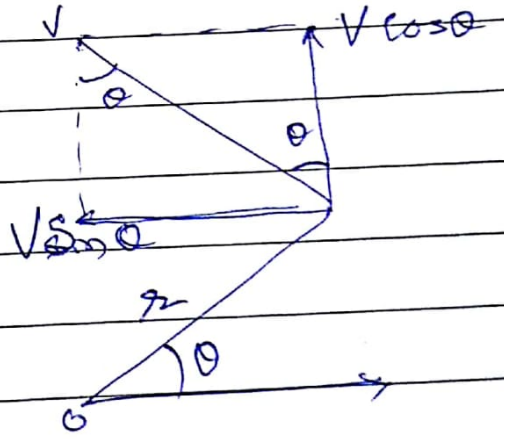
B - Flux density of mag. field in wb/m^2

l – Active length of each conductor in Mtrs

r – radius of circular path traced by conductor

ω – angular velocity in rad/sec

v – linear velocity in m/s.



Now $V = r\omega$.

According to Faraday's law

$e = Blv\sin\theta$

$e = E_m = Blv$ when $\theta = 90°$

$\therefore \quad e = E_m \sin\theta$

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Equation of an Alternating Quantity -

Let, B - flux density in wb/m^2

l - Active length of the conductor in mtrs

r - Radius of circular path traced by the cond^n in mtrs

ω - Angular velocity of coil in rad/sec

v - linear velocity in m/s

Now $v = r\omega$.

$\theta = \omega t$.

According to Faraday's Laws of electromagnetic induction,

$e = Blv \sin\theta$

When $\theta = 90°$ $\sin\theta = 1$

$\therefore$ Max. emf induced is $E_m = Blv$

Hence the instantaneous value of generated emf is

$e = E_m \sin\theta = E_m \sin\omega t$.

Ex: An alternating vg of time period 0.02 sec has max value of 12V. Write the eq^n for its instantaneous value. Calculate the inst. value of the vg after time 0.002 secs, where req. is taken from the inst. of zero vg. & is becoming +ve. Also, calculate the time req. for the vg to reach 4V for the first time.

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Soln- Given data: $T = 0.02$ sec $E_m = 12V$

WKT $e = E_m \sin \omega t = E_m \sin \frac{2\pi t}{T}$

$= 12 \sin(100\pi t) V$

at $t = 0.002$ sec, $e = 12 \sin(100 \times \pi \times 0.002)$

$= 7.053V$.

Now, the inst. value is $e = 4V$

$\therefore 4 = 12 \sin(100\pi t)$

$\sin(100\pi t) = 4/12$.

$\therefore t = 1.084 \times 10^{-3}$ secs.

Effective value: (RMS Value)

An alternating quantity varies from instant to instant, while the direct ct is const. w.r.t. time. So, for the comparison of two, there must be some common platform. Such platform can be the effect produced by the two cts. One of the such effects is the heating of resistance, du to ct passing through it.

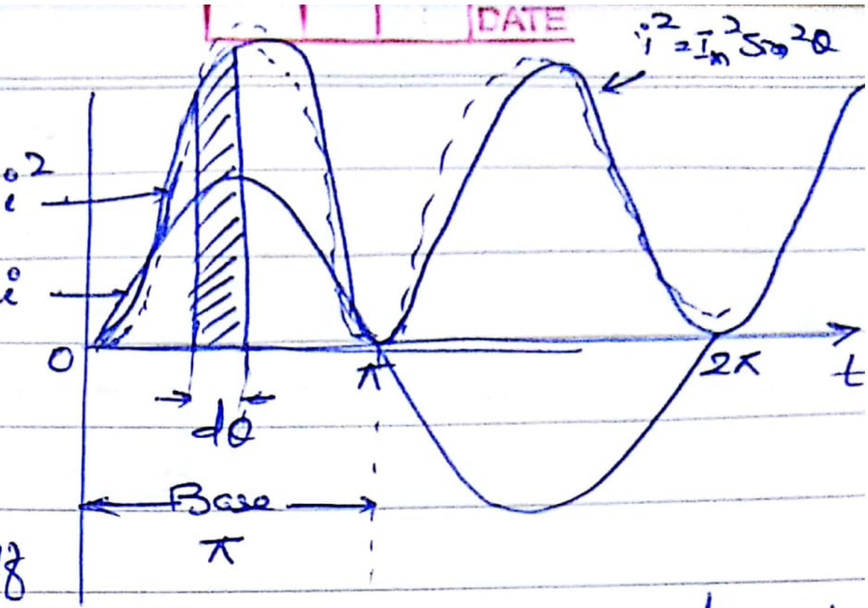
"The effective or rms value of an alternating ct is given by that steady ct (DC) which when flowing throug a given ckt for a given time, produces the same amount o heat as produced by the alternating ct, which when flow through the same ckt for the same time.

RMS Value –

Cs, sinusoidally varying alternating ct & square of this ct

ct $i = I_m \sin\theta$ while

$i^2 = I_m^2 \sin^2\theta$



Area of curve over a half cycle can be calculated by considering an interval $d\theta$ as shown.

Area of square curve over half cycle

$$= \int_0^\pi i^2 \, d\theta$$ & the length of the base is π

$\therefore$ Avg value of square of the ct over half cycle

$$= \frac{\text{Area of curve over half cycle}}{\text{Base over half cycle}} = \frac{\int_0^\pi i^2 \, d\theta}{\pi}$$

$$= \frac{1}{\pi} \int_0^\pi I_m^2 \sin^2\theta \, . \, d\theta = \frac{I_m^2}{\pi} \int_0^\pi \left[\frac{1 - \cos 2\theta}{2}\right] d\theta$$

$$= \frac{I_m^2}{2\pi} \left[\theta - \frac{\sin 2\theta}{2}\right]_0^\pi = \frac{I_m^2}{2\pi} (\pi)$$

$$= \frac{I_m^2}{2}$$

$\therefore$ Root Mean Square Value can be calculated as

$$I_{rms} = \sqrt{\text{Avg. of square of ct}} = \sqrt{\frac{I_m^2}{2}} = \frac{I_m}{\sqrt{2}} =$$

$$\therefore I_{rms} = 0.707 \, I_m$$

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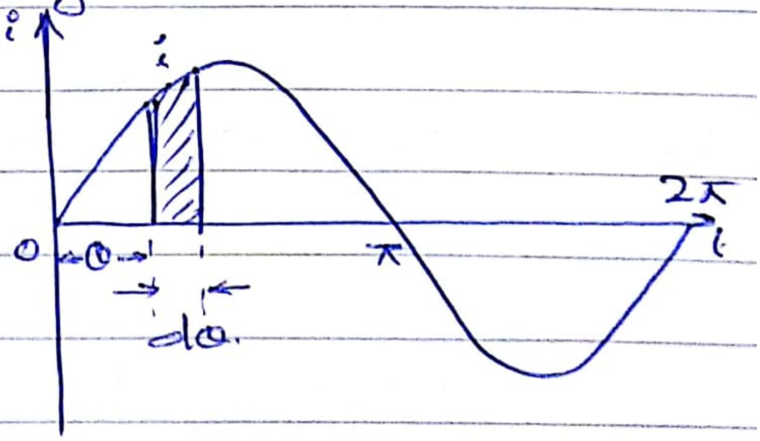
Importance of RMS Value –

1. In case of a.c. rms value specifies magnitudes of a.c
2. The ammeters, voltmeters record rms values of ct & vg.
3. The heat produced due to ac is proportional to square of the rms value of the ct.

2. Average Value –

It is defined as that value which is obtained by averaging all the instantaneous values over a period of half cycle

For an unsymmetrical ac, the avg value must be obtained for one complete cycle but for symmetrical ac, it is to be obtained for half cycle.



Cz, sinusoidally varying ct $i = I_m \sin\theta$

Cz, a small interval of $d\theta$

The avg inst. value of ct in this interval is say 'i'.

The avg value can be obtained by taking ratio of area under curve over half cycle to the base for half cycle

$$\therefore I_{av} = \frac{\text{Area under curve for half cycle}}{\text{Length of base over half cycle}}$$

$$= \frac{\int_0^{\pi} i \, d\theta}{\pi}$$

$$= \frac{1}{\pi}\int_0^{\pi} I_m \sin\theta \cdot d\theta = \frac{I_m}{\pi}(-\cos\theta)\Big|_0^{\pi}$$

$$= \frac{I_m}{\pi}\left[-\cos\pi + \cos 0\right]$$

$$= \frac{2I_m}{\pi}$$

$$\therefore I_{av} = 0.637 I_m$$

Importance of Avg. value –

1. The avg. value ~~is~~ indicates dc quantity.
2. The avg. values of vg & cts play an imp. role in analysis of the rectifier. ckts
3. The charge transferred in capacitor ckts is measured using avg. values.

Form Factor (Kf)

It is the ratio of rms value to the avg. value

$$K_f = \frac{\text{rms value}}{\text{avg value}} = \frac{0.707 I_m}{0.637 I_m} = 1.11$$

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Crest (Peak) Factor: (K_p)

It is the ratio of max. value to the rms value of a c quantity

$$K_p = \frac{I_m}{0.707 I_m} = 1.414.$$

Ex: An alternating vg has an effective value of 70.7106 V & freq. of 60 Hz. Find its avg value, form factor, crest factor assuming it to be purely sinusoidal.

Soln: Given data: $E_{rms} = 70.7106\text{ V}$, $f = 60\text{ Hz}$

$E_m = 1.414 \times 70.7106 = 100\text{ V}$ or $\sqrt{2}\, E_{rms} = 100\text{ V}$.

$E_{av} = 0.637 E_m = 63.7\text{ V}$

$K_f = \frac{70.7106}{63.7} = 1.11$ & $K_p = \frac{100}{70.7106} = 1.414$

Ex: An alternating ct of freq. 60 Hz has a max. value of 12 A. (i) Write the eqn for inst. values. (ii) Find the value of ct after 1/360 secs (iii) Time taken to reach 9.6 A for the first time.

In the above cases assume that time ref. is zero when ct wave is passing through zero & increasing in the +ve direction.

Soln: $f = 60\text{ Hz}$, $I_m = 12\text{ A}$ $\omega = 2\pi f = 377\text{ rad/sec}$

(i) $i = I_m \sin \omega t = 12 \sin 377t$

(ii) $t = 1/360$ $\therefore i = 12 \sin 377 \cdot 1/360 = 10.3924\text{ A}$

(iii) $i = 9.6\text{ A}$ $\therefore 9.6 = 12 \sin 377t$ $\therefore t = 2.459\text{ msec}$

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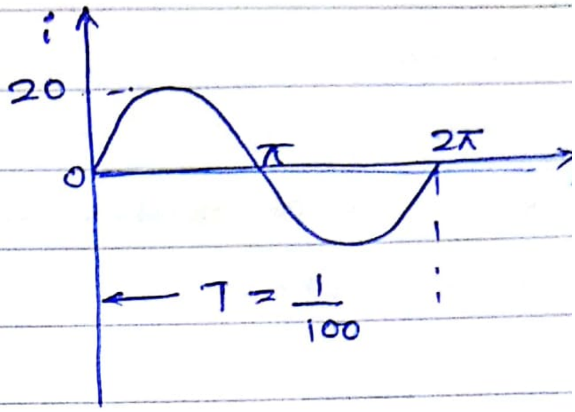
Ex: For the ct wave shown in fig. Find (i) Peak ct (ii) Avg value (iii) Freq. (iv) Periodic time. (v) Inst. value at ~~t=3s~~ t = 3 ms.



Sol^n Given data:

$I_m = 20A$

$T = 1/100$ sec

(i) Peak value $I_m = 20A$

(ii) Avg value $I_{avg} = 0.637 \times 20 = 12.73A$

(iii) Freq. $f = 1/T = 1/(1/100) = 100 Hz$

(iv) Periodic time $T = 1/100 = 0.01$ sec

(v) Inst. value at t = 3 ms $= I_m \sin \omega t$

$\therefore i = 20 \sin(2\pi f \times 3 \times 10^{-3})$

$= 19.02A.$

Ex: An alternating ct has an effective value of 200A. If its freq. is 25 Hz, find its avg. value. Write the expression for the ct

Phasor Representation of an Alternating Quantity –

In the analysis of ac ckts, it is very difficult to deal with ac quantities in terms of their waveforms & mathematical equ^s. ~~The~~ Adding, subtracting etc of the two alternating quantity is tedious & time consuming in terms of their Mathematical eq^s. Hence it is necessary to study a method which gives an easier way of representing an alternating quantity. Such a representation is called "Phasor Representation" of an alternating quantity.

In this method,
The sinusoidally varying alternating quantity can be represented graphically by a straight line with an arrow. The length of the line represents the magnitude of an alternating quantity & arrow indicates the direction. This is similar to vector representation. Such a line is called 'Phasor'.

['The phasors are assumed to be rotated in anticlockwise direction'.]

One complete cycle of a sine wave is represented by one complete rotation of phasor.

Cr, a phasor, rotating in anticlockwise direction, with uniform angular velocity, with its starting point 'a'. If we project this phasor on Y-axis ~~eg~~ & plot against the angle

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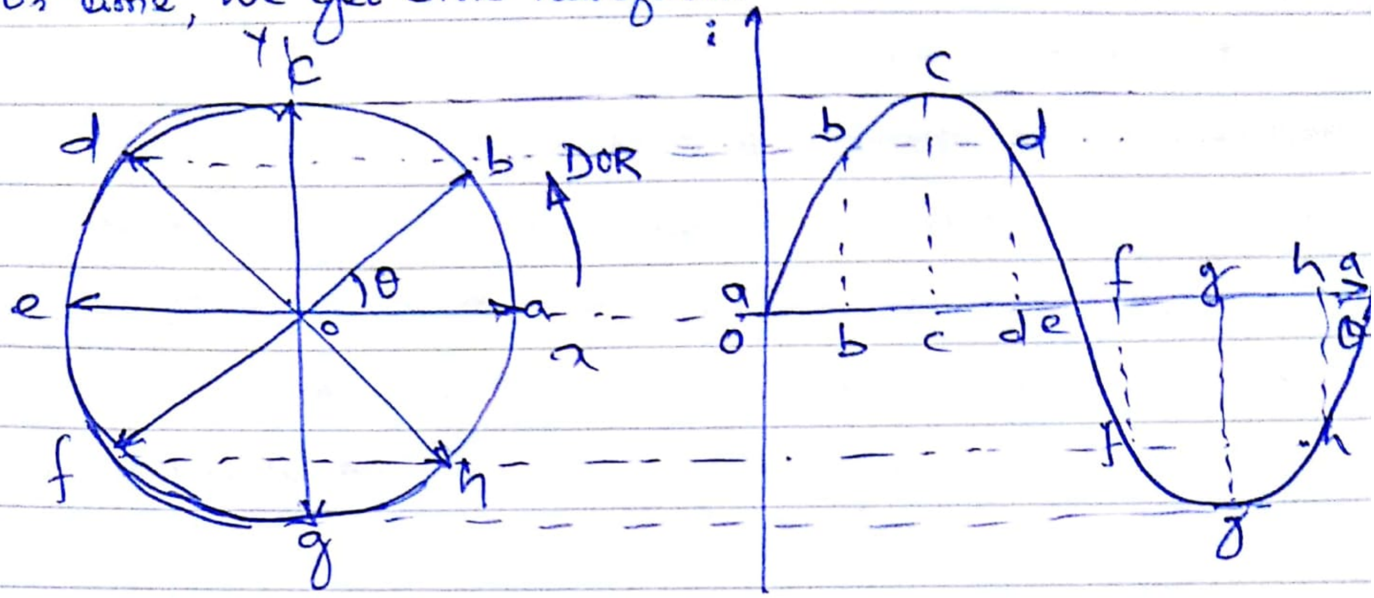
'θ' vs time, we get sine waveform.



Cs, various positions as shown,

1. At pt a, the Y-axis projection is zero. The inst. value of ct is also zero.
2. At pt b, the Y-axis projection is ob $\sin\theta = l \sin\theta$. The length of the phasor is equal to max. value of an alternating quantity. So, inst. value of ct at this position is $i = I_m \sin\theta$.
3. At pt. c, the Y-axis position is OC & it represents the entire length of the phasor ie the inst. value represents its max. value
4. At pt. d, Y-axis projection becomes $I_m \sin\theta$ which is the inst. value of ct at that inst.
5. At pt. 'e', the Y-axis projection is zero. & inst value of ct is also zero at this inst.
6. Similarly. at pts, f, g & h, the Y-axis projections give us inst. values of cts at resp. insts & when plotted give us -ve cycle of alternating quantity.

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Thus, if the length of the phasor is taken equal to the max. value of the alternating quantity, then its rotation in space at any inst. is such that the length of its projection on the Y-axis gives the inst. value of the alternating quantity at that particular inst. The angular velocity 'ω' of the phasor should be such that it completes one revolution in the same time as taken by the alternating quantity to complete one cycle.

ie $\theta = \omega t$, $\omega = 2\pi f$.

In practice, the alternating quantities are represented by their rms values. Hence, the length of the phasor represents rms value of the alternating quantity.

Phasors are always assumed to be rotated in anti-clockwise direction.

Two alternating quantities of same freq. can be represented on same phasor diagram.

If freq. of two alternating quantities are diff., then such quantities cannot be represented on the same phasor diagram.

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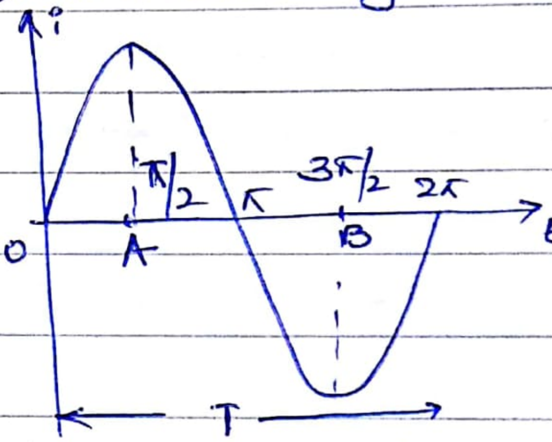
Phase –

An alternating quantity changes its magnitude & direction at every inst. So, it is necessary to know the cond^{n} of the alternating quantity at a particular instant. The location of the cond^{n} of the alternating quantity at any particular instant is called its phase.

Phase may be defined as '~~the alternating quantity at any particular~~ the fractional part of a period through which the quantity has advanced from the selected origin.

e.g.- phase of ct at pt. 'A' is $T/4$ sec, or $\pi/2$ rad.



Phase difference – (Lagging or Leading of Sinusoidal wave)

When two alternating quantities, say two vgs or two cts or one vg & one ct are considered simultaneously, the freq. being the same, they may not pass through a particular point at the same instant.

One may pass through a max. value at the instant when the other passes through a value other than its max. value. These two quantities are said to have a phase difference. Phase diff. is specified either in degrees or in radians.

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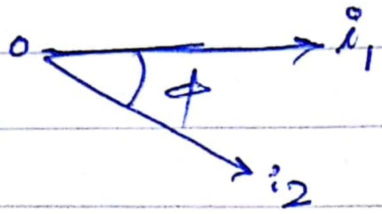

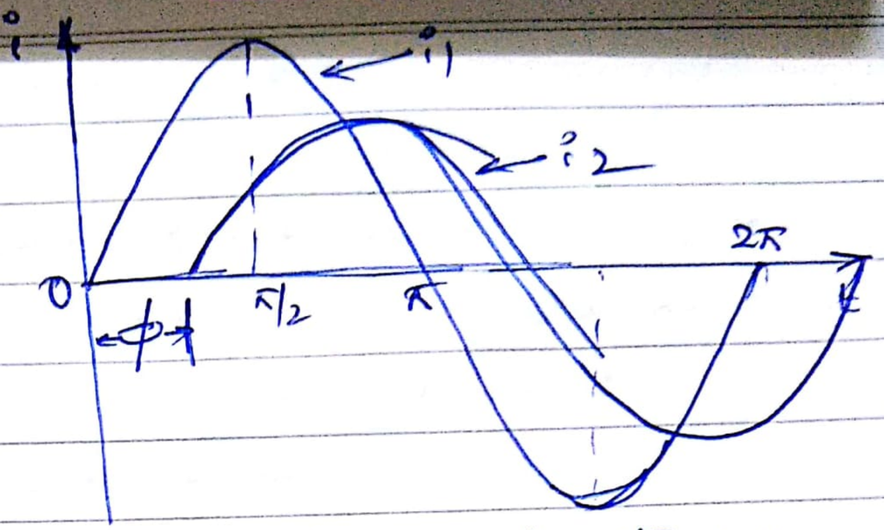

The quantity ahead in phase or which reaches its max. value first is said to lead the other quantity, whereas the other quantity is said to lag behind the first quantity.

If i_1 is taken as ref. then i_2 lags i_1 by an angle ϕ.

If i_2 is taken as ref. then i_1 leads i_2 by an angle ϕ.

$i_1 = I_{m1} \sin \omega t$, then $i_2 = I_{m2} \sin(\omega t - \phi)$

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