Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q .1) A) Attempt any SIX of the following: 12

a) Define potential difference and current.
(Definition of potential difference 1M, current 1M)

Ans.

Potential difference: The difference between the electrical potentials at any two given points in the electrical circuit is known as potential difference.

Current: The rate of flow of electric charge from a given conductor is called current.

b) State Kirchhoff's current law.
(Statement of Kirchhoff's current law 2M)

Ans. Kirchhoff's current law: In any electrical network, the algebraic sum of the currents meeting at a point (or junction) is zero.

$$\sum I = 0$$

c) Give expression of the following:
(i) Delta to star conversion of resistances.
(ii) Star to delta conversion of resistances.
(Each expression of 1M)

Ans.

(i) Delta to star conversion of resistances:

$$R_1 = \frac{R_{12}\,R_{31}}{R_{12} + R_{23} + R_{31}}$$

OR

$$R_1,\ R_2,\ R_3 = \frac{\text{Product of adjacent resistors}}{\text{Sum of all resistors in delta}}$$

(ii) Star to delta conversion of resistances.

$$R_{12} = \frac{R_1R_2 + R_2R_3 + R_3R_4}{R_3}$$

OR

$$R_{12}, R_{23} \text{ or } R_{31} = \frac{\text{Equivalent resistance in star}}{\text{Opposite resistor in star}}$$

d) Define the following terms:
(i) Electromagnetism.
(ii) Magnetic flux.
(Define Electromagnetism1M, Magnetic flux 1M)

Ans.

(i) Electromagnetism: The emf is induced in any conductor when the conductor cuts or is cut by a magnetic flux is known as electromagnetism.

(ii) Magnetic flux: The amount of magnetic field produced by a magnetic source is called magnetic flux.

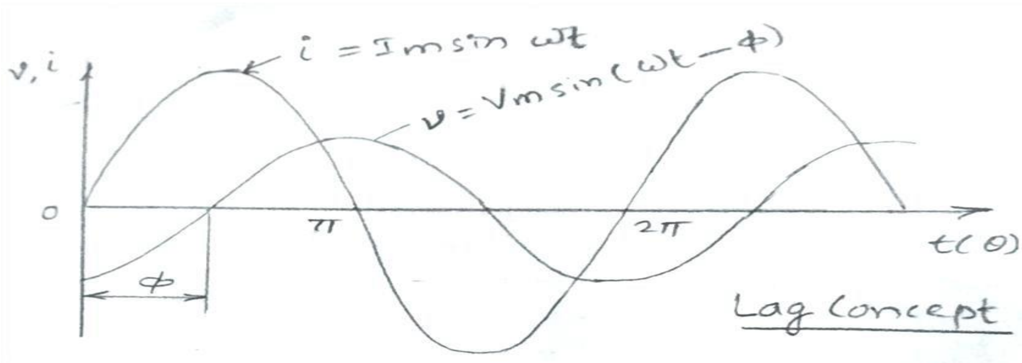
e) What do you understand by the terms lag and lead in relation to alternating quantities?
(Relevant description 2M)

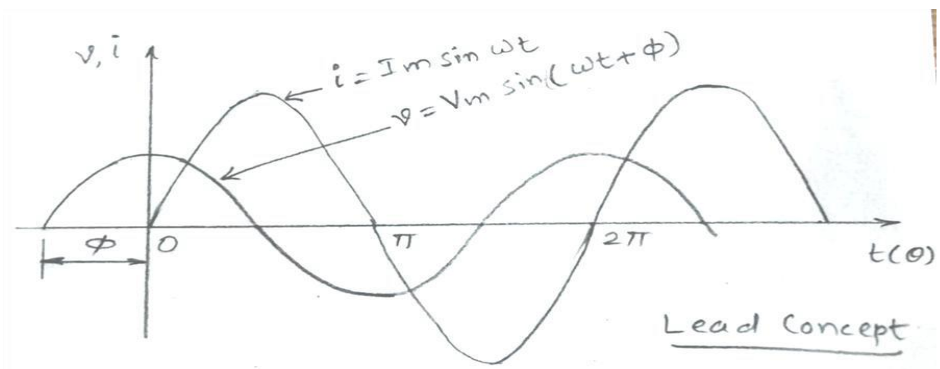
Ans.

A leading quantity is one which attains its maximum or zero earlier as compared to reference quantity.

A lagging quantity is one which reaches its maximum or zero value later than the other quantity.

OR





f) **Draw the waveform of 3-phase AC supply.**
(Correct diagram 2M)

Ans.

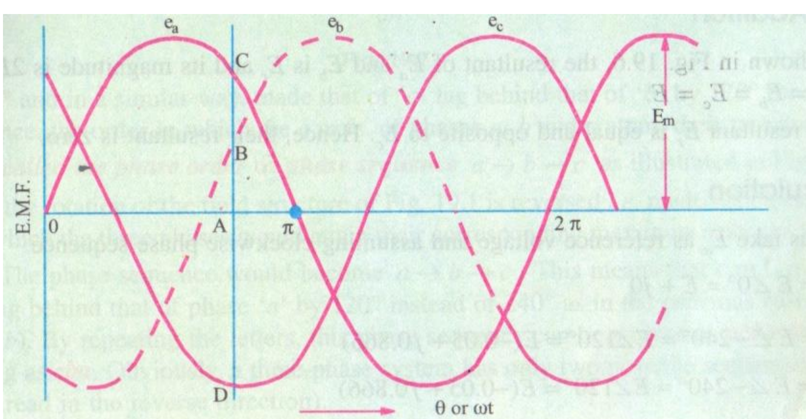


Fig: Waveform of 3-phase AC supply.

g) **State the necessity of fuse.**
(Any 2 points 2M)

Ans. (i) To safeguard electrical circuit against harmful effect of excessive currents.
(ii) To protect the electrical installation against short circuiting and earth faults.
(iii)It also helps in isolating only required part of the circuit without affecting the remaining circuit during maintenance.

h) Give any two precautions against electric shock.
(Any 2 points 2M)

Ans.

Precautions against electric shock:
1) While using any electrical device put on rubber sole footwear and keep your hands dry.
2) Always switch off main switch before replacing a blown fuse.
3) Electrical equipment should be properly earthed.

Q .1) B) Attempt any TWO of the following: 8

a) Draw a labelled diagram showing constructional details of single phase transformer. State its working principle.
(Labelled diagram 2M, Working principle 2M)

Ans.

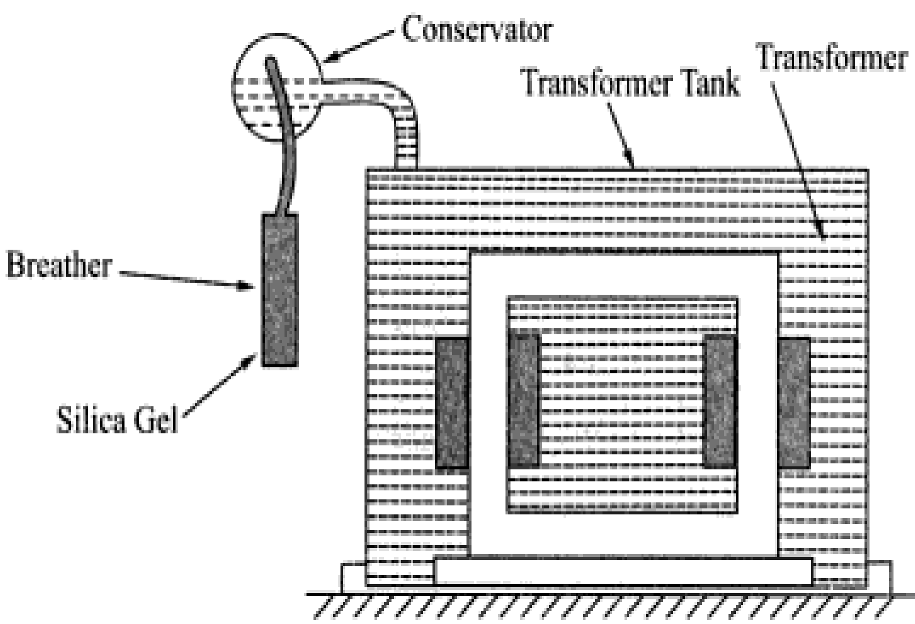
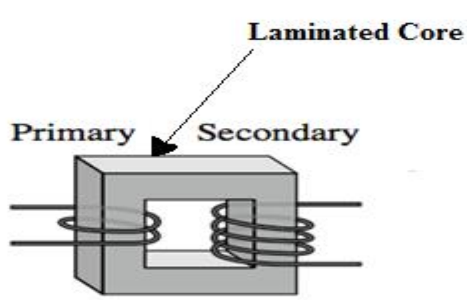


Fig: Single phase transformer

OR



Working principle of single phase transformer:

(i) When the primary winding is connected to AC supply, an AC current starts flowing through it.

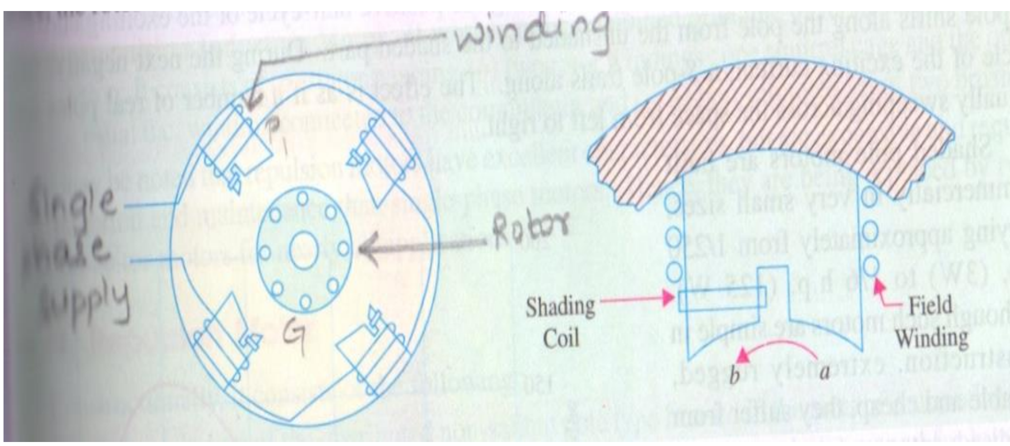
(ii) The AC primary current produces an alternating flux ϕ in the core.

(iii) The changing flux will induce voltage in the secondary winding due to mutual induction and the emf is induced in the secondary called as mutually induced emf.

b) Draw and explain circuit diagram of shaded pole motor.
(Diagram 2M, explanation 2M)

Ans.

Diagram of shaded pole motor:



Shaded pole motor: Shaded pole motors have salient poles on the stator and a squirrel-cage type motor. Above diagram shows a four-pole motor with the field poles connected in series for alternate polarity. In addition to it each pole carries a copper shading coil, on one of its unequally divided parts.

c) Write comparison between MCB and fuse on the basis of

(i) Function

(ii) Cost

(iii) Operation

(iv) Safety

(Each point 1M)

Ans.

Sr.No.	Parameter	Fuse	MCB
1	Function	Performs both detection and interrupt function	Performs Interruption only. Detection is made by relay system
2	Cost	Relatively cheaper	Costlier when compared to fuse.
3	Operation	Completely automatic	Requires separate automatic action
4	Safety	Use for protection against small circuit and over current.	Use for protection against over current for large circuit.

Q .2) Attempt any FOUR of the following: 16

a) Determine the current through 20 ohm resistance in Fig. No. 1 using node voltage method.

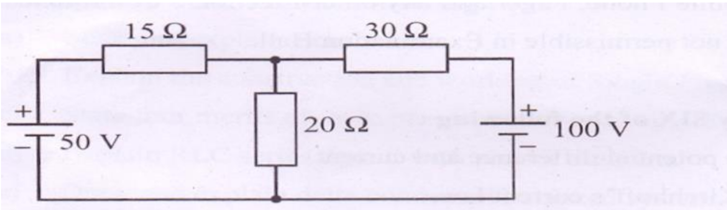
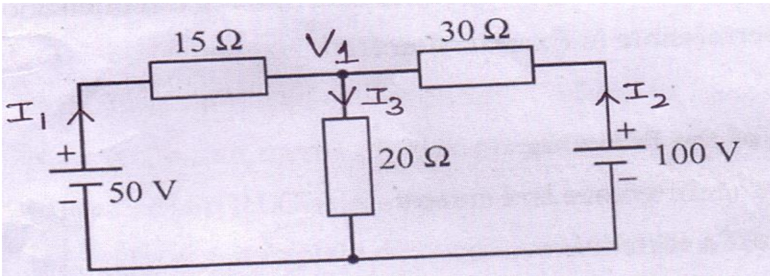


Fig.No.1

(Equation 2M, Answer with unit 2M)

Ans.



Apply Kirchhoff's current law at Node-1

$$I_1 + I_2 - I_3 = 0$$

$$\frac{50-V_1}{15}+\frac{100-V_1}{30}-\frac{V_1}{20}=0$$

$$\frac{100-2V_1+100-V_1}{30}=\frac{V_1}{20}$$

$$2(200-3V_1)=3V_1$$

$$400=9V_1$$

$$V_1=\frac{400}{9}$$

$$V_1=44.4\text{ V}$$

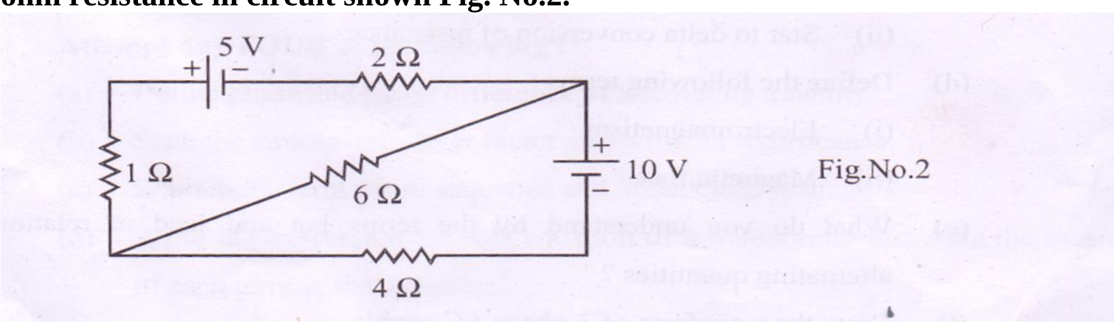
Current through 20 ohm resistance,

$$I_3=\frac{V_1}{20}$$

$$=\frac{44.4}{20}$$

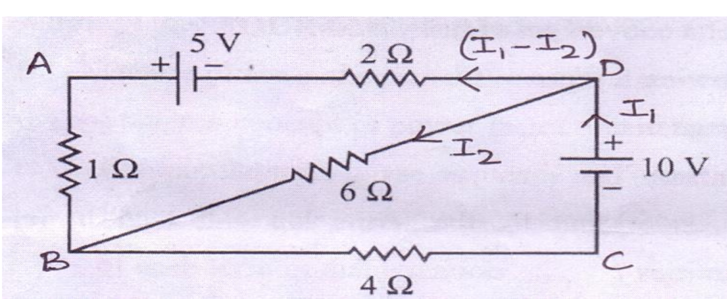
$$\boxed{I_3=2.22A}$$

b) Using Kirchhoff's Laws find the current in 6 ohm and hence power consumed by 6 ohm resistance in circuit shown Fig. No.2.



(Equation of two loop 2M, Current 1M, Power 1M)

Ans.



Consider loop ABDA,
Applying KVL,

$-(I_1 - I_2) + 6I_2 - 2(I_1 - I_2) + 5 = 0$

$-3I_1 + 9I_2 = -5$

$3I_1 - 9I_2 = 5$ ……………………………………………………………(1)

Consider loop BCDB,
Applying KVL,

$-4I_1 + 10 - 6I_2 = 0$

$4I_1 + 6I_2 = 10$……………………………………………………………(2)

Solving equation (1) and (2),
$12I_1 - 36I_2 = 20$
$12I_1 + 18I_2 = 30$

$-54I_2 = -10$

$I_2 = \frac{10}{54}$

$\boxed{I_2 = 0.18A}$

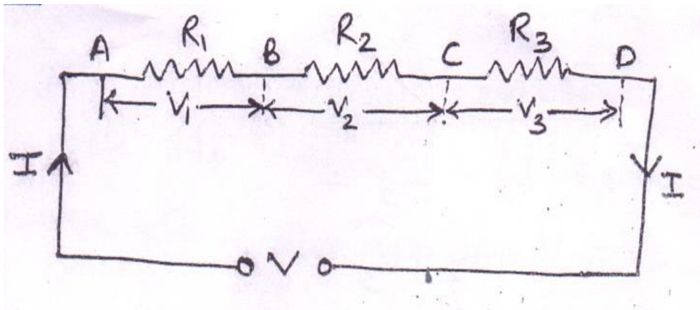
Power,
$P = I_2^2 R$

$= (0.18)^2$ X 6 = 0.1944W

c) Explain series and parallel circuits with diagram and necessary equations.
(Diagram 1M each, equation of each circuit 1M)

Ans.

Series circuit diagram:

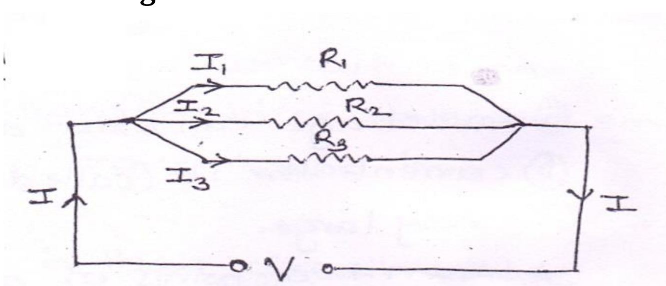


Equation:

Total voltage in series circuit, $V = IR_1 + IR_2 + IR_3$

Equivalent resistance, $R = R_1 + R_2 + R_3$

Parallel circuit diagram:



Equation:

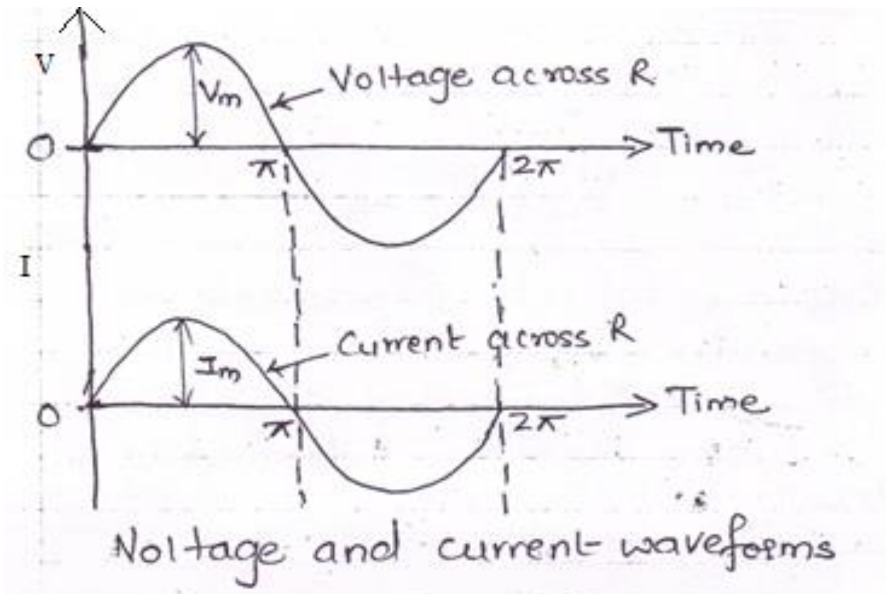
Total current in parallel circuit, $\frac{I}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$

Equivalent resistance, $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

d) Draw waveform and phasor diagram of a simple resistive circuit when AC is applied across it.
(Waveform 2M, Phasor diagram 2M)

Ans.

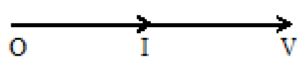
Waveform of simple resistive circuit:



Noltage and current waveforms

Phasor Diagram:

Phase difference between the voltage and current is cosϕ = 0.



e) Define the terms and write their mathematical expression:

(i) Real Power

(ii) Apparent power

(Definition 1M each, expression 1M each)

Ans.

(i) Real Power: It is defined as the average power Pav consumed by the given circuit.

$$\boxed{P = VI\cos\phi \text{ watts}}$$

(ii) Apparent Power: It is defined as the product of rms values of voltage and current.

$$\boxed{S = VI \text{ KVA}}$$

f) A coil of resistance 10 ohm and inductance 0.1H is connected in series with a capacitor of 150 microfarad across 220V, 50Hz supply, Calculate.

(i) Inductive reactance

(ii) Capacitive reactance

(iii) Impedance

(iv) Current
(1M for each answer)

Ans. Given

$R = 10\ \Omega$
$L = 0.1H$
$C = 150\mu F = 150 \times 10^{-6}$ F
$V = 220v$
$f = 50H_Z$

(i) Inductive Reactance:

$$X_L = 2\pi fL$$
$$= 2\pi \times 50 \times 0.1$$
$$= 31.42\Omega$$

(ii) Capacitive reactance:

$$X_C = \frac{1}{2\pi fC}$$
$$= \frac{1}{2\pi \times 50 \times 150 \times 10^{-6}}$$
$$= 21.22\ \Omega$$

(iii) Impedance:

$$Z = \sqrt{R^2 + (X_L - X_c)^2}$$
$$= \sqrt{10^2 + (31.42 - 21.22)^2}$$
$$= 14.28\ \Omega$$

(iv) Current:

$$I = \frac{V}{Z}$$
$$= \frac{220}{14.28}$$
$$= 15.4\ A$$

Q .3) Attempt any FOUR of the following: **16**

a) Define the following terms related to a.c.

(i) Crest factor
(ii) Effective value
(iii) Angular velocity

(iv)Frequency
(Each definition: 1M)

Ans.

i) Crest Factor:

It is the ratio of maximum value (amplitude) of an AC quantity to its rms value. This is also known as Peak factor.

Crest factor(Peak Factor) = $K_P = \frac{V_m}{V_{rms}} = \frac{V_m}{0.707\,V_m} = \mathbf{1.414}$

ii) Effective Value: (RMS value)

RMS value (Root Mean Square) value of an AC current is equal to the DC current which is required to produce the same amount of heat as produced by the AC current with the resistance and time remaining constant.

iii) Angular Velocity :

Angular velocity is the rate of change of angle with time. It is denoted by omega (ω). It is denoted by

$\omega = \frac{d\theta}{dt} = 2\Pi\,f$

iv) Frequency:
No. of cycles completed by an AC quantity in one second. It is also given by
$f = \frac{1}{T}$

b) Write difference between statically induced emf and dynamically induced emf with example. (any 4 points).
(Any 4 differences: 1M each)

Ans.

Sr. No.	Statically induced emf	Dynamically Induced emf
1.	When varying current is applied to any stationary conductor, the flux generated around conductor and emf get induced in it.	When a conductor cuts the lines of fluxes of stationary field emf get induced in it.

2.	Conductor is stationary and no field is used	Either conductor or field is stationary
3.	Direction of emf given by Lenz's law	Direction of emf given by Flemings Right Hand Rule
4.	Used in transformers.	Used in Generators.
5.	Two types of emf Mutually induced emf and self-induced emf.	No separate types of emf.

c) An alternating voltage is represented by the following equation v = 25 sin $200\pi t$
Find the following:
(i) Amplitude value
(ii) Time period
(iii) Angular velocity
(iv) Form factor
(Each answer 1M)

Ans. Given v = 25 sin $200\pi t$

V_m= 25 volts   w = 200 π

(i) Amplitude value: V_m= 25 volts

(ii) Time period:

$$w = 2\pi f = 200\pi$$
$$\therefore 2f = 200$$
$$f = 100$$
$$T = \frac{1}{f} = \frac{1}{100} = 0.01 \text{ sec}$$

(iii) Angular velocity:

$$w = 2\pi f$$
$$= 200\pi$$
$$= 628.39 \text{ rad/sec}$$

(iv) Form Factor:

$$\text{Form Factor} = \frac{RMS\ value}{Average\ value}$$

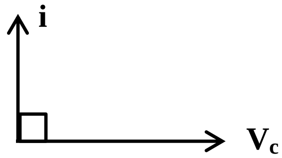
$$= \frac{0.707\, v_m}{0.637 v_m}$$

$$= 1.11$$

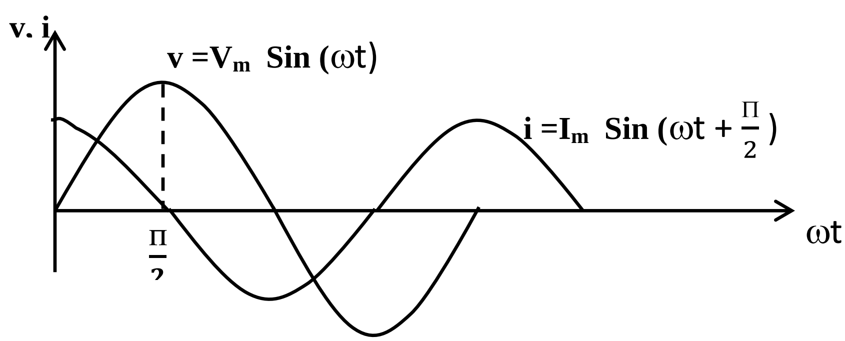
d) Draw the phasor diagram for a pure capacitor connected to an ac source. Also show the voltage and current waveforms.
(Phasor diagram: 2M; Waveforms: 2M)
(Separate waveforms for voltage and current can also be considered)

Ans.

Phasor Diagram:



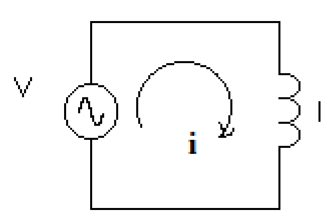
Waveforms:



e) Explain behavior of AC circuit containing inductance only with the help of waveform and vector diagram.
(Waveform: 1M; vector diagram: 1M; circuit diagram: 1M; explanation: 1M)

Ans.

Explanation:



An AC circuit containing an inductance L and negligible resistance is as shown in the circuit diagram. When AC signal is applied, the current produces a magnetic field which is alternating in nature. This change in magnitude induces emf, called self-induced emf. The magnitude depends on the rate of change of current and the inductance of the coil. Therefore,

Emf e $= - L \frac{di}{dt}$

At every instant, the applied emf is equal and opposite to the induced emf.

Hence, $V = -\left(- L \frac{di}{dt}\right)$

We know that $v = V_m \sin(\omega t)$

Therefore,

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

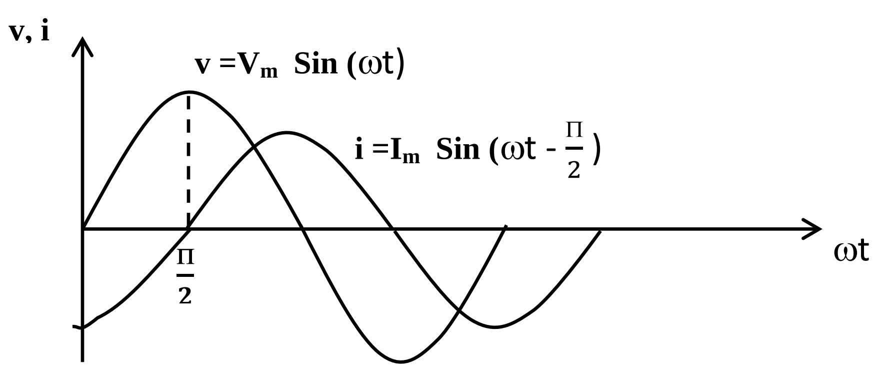
$$di = \frac{V_m}{L} \sin(\omega t)$$

Integrating on both side,

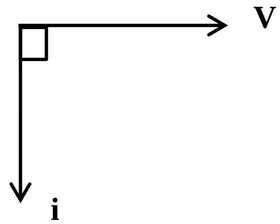
$$i = I_m \sin\left(\omega t - \frac{\Pi}{2}\right)$$

Thus from the waveforms it is clear that current lags behind the applied voltage by 90^0.

Waveforms:

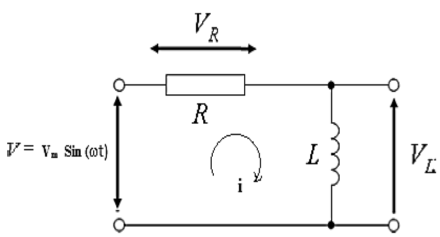


Phasor Diagram:



f) Draw phasor diagram and circuit diagram for a RL series circuit and label it.
(Phasor Diagram: 2M; Circuit diagram: 2M)

Ans: Circuit Diagram:



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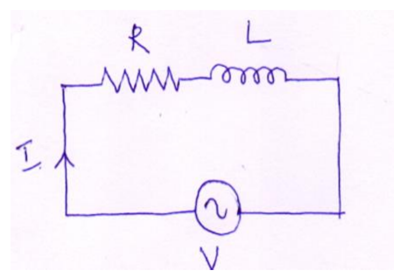
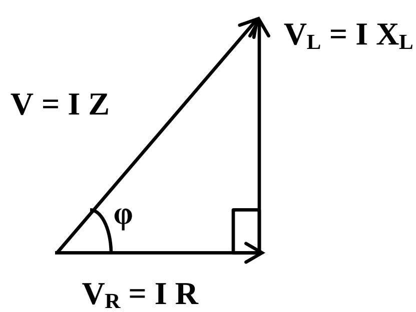


Phasor diagram:



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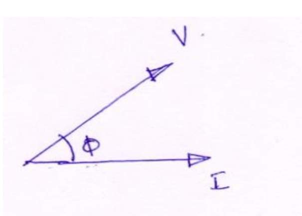

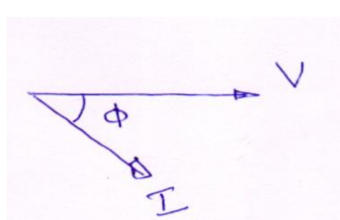

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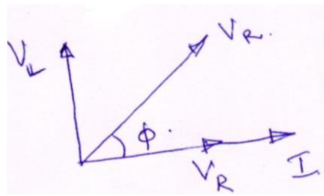


Q .4) Attempt any FOUR of the following: 16

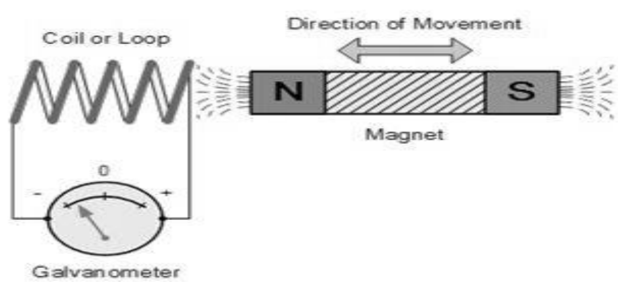
a) State and explain Faraday's Law of electromagnetic induction.
(Faraday's First Law: 2M, Faraday's Second Law:2M)

Ans.

Faraday's first law:

This states that whenever magnetic flux linked with a circuit changes, an emf is always induced in it.

Consider a coil of several turns connected to a galvanometer as shown below. If the magnet is moved towards the coil, G shows deflection in one direction. This production of emf and hence the current in the coil is due to the fact that when the magnet is in motion, the amount of flux linking coil changes, which induces emf. When the movement is stopped no change of flux and hence no emf.



OR

Whenever a conductor cuts the magnetic flux, an emf is induced in that conductor.

Faraday's Second Law:

This states that the magnitude of the induced emf is equal to the rate of change of flux linkages.

Suppose a coil has N turns and flux through it changes from the initial value of ϕ_1 webers to the final value of ϕ_2 in time t secs.

Initial flux linkages = N ϕ_1

Final flux linkages = N ϕ_2

Induced emf = e = $\dfrac{N\,\phi 2 - N\,\phi 1}{t}$ wb/sec

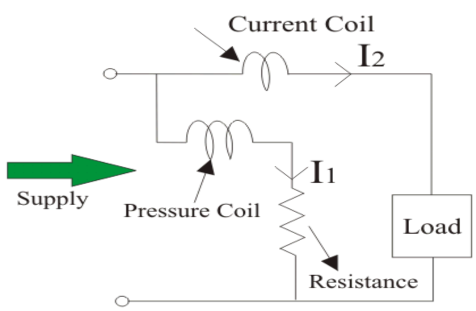
$$= \mathbf{N}\,\frac{d\phi}{dt}\ \textbf{volts}$$

A minus sign is attached to signify the direction of the emf opposing its cause.
Therefore,

$$\mathbf{e = -\,N}\,\frac{d\phi}{dt}\ \textbf{volts}$$

b) Draw circuit diagram for measurement of single-phase power using dynamometer type wattmeter.
(Correct diagram: 4M)

Ans. Dynamometer type wattmeter:



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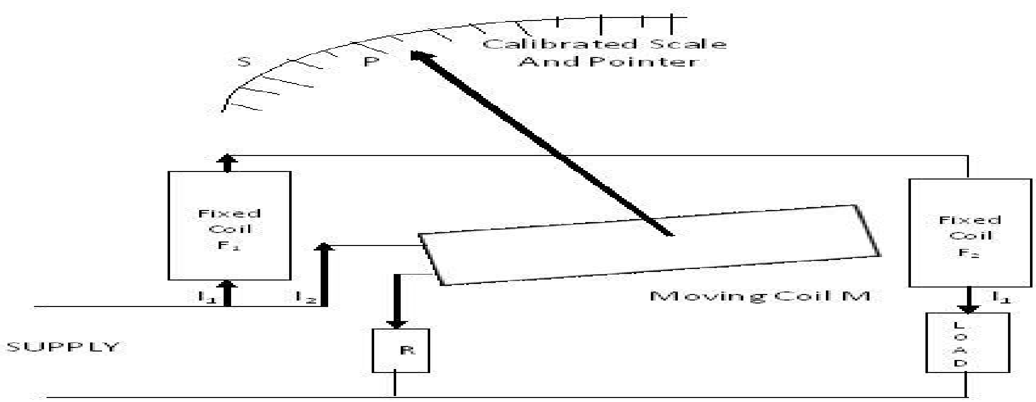


c) Explain concept of impedance and impedance triangle.
(Impedance 2M, Impedance triangle 2M)

Ans.

Impedance:

Impedance is defined as the opposition to the flow of alternating current in an AC circuit. It is denoted by Z and its Unit is ohms.

An AC circuit may contain resistance, inductance and capacitance. The total resistance offered is taken as Z.

The rectangular form of Impedance is given as

Z = R + i X ; Where R = Resistance

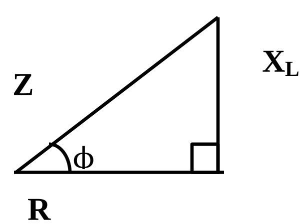
X = Reactance of the circuit;

The magnitude of Z = $|Z| = \sqrt{R^2 + X^2}$

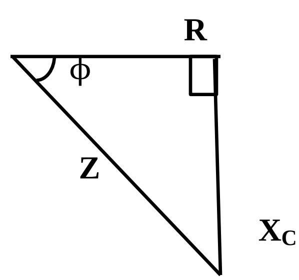
The phase angle $\phi = \tan^{-1} = \left(\frac{X}{R}\right)$

Impedance Triangle:

Impedance triangle can be obtained by considering the resistive part and reactive part of an AC circuit. If the circuit is inductive in nature, the impedance triangle can be given as shown below.

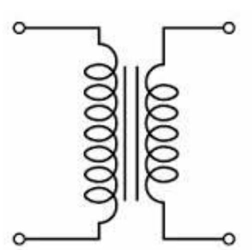
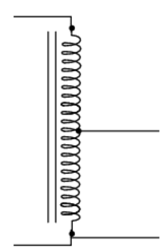


If the circuit is capacitive in nature, the impedance triangle can be given as shown below.



d) Compare two winding transformer with autotransformer. (any 4 points)
(Any 4 points: 1M each)

Ans.

Two Windings	Autotransformer
There are two separate windings for primary and secondary	A part of the winding is common between primary and secondary
There is no movable contact between primary and secondary windings	There is movable contact to vary output voltage
Electrical isolation is present between primary and secondary	No electrical isolation between primary and secondary
Used in mains transformer, power supplies	Used in starting of ac motors, variac
Losses are more in two windings transformer	Losses are less compare to two windings transformer
Efficiency is less as compare to autotransformer	Efficiency is more as compare to two winding transformer
Symbol 	Symbol 

e) Three impedance each of 4 ohm resistance and 10 ohm inductive reactance in series are connected in delta across 3-phase 400 V, 50 Hz ac supply. Find
(i) Phase current, (ii) Line current, (iii) Power factor, (iv) Total power.
(Each correct answer 1M)

Ans.

Given :
$R = 4\Omega$

$X_L = 10\ \Omega$

$V_L = 400V$

$f = 50Hz$

i) Phase Current I_{ph}

$I_{ph} = \frac{V_{ph}}{Z}$

In delta connected load, $V_L = V_{ph} = 400V$

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

$= \sqrt{4^2 + 10^2}$

$= 10.77\ \Omega$

$I_{ph} = \frac{400}{10.77}$

I_{ph} = 37.14A

ii) Line Current I_L :

In delta connected load,

Line current $I_L = \sqrt{3}\ I_{ph}$

$= \sqrt{3} \times 37.14$

I_L = 64.33 A

iii) Power factor:

Power factor $= \cos\phi = \frac{R}{Z} = \frac{4}{10.77} = 0.371$

iv) Total power P:

Total Power $P = \sqrt{3}\ V_L\ I_L \cos\phi$

$= \sqrt{3} \times 400 \times 64.33 \times 0.371$

P = 16,535 Watts OR 16.535 KWatts

f) Define: (i) Voltage ratio, (ii) Current ratio, (iii) Turns ratio, (iv) KVA rating of a transformer.

(Each definition: 1M)

Ans.

(i) Voltage Ratio: The ratio of primary to secondary terminal voltage is called the voltage ratio.

$$\text{Voltage Ratio} = \frac{\text{Primary voltage } (V1)}{\text{Secondary voltage } (V2)}$$

(ii) Current ratio: The ratio of primary current to secondary current is called current ratio.

$$\text{Current Ratio} = \frac{\text{Primary current } (I1)}{\text{Secondary current } (I2)}$$

(iii) Turns ratio: The ratio of no. of turns of primary winding to the no. of turns of the secondary winding is called the turns ratio.

$$\text{Turns Ratio} = \frac{\text{No.of Turns in primary } (N1)}{\text{No.of Turns in Secondary } (N2)}$$

(iv) KVA rating of a transformer:

Rating of a transformer indicates how much maximum power a transformer can supply. It is given by,

Rating of a transformer = Primary voltage X Primary Current

= Secondary Voltage X Secondary Current

Rating in KVA = $V_1 I_1 = V_2 I_2$

Units of transformer ratings are Volt Ampere (**VA**) Or **KVA** (Kilo Volt Ampere)

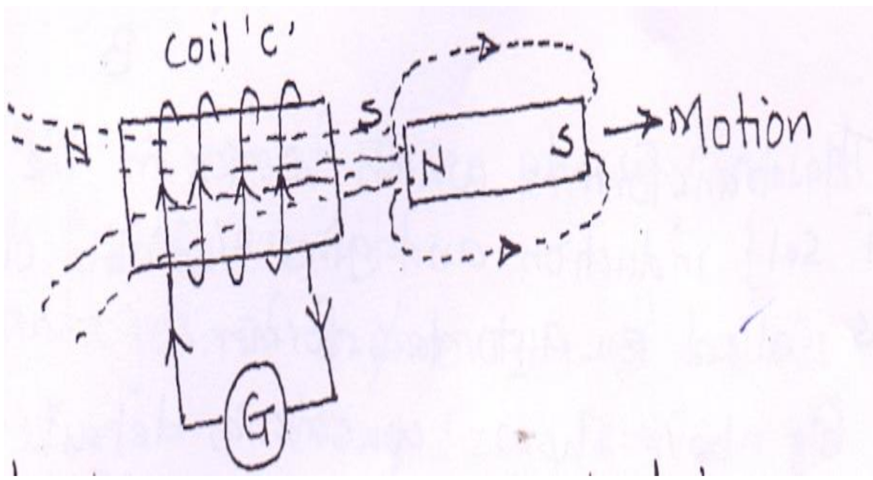
Q.5) Attempt any FOUR of the following: **16**

a) State and explain Lenz's Law.

(Statement 2M, Explanation 2M)

Ans.

Lenz's Law: It states that the direction of an induced emf produced during the process of electromagnetic induction is always such that it tends to set up a current opposing the basic causes responsible for inducing that emf.
This Law gives the direction of induced emf.



(i) Consider the coil 'C' is connected to a galvanometer.

(ii) Assume that the magnet is being withdrawn from the coil.

(iii)The induced current in this condition will flow in such a direction that the end of the will facing the magnet will be south pole. Thus, the force of attraction exerted by the south pole of the coil working as an electromagnet on the north pole of the magnet will oppose the withdrawal of the magnet from the coil.

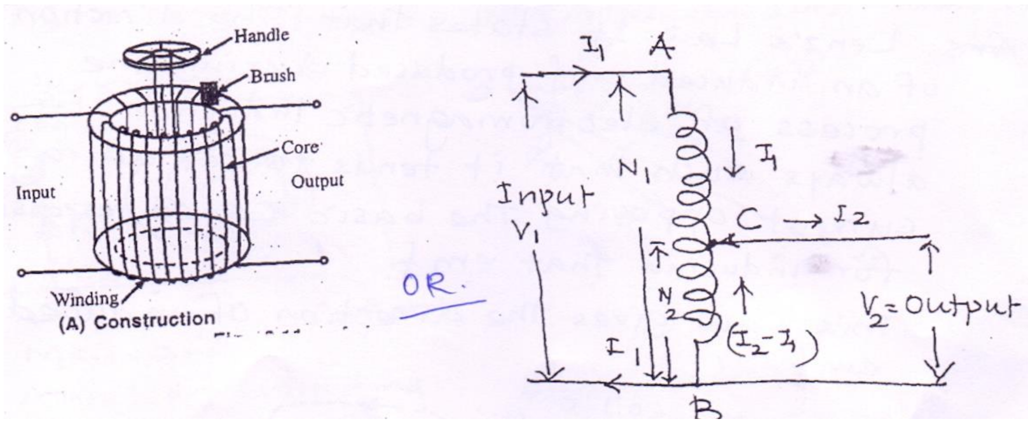
(iv)Thus, the motion of the magnet in either direction which is responsible for inducing the emf in the coil will be opposed by the current set up by that emf.

(v) Therefore the magnitude of induced emf is given by

$$e = \frac{-Nd\phi}{dt}$$

b) Explain the construction and working of Single Phase Auto Transformer.
(Diagram 1M, Construction 1 1/2M, Working 1 1/2M)

Ans. Diagram for Single Phase Auto Transformer:



Construction of single phase auto transformer:

In above diagram shows construction details of an auto transformer.

(i) It has only one winding wound on a laminated circular magnetic core.

(ii) The core is made of silicon steel stampings.

(iii) The two terminals of the winging are connected to the supply.

(iv) A variable point on the winding is connected to a carbon brush and brush can be moved by a circular handle.

Working of single phase auto transformer:

(i) The transformer which works on the principle of self-induction and gives variable output voltage is called an auto transformer.

(ii) The primary winding is connected to the supply and it has N_1 number of turns between portion AB as shown in above diagram.

(iii) By moving the handle we can select N_2 number of turns on the secondary i.e. between portion BC. Thus the same winding can function as primary as well as secondary.

$$\frac{V_2}{V_1} = \frac{N_2}{N_1}$$

(iv) Hence, from the auto-transformer we can get a variable voltage by varying N_2 by moving the brush with the help of handle.

c) State four merits of three phase circuits over single phase circuits.
(Any four merits: 1M each)

Ans.

Merits of Three Phase circuits are as follows:

(i) Three phase motors are self-starting.

(ii) The output of 3 - ϕ circuits is high then 1 - ϕ circuits.

(iii)Transmission efficiency is high compared to 1 - ϕ.

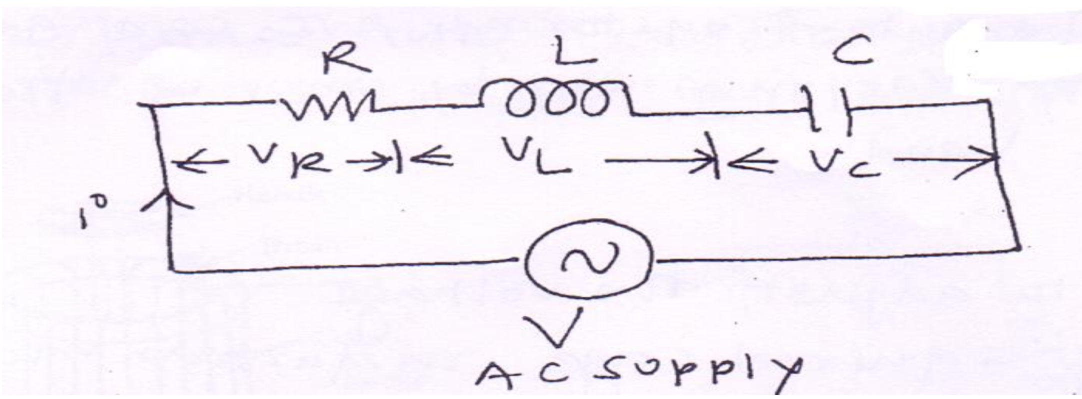
(iv)The size of 3 - ϕ motor is smaller than 1 - ϕ motors of same capacity.

(v) 3 - ϕ circuits gives output voltage of 440v, 230v whereas 1 - ϕ gives 230v.

(vi)Three phase can be used in large power and industrial applications.
(vii)Power factor is better in 3 - ϕ system.

d) Explain RLC series circuit with phasor diagram.
(Series diagram 1M, Each case with phase diagram 1M)

Ans.



(i) Consider the RLC series circuit as shown in above diagram.
(ii) Resistance (R), Inductance (L) and Capacitance (c) are connected in series across 1- ϕ ac supply.
(iii) Let, $V_R = I_R$ = voltage across resistance.
$V_L = IX_L$ = voltage across inductor
$V_C = IX_C$ = voltage across capacitor

(iv) Total applied voltage,

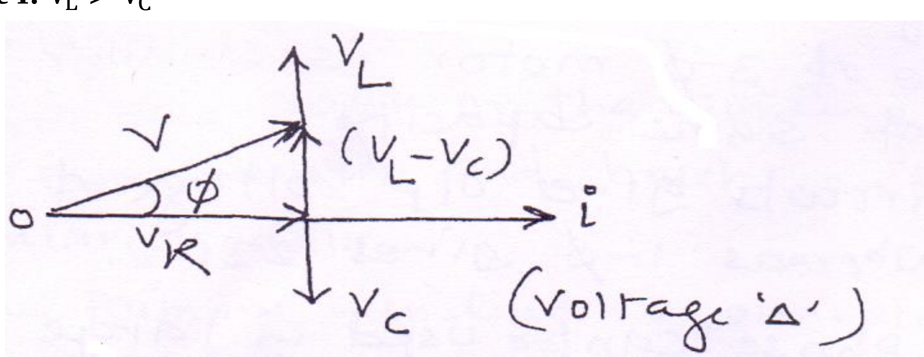
$$\bar{V} = \bar{V_R} + \bar{V_L} + \bar{V_C}$$

At (i) $V_L > V_C$

(ii) $V_L < V_C$

(iii) $V_L = V_C$

Case I: $V_L > V_C$



$\therefore\ V^2 = VR^2 + (V_L - V_C)^2$

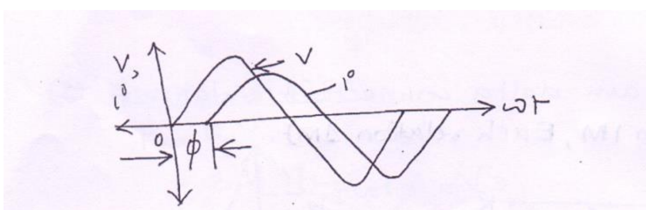
$\therefore\ Z^2 = R^2 + (X_L - X_C)^2$

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

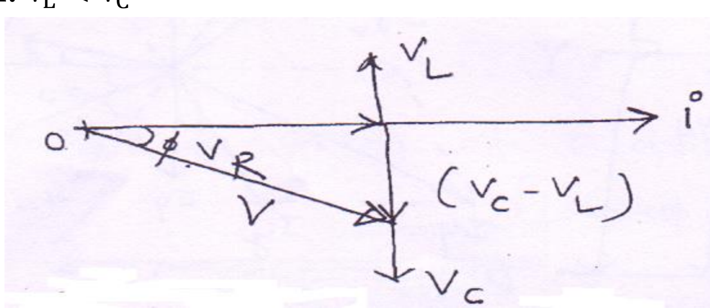
Current and voltage equation:

$V = V_m$ sincot

$I = I_m$ sin(cot- ϕ)



Case II: $V_L < V_C$



$V^2 = V_R^2 + (V_C - V_L)^2$

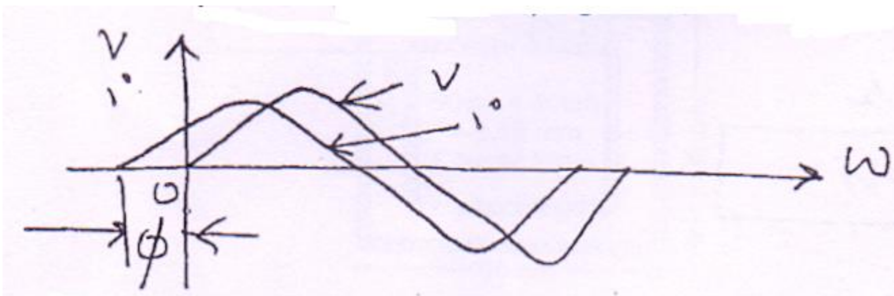
$V^2 = V_R^2 + (V_L - V_C)^2$

$Z^2 = R^2 + (X_L - X_C)^2$

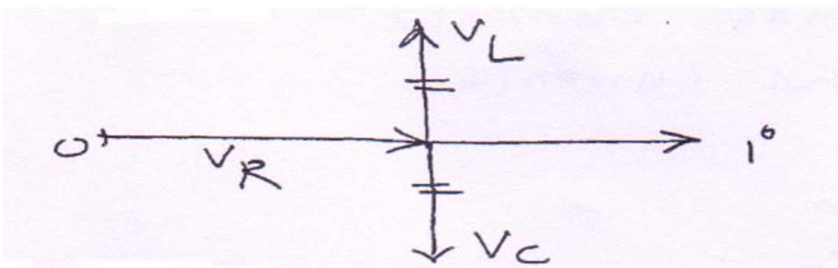
Current and voltage equation:

$V = V_m \sin\omega t$

$I = I_m \sin(\omega t + \phi)$



Case III: $V_L = V_C$



$\therefore V = V_R$

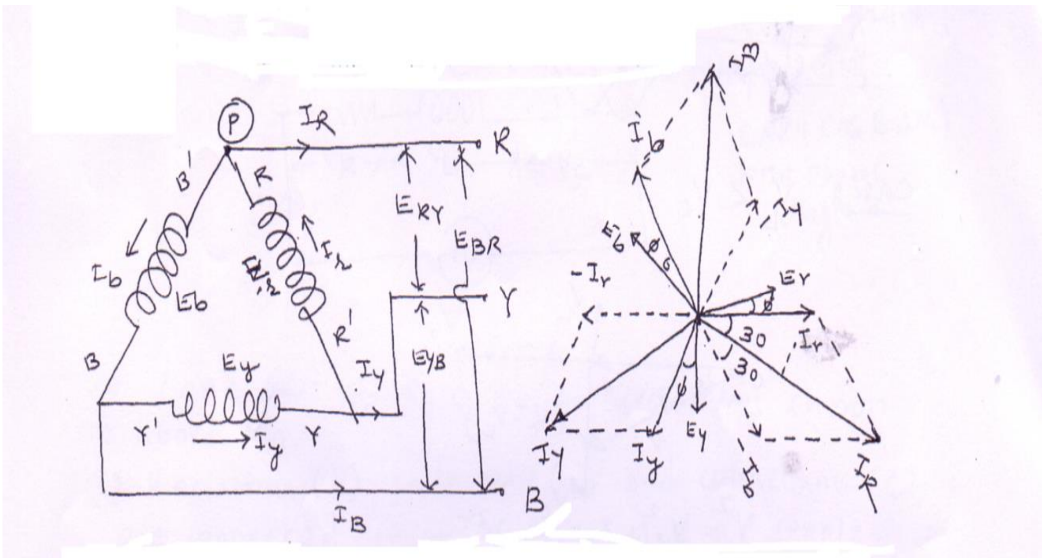
This condition is called Resonance used current and voltage equation

$V = V_m \sin\omega t$

$I = I_m \sin\omega t$

e) Draw and explain delta connected balanced system.
(Diagram 1M, Each relation 1M)

Ans.



(i) In above diagram 3-ϕ balanced delta connected system.

(ii) Three windings R R[1], YY[1], BB[1] connected in delta connection.

(iii) Voltage Relation:

Let, E_r, E_Y, E_b be phase voltages.

E_{RY}, E_{YS}, E_{BR} be line voltage

$$\therefore E_{RY} = E_r$$

$$\therefore V_L = V_{ph}$$

(iv) Current relation:

Let I_r, I_y, I_b be phase currents

I_R, I_Y, I_B line currents

KCL at point (P)

$I_r = I_R + I_b$

$$\therefore \bar{I}_R = \bar{I}_r - \bar{I}_b$$

From phasor diagram

$$I_R = 2I_r \cos 30$$

$$\therefore\ I_R = 2I_r\frac{\sqrt{3}}{2}$$

$$\therefore\ I_R = \sqrt{3}I_r$$

$$\boxed{\therefore I_L = \sqrt{3}I_{ph}}$$

(v) Power relation

$$P_T = 3V_{pn}\,I_{ph}\cos\phi$$

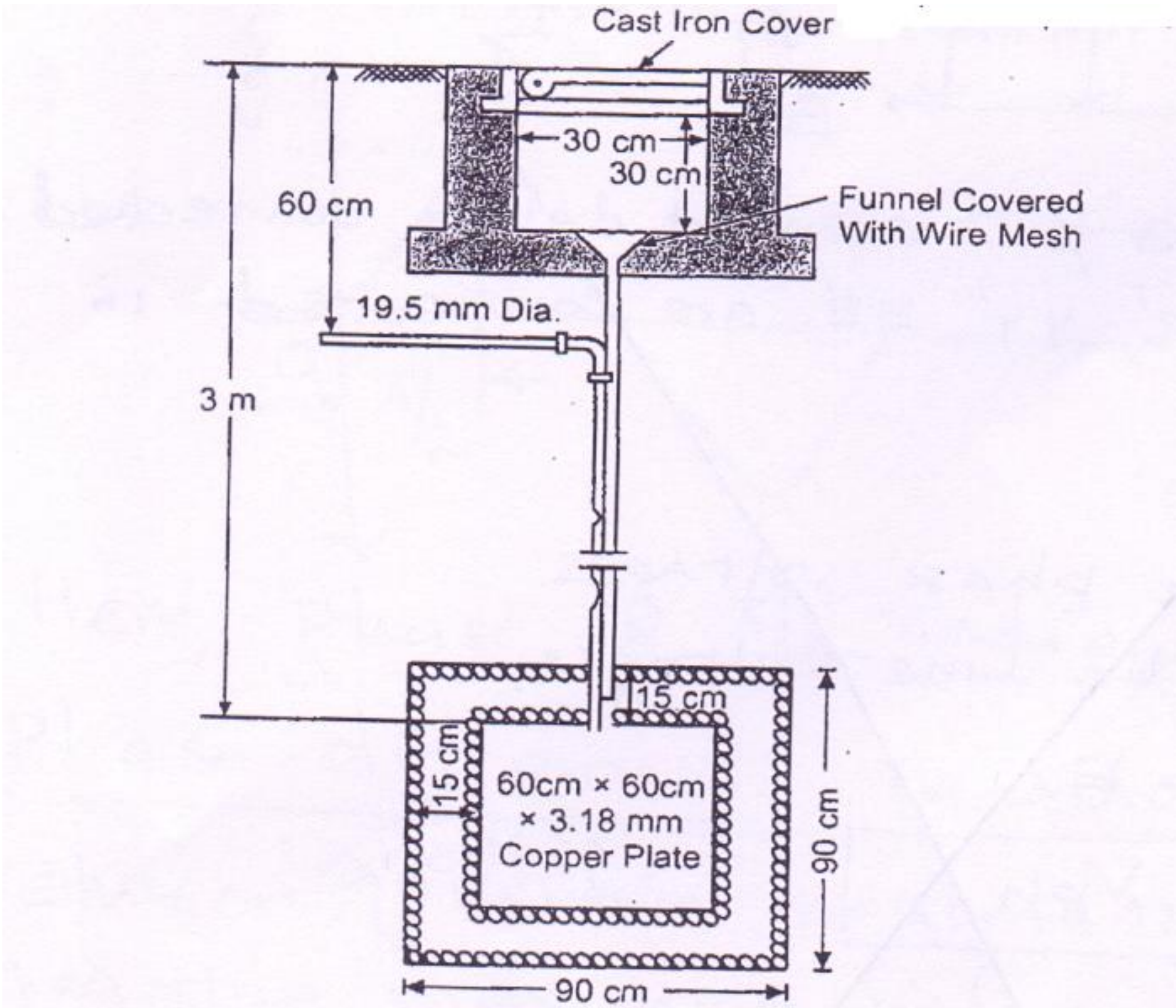
$$= 3V_L\frac{I_L}{V_3}\ cos\phi\ \times\frac{\sqrt{3}}{\sqrt{3}}$$

$$\boxed{P_T = \sqrt{3}\,V_L\,I_L cos\phi}$$

f) Draw neat diagram of plate earthing.

(Correct labelled diagram 4M)

Ans. Diagram of plate earthing:



(a)

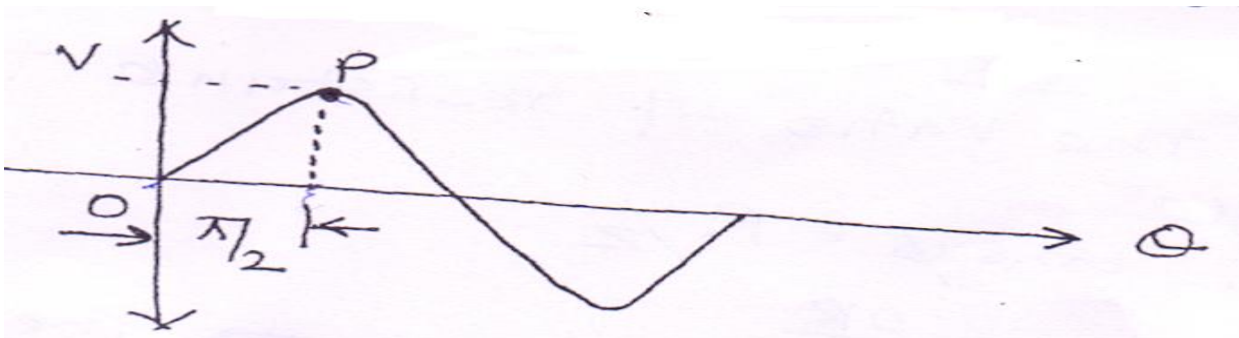
Q.6) Attempt any FOUR of the following: 16

a) Define phase and phase difference of alternating quantity.
(Definition with wave form 2Meach)

Ans.

Phase: The angular displacement of an alternating quantity to achieve certain instantaneous value is known as phase of that alternating quantity.

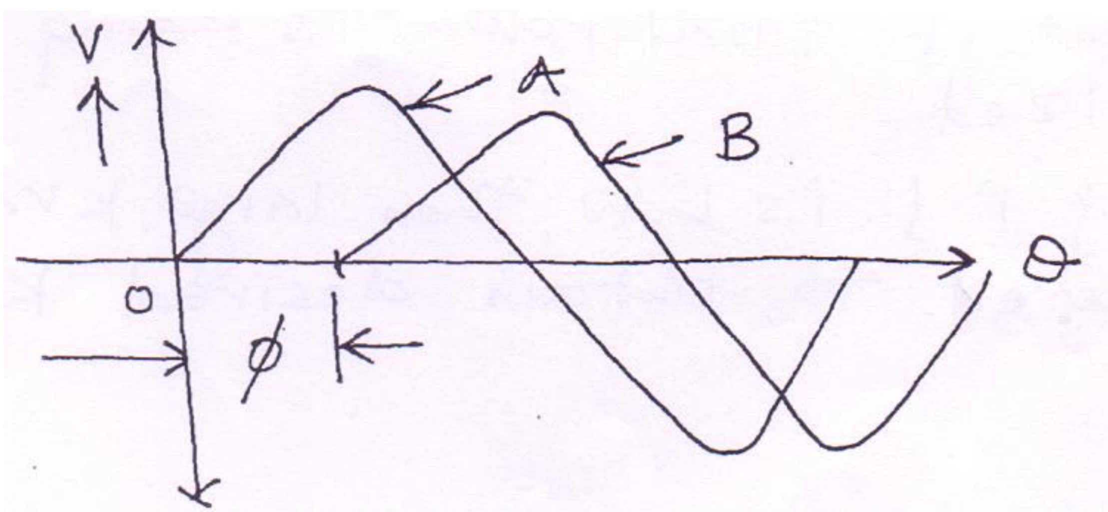
e.g.



Here, Phase is $\underline{\pi/2}$ radians at point P and the value of voltage is 'V'

Phase difference: The angular displacement between two alternating quantity of same frequency either positive maximum, zero and negative maximum values is called phase difference it is denoted by 'ϕ'.

e.g.



Here, phase difference is ϕ i.e. $\phi = \pi/2$ between A and B

So equation for A,

$$V_A = V_{AM}\, sin\omega t$$
$$V_B = V_{BM}\, \sin(\omega t - \phi)$$

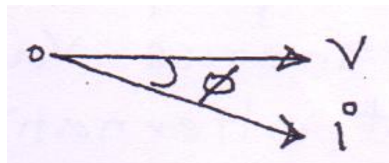
b) State the concept of power factor and write its significance.
(Power factor 2M, significance 2M)

Ans.

Power factor:

(i) The cosine of angle between voltage and current of the circuit is called power factor.

$\therefore \mathrm{P.F.} = cos\phi$



OR

(ii) It is the ratio of resistance to impedance

$$\therefore cos\phi = {}^{\mathrm{R}}/_{\mathrm{Z}}$$

OR

(iii)The ratio of true power to the apparent power is called power factor.

Significance of power factor:

(i) The power factor of a circuit gives the ability of a circuit to convert its apparent power into true power.
(ii) Low p.f. indicates that a very small amount of total power is being actually utilized.
(iii) If p.f. is Low, then large KVA is required to obtain desired KW.

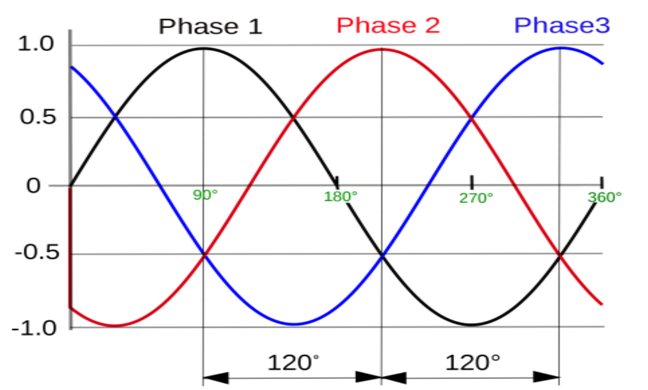
c) Explain the term phase sequence and unbalanced load.
(Phase sequence with waveform 2M, unbalanced load with diagram 2M)

Ans.

Phase Sequence:

(i) The order in which the voltages in three phases reach their maximum positive values is called the phase sequence.

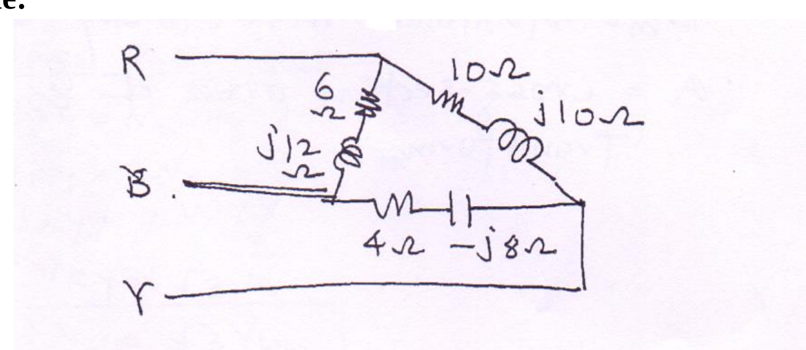
(ii) The standard phase sequence is R → Y → B.
(iii) The colours used to denote the phase sequence are Red, Yellow and Blue.
(iv) Phase sequence is essential for finding the direction of rotation of a.c. motors, in parallel operation of alternators and transformer.



Unbalanced Load:

(i) The power drawn by each phase is not equal.
(ii) Impedance of each phase is not equal.
(iii) Current drawn by each phase is not equal.

Example:



d) Write the expression for emf equation of a transformer and state the meaning of each term in that equation.
(Equation 2M, Explanation 2M)

Ans.

The expression for emf equation of a transformer:

$$E_1 = 4.44\ \phi_m f\ N_1$$
$$E_2 = 4.44\ \phi_m f\ N_2$$

OR

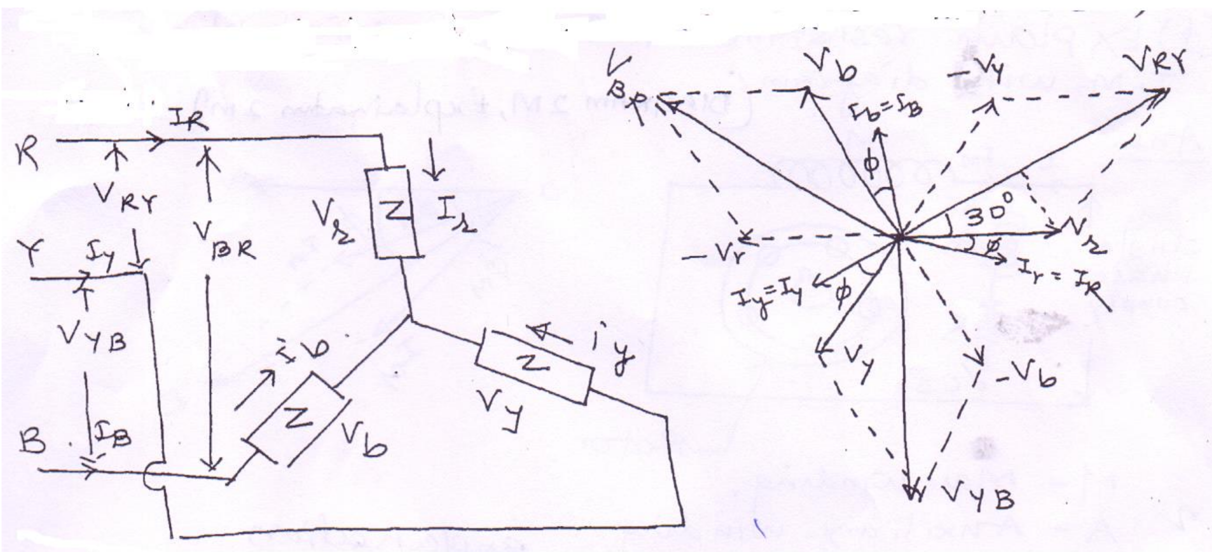
$$E_1 = 4.44\ B_m A f\ N_1$$
$$E_2 = 4.44\ B_m A f\ N_2$$

Where,

E_1 = Emf induced in primary winding
E_2 = Emf induced in secondary winding
ϕ_m = Maximum flux in Weber
f = frequency in Hz
N_1= Number of primary turns
N_2 = Number of secondary turns
B_m = Maximum flux density in Wb/m^2
A = Cross-section area of core of transformer

e) Draw and explain star connected balanced load.
(Diagram 1M, three relation 1M each)

Ans.



i. In above diagram shows a balanced three phase star connected load.
ii. Three impedances of equal magnitude and nature are connected in star.
iii. Let V_r, V_b, V_y be the phase voltages and I_r, I_b, I_y be the phase currents.
iv. Let V_{RY}, V_{YB}, V_{BR} be the line voltages and I_R, I_Y, I_B be the line currents.
v. Current Relation:

$$I_Y = I_R$$

$$\boxed{I_{ph} = I_L}$$

vi. Voltage Relation:

$$\overline{V}_{RY} = \overline{V}_r - \overline{V}_y$$

$$\therefore\ V_{RY} = 2V_r cos30$$

$$\therefore\ V_{RY} = 2V_r \frac{\sqrt{3}}{2}$$

$$\therefore\ V_{RY} = \sqrt{3}\ V_r$$

$$\therefore\ V_L = \sqrt{3}\ V_{ph}$$

vii. Power Relation:

Total Power

$$P_T = 3V_{ph}\ I_{ph} \cos\phi$$

$$= 3\ \frac{V_L}{\sqrt{3}} I_L \cos\phi \times \frac{\sqrt{3}}{\sqrt{3}}$$

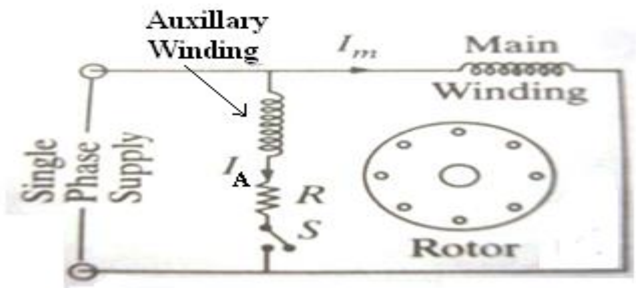
$$= P_T = \sqrt{3}\ V_L\ I_L \cos\phi$$

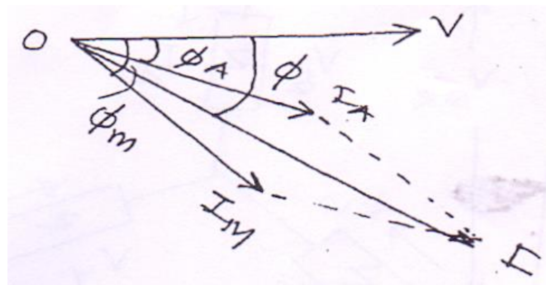
f) Explain resistance split phase single phase I.M. with diagram.
(Diagram: 2M; Explanation: 2M)

Ans.

Figure below shows the circuit diagram of resistance split phase induction motor.

The stator of this type of motor carries two windings called main winding (M) and auxillary (A) or starting winding (S).





- These windings are displaced 90^0 apart to each other.
- The rotor of the motor is of normal cage type
- When 1-ϕ AC supply is switched on, centrifugal switch (S) turns into ON state by connecting "A" winding in the circuit.
- Current will flow through Main and auxillary winding.
- A rotating magnetic field is therefore produced.
- The motor thus develops a starting torque.
- Once the motor is started, the auxillary winding is disconnected with the help of centrifugal switch at about 75 to 85% of synchronous speed
- Motor rotates to its rated speed.