Important suggestions 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 principle components indicated in a 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 some questions credit may be given by judgment on part of examiner of relevant answer based on candidate understands.
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 Marks**
a)	**Define peak factor and form factor for a sinusoidal quantity.**
Ans:	**1. Peak factor for a sinusoidal quantity:** **(Each Definition : 1 Mark)** It is defined as the ratio of Maximum value to the RMS value. **2. Form factor for a sinusoidal quantity:** It is defined as the ratio of RMS value to the Average value of an alternating quantity
b)	**State Fleming's Right Hand Rule.**
Ans:	**Fleming's Right Hand Rule: (2 Mark)** Arrange three fingers of right hand mutually perpendicular to each other ,if the first figure indicates the direction of flux, thumb indicates the direction of motion of the conductor, then the middle finger will point out the direction of inducted current.
c)	**List the various losses that occur in a transformer.**
Ans:	**The various losses that occur in a transformer:** **(1 Mark each)** 1) Copper losses 2) Core or Iron losses: a) Hysteresis loss b) Eddy current loss

d)	**Why transformer rating is in kVA and not in kW ? Explain.**
Ans:	**Reason & explanation for transformer rating is in kVA and not in kW** **(2 Mark)** We know that copper loss in a transformer depends on current and iron loss depends on voltage. Therefore, the total loss in a transformer depends on the volt-ampere product only and not on the phase angle between voltage and current i.e., it is independent of load power factor. For this reason, the rating of a transformer is in KVA and KW.
e)	**List two applications of universal motor.**
Ans:	**Application of Universal Motor:** **(Any Two application expected : 1 Mark each)** 1) Mixer 2) Food processor 3) Heavy duty machine tools 4) Grinder 5) Vacuum cleaners 6) Refrigerators 7) Driving sewing machines 8) Electric Shavers 9) Hair dryers 10) Small Fans 11) Cloth washing machine 12) portable tools like blowers, drilling machine, polishers etc
f)	**State necessity of earthing.**
Ans:	**Necessity of Earthing:** **(Any two point expected: 1 Mark each)** ➢ Earthing is provided to protect human from shocks due to leakage current. **OR** ➢ Earthing is to ensure safety or Protection of electrical equipment and Human by discharging the electrical leakage current to the earth. **OR** ➢ Earthing provides protection to the electrical motors and appliances**.** due to leakage current.
g)	**For star connected load, state numerical relationship between: (i) Line current and Phase current. (ii) Line voltage and Phase voltage.**
Ans:	**i) The relation between line current and phase current in star connected load.** $I_L = I_{ph}$ **(1 Mark)** **ii) The relation between line voltage and phase voltage in star connected Load** $V_L = \sqrt{3}\, V_{Ph}$ **(1 Mark)**

h) **Define: Phase sequence and unbalanced load.**

Ans: **1. Phase sequence:** **(1 Mark)**

The phase sequence is defined as the sequence in which all the phases attain there maximum positive values.

2. Unbalanced load : **(1 Mark)**

In unbalanced load The respective Magnitude and phase angle currents are not identical in three phases. **OR**

Impedances of one or more phases are different from other phases. (Z1, Z2, & Z3 are not identical simultaneously) **OR**

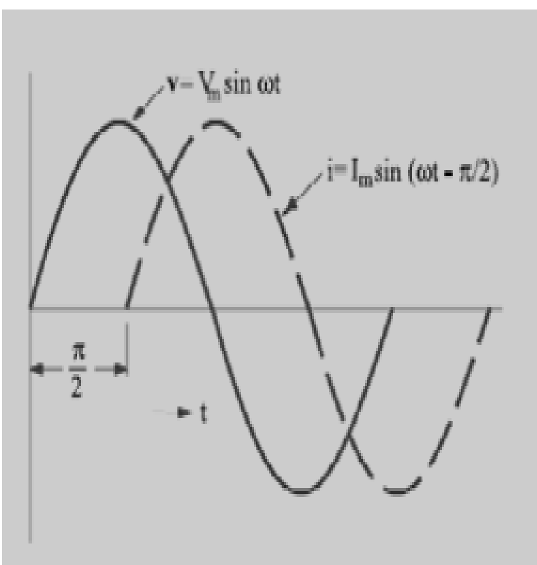
Magnitude and phase angle of load impedance are not identical.

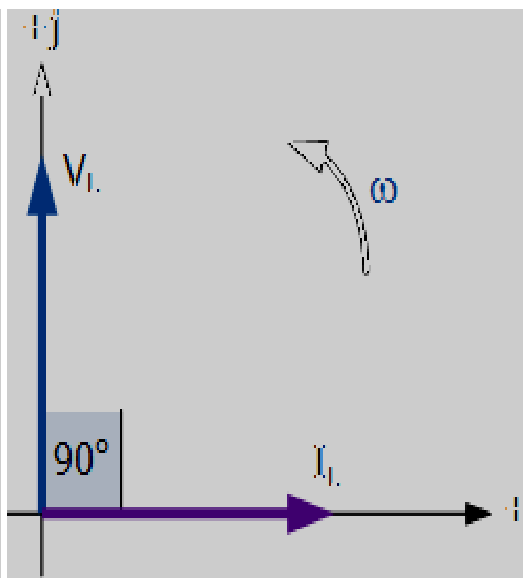
Q.1 B) **Attempt any TWO of the following:** **08 Marks**

a) **With the help of waveforms and phasor diagrams show the phase relationship between voltage and current in pure inductive and pure capacitive circuits.**

Ans: **Pure inductance circuit :** **(Waveform, Phasor Diagram and relationship between voltage and current : 2 Mark)**

Waveform: **Phasor Diagram :**



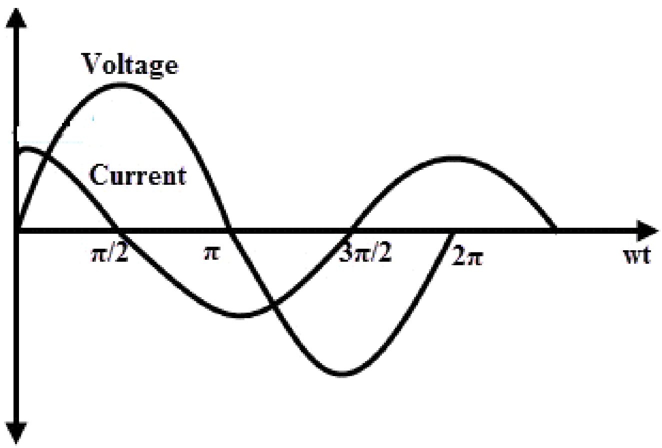


1. Equation for voltage V= V_m sin ωt

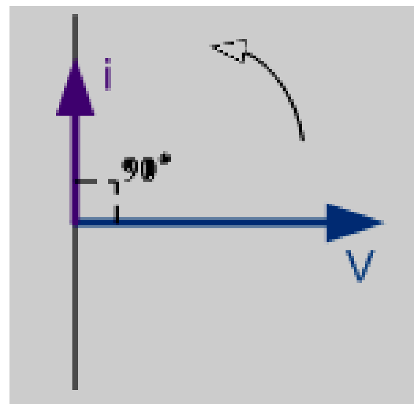
2. Equation for current I = I_m sin (ωt- –) or I_m sin (ωt-90^0)

Pure capacitive circuit: **(Waveform, Phasor Diagram and relationship between voltage and current : 2 Mark)**

Waveform:



Phasor Diagram :



1. Equation for voltage $V = V_m \sin \omega t$
2. Equation for current $I = I_m \sin (\omega t + -)$ or $I_m \sin (\omega t + 90^0)$

b) **Write four advantages of 3-phase system over 1-phase system.**

Ans: **Advantages of 3-phase system over 1-phase system: -**

(Any Four points expected each point 1 Mark)

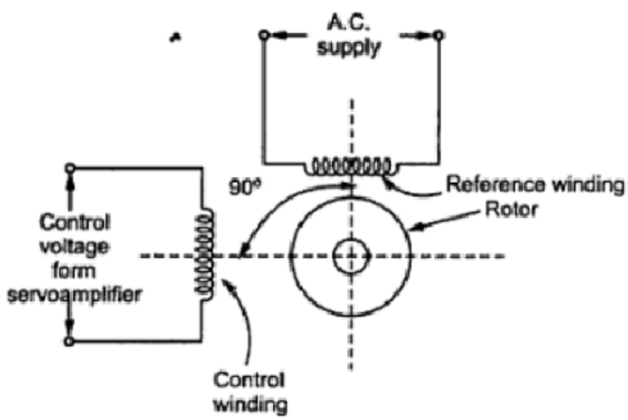
1. More output: - For the same size output of poly-phase machines is always higher than single phase machines.
2. Smaller size:- for producing same output the size of three phase machines is always smaller than that of single phase machines.
3. More power is transmitted:- It is possible to transmit more power using a three phase system than single system.
4. Smaller cross-sectional area of conductors:- If the same amount of power is transmitted then the cross-sectional area of the conductors used for three phase system is small as compared to that of single phase system.
5. Better power factor:- power factor of three phase machines is better than that of single phase machines.
6. Three phase motors are self starting-three phase ac supply is capable of producing a rotating magnetic field when applied to stationary windings, the three phase ac motors are self

starting. While single phase induction motor needs to use additional starter windings

7. Horse power rating of three phase motors is greater than that of single phase motor.
8. Power delivered by a single phase system fluctuates whereas for three phase system power delivered to the load is the same at any instant.

c) Draw the schematic representation and state the principle of working of servo motor.

Ans: **Schematic representation :** **(Figure : 2 Mark & Principle : 2 Mark)**



or equivalent figure

Principle of working of servo motor:

There are some special types of application of electrical motor where rotation of the motor is required for just a certain angle not continuously for long period of time. For these applications some special types of motor are required with some special arrangement which makes the motor to rotate a certain angle for a given electrical input (signal). Such motors can be ac or dc motors. When controlled by servo mechanisms are termed as servomotors.

These consist of main and control winding and squirrel cage / drag cup type rotors. Vr is the voltage applied to the main or reference winding while Vc is that applied to control winding which controls the torque- speed characteristics. The 90^0 space displacement of the two coils/windings and the 90^0 phase difference between the voltages applied to them result in production of rotating magnetic field in the air gap due to which the rotor is set in motion. The power signals can be fed from servo amplifiers either to the field or armature depending upon the required characteristics.

OR

Working of AC Servomotor:

- The control Phase is usually supplied from a servo amplifier.
- The speed and torque of the rotor are controlled by the phase difference between the

control voltage and the reference phase voltage.

- The direction of rotation of the rotor can be reversed by reversing the phase difference, from leading to lagging (or vice versa) between the control phase voltage and the reference phase voltage.

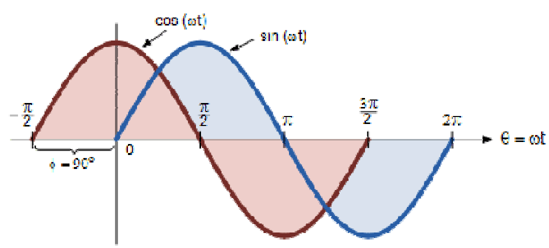
Q.2 Attempt any FOUR of the following : 16 Marks

a) What is leading and lagging phase difference? Show it by waveforms.

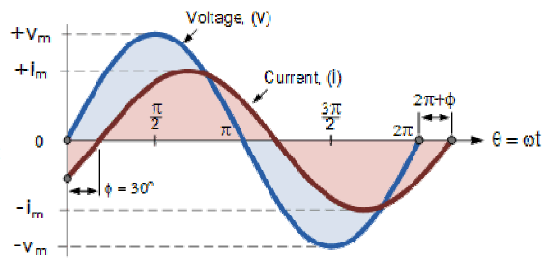
Ans: **(Meaning - 2 Marks , waveforms -2 Marks)**

- When phase angle is positive than it is called as leading
- When phase angle is negative than it is called as lagging

Leading Phase difference waveform:



Lagging Phase difference waveform

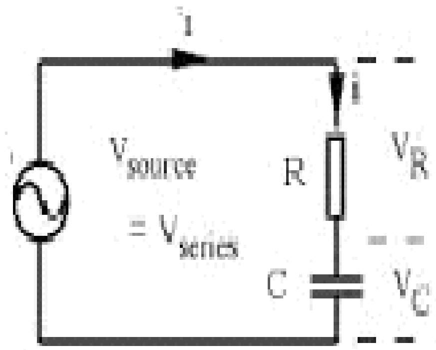


OR equivalent figure

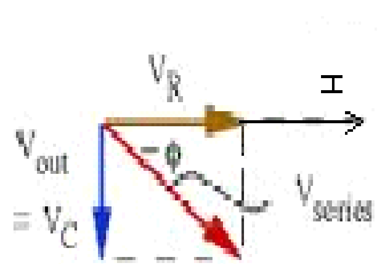
b) Draw a RC circuit and its vector diagram. Write its voltage and current equations.

Ans: **(Diagram: 1 Mark, Vector Diagram: 1 Mark, Each Equation : 1 Mark)**

Circuit diagram of RC circuit

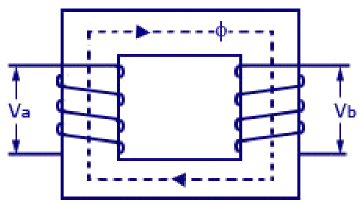
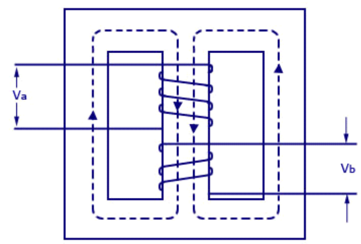


Vector diagram of RC series circuit

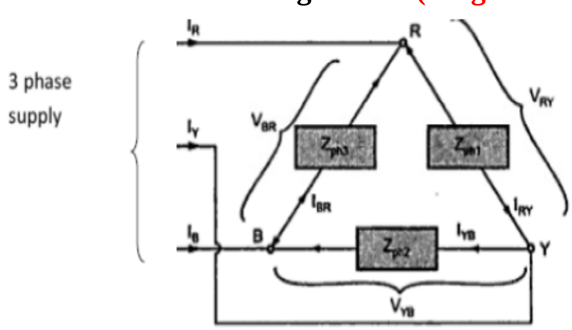


1. Equation for voltage $V = V_m \sin \omega t$
2. Equation for current $I = I_m \sin(\omega t + \varphi)$

c)	**Compare core type and shell type single phase transformer (any four points).**
Ans:	**(Any Four points expected each:1 Marks)**

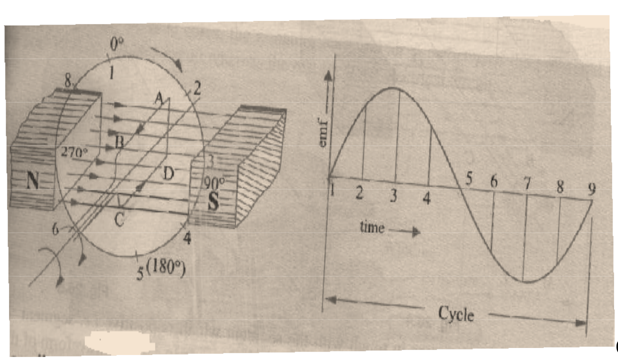
S.No	Core Type Transformer	Shell Type Transformer
1.		
2.	The Winding surround the core	The core surround the windings
3.	Magnetic Flux has only one continuous path	Magnetic Flux is distributed into 2 paths
4.	Suitable for high voltage & less output	Suitable for less voltage & high output
5.	Easy for repairs	Difficult for repairs
6.	Less in Weight	More in Weight
7.	It has one window opening	It has two windows opening

d)	**Draw a delta connection for 3-phase power supply and show line current, line voltage, phase current and phase voltage on it and state the relation between currents and voltages (phase values and line values)**
Ans:	**i) Draw the connection diagram:-** **(Diagram : 2 Marks& equation: 2 Mark)**



OR **equivalent diagram**

1. Line voltages = Phase voltages
2. Line currents = I_R, I_Y, and I_B.
3. Phase currents = I_{RY}, I_{YB}, and I_{BR}.
4. $V_{Line} = V_{Phase}$,
5. $I_{Line} = \sqrt{3}\ I_{Phase}$

e)	**Define : (i) RMS value (ii) Instantaneous value (iii) Angular frequency (iv) Phase angle with reference to AC quantities**
Ans:	**(i) RMS value :** **(1 Mark)** The RMS value of an AC is equal to the steady state or DC that is required to produce the same amount of heat as produced by AC provided that the resistance and time for which these currents flow are identical. **(ii) Instantaneous value:** **(1 Mark)** The Value of AC quantity at any particular time instant is called as Instantaneous value. **(iii) Angular Frequency:** **(1 Mark)** The change in angle in radian pre seconds It is denoted by ω **(iv) Phase Angle:** **(1 Mark)** It is the angle between current and voltage.
f)	**Explain the resonance in R-L-C series circuit**
Ans:	**Explanation of resonance in R-L-C series circuit :** **(4 Marks)** The **resonance** of a **series** RLC circuit occurs when the inductive and capacitive reactances are equal in magnitude. **OR** Resonance is the phenomenon in AC circuit in which circuit exhibits unity power factor or applied voltage and resulting current are in phase with each other. ➢ Under series resonance condition $X_L=X_C$, ➢ Power factor is unity or 1 i.e. cosΦ =1 ➢ Impedance (Z) = resistance (R) ➢ Current is maximum
Q.3	**Attempt any FOUR of the following :** **16 Marks**
a)	**Explain the generation of single phase AC by an elementary alternator.**
Ans:	**(Figure -2 Marks & Explanations- 2 Marks)**  **or equivalent figure**

Imagine the coil ABCD to be rotating in clockwise direction, as the coil assumes successive positions in the field the flux linked with it changes/cuts. Hence an EMF induced in it which is proportional to the rate of change of flux linked.

When the plane of the coil is at right angle to line of fluxes i.e. when its position 1 then flux linked with the coil is maximum but rate of change of flux linked is minimum. Hence minimum emf is induced in the coil at this position shown in figure.

The coil plane is horizontal i.e. parallel to lines of flux i.e. at $\theta = 90^0$,C at position 3, at this stage the flux linked with the coil is minimum but rate of change of flux linked is maximum. Hence maximum emf is induced in the coil at this position shown in figure.

From 90^0C to 180^0C the flux linked with the coil gradually increases but the rate of change of flux linkage decreases. Hence the induced emf decreases gradually till in position 5 of the coil it is reduce to zero value

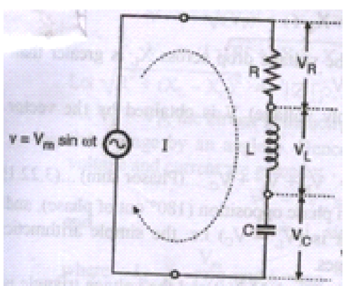
The direction of induced emf can be found by Fleming's right hand rule.

In the next half revolution i.e. from 180^0C to 360^0C the variation in the magnitude of emf is similar to those in the first half revolution but in opposite direction.

b) Draw a R-L-C series circuit and phasor diagram. Also write equations.

Ans: **(R-L-C series circuit- 2 Marks, Phasor diagram-1Mark, Equations-1Mark)**

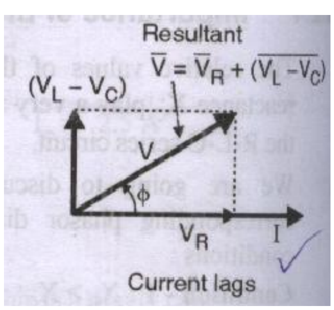
R-L-C Series circuit with phasor diagram :-



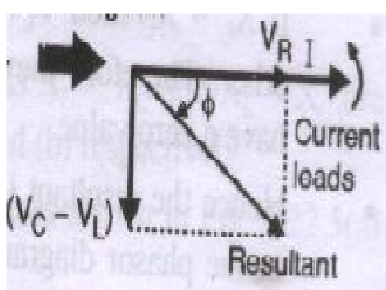
or Equivalent fig.

Phasor Diagram: (Any one phasor diagram expected)

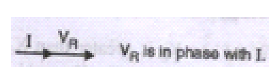
i) $X_L > X_C$ (lagging)



ii) $X_C > X_L$ (leading)



iii) $X_L = X_C$ (UPF)



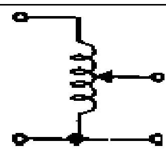
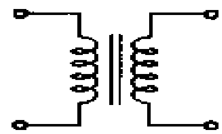
	Equations for R-L-C series circuit: **(Any Two equation expected)** $X_C=\frac{1}{2\pi f C}$ $X_L=2\pi f L$ $\text{Impedance } Z=\sqrt{(R)^2+(X_l-Xc)^2}$ $I=\frac{V}{Z}$ $Cos\,\phi=\frac{R}{Z}$ **For $X_c > X_L$:** 1. Equation for voltage $V= V_m \sin \omega t$ 2. Equation for current $I = I_m \sin (\omega t+\varphi)$ **For $X_c < X_L$** 1. Equation for voltage $V= V_m \sin \omega t$ 2. Equation for current $I = I_m \sin (\omega t-\varphi)$ **For $X_L=X_c$:** 1. Equation for voltage $V= V_m \sin \omega t$ 2. Equation for current $I = I_m \sin \omega t$
c)	**A coil has a resistance of 3 ohm and inductance of 0.012739 Henry and is connected across 230 volts, 50 Hz AC supply. Calculate : (i) Inductive reactance (ii) Impedance (iii) Current (iv) Power factor**
Ans:	$\text{Impedance per phase } Z_{ph}=\sqrt{R^2+(X_L)^2}$ **Step-1: To Find Inductive Reactance =** $X_L=2\pi f L,\quad X_L=2\times\pi\times 50\times 0.012739$ $X_L=4.00207\approx 4\ \Omega$ -- **(1 Mark)** **Step-2: To Find Impedance =** $\text{Impedance } Z=\sqrt{3^2+(4.00207)^2}$ $\text{Impedance } Z=\sqrt{3^2+4.00207^2}$ $\text{Impedance } Z=5.00166\,\Omega$ -- **(1 Mark)** **Step-3: To Find Current=**

	$I = \frac{V}{Z}, = \frac{230}{5.00166}$ $I = 45.9847 \approx 46\ Amp$ ---(1 Mark) **Step-4: To Power Factor =** $Cos\ \phi = \frac{R}{Z}, = \frac{3}{5.00166}$ $Cos\phi = 0.5998\ \approx 0.6$ --- **(1 Mark)**
d)	**State and explain Lenz's law.**
Ans:	**Statement :** **(2 Mark)** The direction of induced emf produced due to the process of electromagnetic induction is always such that, it will set up a current to oppose the basic cause responsible for inducing the emf. **Explanation :** **(2 Mark)** The mathematical representation is, e = - N (dΦ/dt), Where 'e' = Induced emf , N = No. of turns in coil, dΦ/dt = rate of change of flux where -ve sign indicates opposition to induced emf.
e)	**Explain the statically induced emf and dynamically induced emf.**
Ans:	**Statically induced emf :** **(2 Mark)** In the Statically induced emf flux linkined with coil or winding changes (dΦ/dt) and coil or winding is stationary such induced emf is called Statically induced emf E = - N (dΦ/dt) **Dynamically induced emf:** **(2 Mark)** If flux linking with a particular conductor is brought about by moving the coil in stationary field or by moving the magnetic field w.r.t. to stationary conductor. Then the e.m.f. induced in coil or conductor is known as "Dynamically induced e.m.f. E = B l. v. sinθ volts

f)	**Explain the working principle of 3-phase induction motor.**
Ans:	**Working principle of 3-phase induction motor:** **(Working principle :4 Mark)** ➢ When 3-phase stator winding is energized from a 3-phase supply, a rotating magnetic field is set up in air gap which rotates round the stator at synchronous speed Ns (= 120 f/P). ➢ The rotating field passes through the air gap and cuts the rotor conductors, which as yet, are stationary. ➢ Due to the relative speed between the rotating flux and the stationary rotor, e.m.f.s are induced in the rotor conductors. ➢ Since the rotor circuit is short-circuited, currents start flowing in the rotor conductors. ➢ The current-carrying rotor conductors are placed in the magnetic field produced by the stator. ➢ Consequently, mechanical force acts on the rotor conductors. ➢ The sum of the mechanical forces on all the rotor conductors produces a torque which tends to move the rotor. ➢ In the same direction as the rotating field according to Lenz's law.
Q.4	**Attempt any FOUR of the following :** **12 Marks**
a)	**An alternating voltage is mathematically expressed as v = 141.42 sin (157.08 t + $\frac{\pi}{12}$) volt. Find maximum value, RMS value, frequency and periodic time.**
Ans:	**Given data :** **v = 141.42 sin (157.08 t +** $\frac{\pi}{12}$ **)** **i) maximum value Vm :** 141.42 V -- **(1 Mark)** **ii) RMS value Vrms =** 0.707 x Vm -- **(1/2 Mark)** = 0.707 x 141.42 = 99.9839 Volt -- **(1/2 Mark)** **iii) Frequency** = $\frac{\omega}{2\pi}$ -- **(1/2 Mark)** $=\frac{157.08}{2\pi}$ $F = 25\ H_Z$ --- **(1/2 Mark)** **iv) Periodic Time** = $\frac{1}{f} = \frac{1}{25}$ -- **(1/2 Mark)** = 0.04 sec --- **(1/2 Mark)**

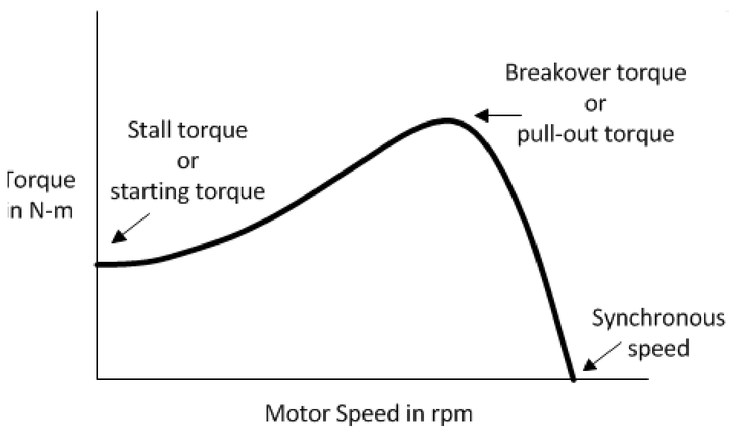
b) Compare auto-transformer and two winding transformer. (any four points)

Ans: **(Any four points expected: Each point 1 Mark)**

S.No.	Points	Autotransformer	Two winding transformer
1.	**Symbol**		
2.	**Number of windings**	It has one winding	It has two windings
3.	**Copper saving**	Copper saving takes more as compared to two winding	Copper saving is less
4.	**Size**	Size is small	Size is large
5	**cost**	Cost is low	Cost is high
6	**Losses in winding**	Less losses takes place	More losses takes place
7.	**Efficiency**	Efficiency is high	Efficiency is low
8.	**Regulation**	Regulation is better	Regulation is poor
9.	**Electrical isolation**	There is no electrical isolation	Electrical isolation is present in between primary and secondary winding
10.	**Movable contact**	Movable contact is present	Movable contact is not present
11.	**Application**	Variac, starting of ac motors, dimmerstat.	Mains transformer, power supply, welding, isolation transformer

c) Draw and explain torque-speed characteristics of 3-phase I.M.

Ans: **Torque-Speed characteristics :** **(characteristics -3 Marks & Explanation:- 1 Mark)**

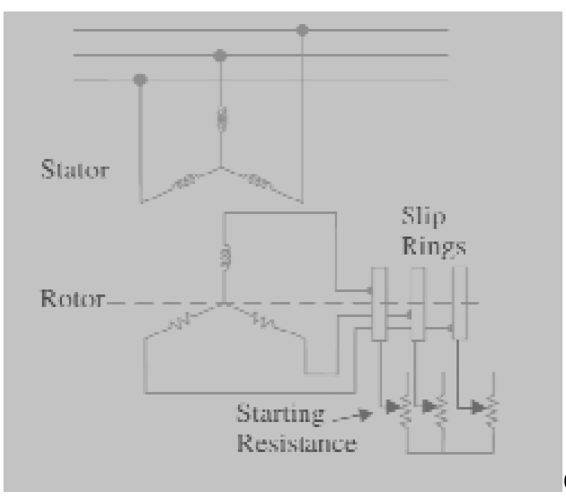


Speed-Torque Curve for a Three-Phase Induction Motor

or Equivalent fig

	Explanation: From the above characteristics:- ➢ When Slip (S) ≅ 0 (i.e N ≅ Ns) torque is almost zero at no load, hence characteristics start from origin ➢ As load on motor increases Slip increases and therefore torques increases. ➢ For lower values of load, torque proportional to slip, and characteristics will having linear nature. ➢ At a particular value of Slip, maximum torque conditions will be obtained which is $R_2 = SX_2$ ➢ For higher values of load i.e. for higher values of slip, torque inversely proportional to slip and characteristics will having hyperbolic nature. In short breakdown occurs due to over load. ➢ The maximum torque condition can be obtained at any required slip by changing rotor resistance.
d)	**Explain construction of 3-phase I.M. with diagram.**
Ans:	**(Any one Method expected Figure : 2 Mark & Construction: 2 Mark)**

1. Constructional detail of slip ring induction motor:



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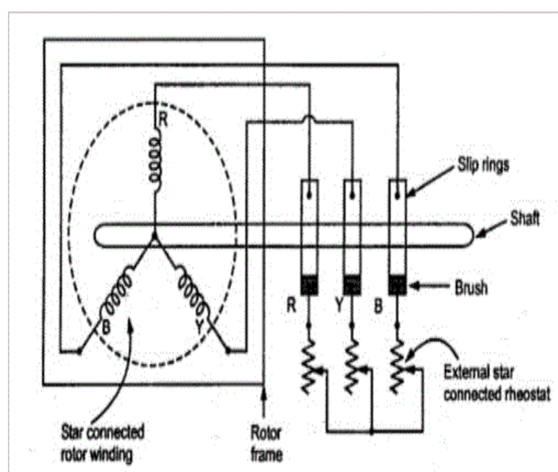


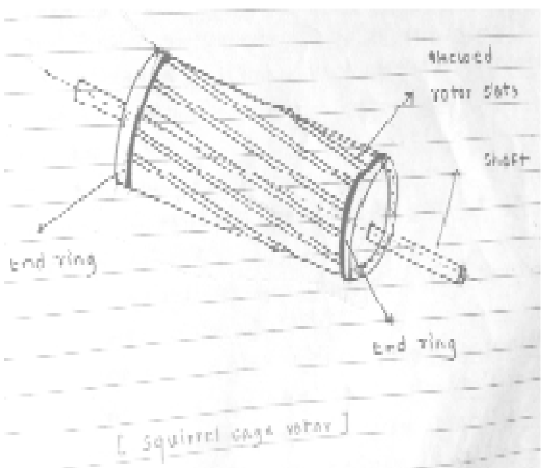
Explanation:

➢ It consist laminated cylindrical core and it carries three phase windings.

➢ The rotor winding may be single layer or double layer.

- The rotor winding is uniformly distributed in slots and it is always star connected.
- Rotor is wound for same number of poles as that of the stator winding.
- Three phases of rotor winding is are shorted internally to form star point and other three winding terminals are brought out and joined to three insulated slip rings mounted on the rotor shaft.
- One brush is resting on each slip ring. These three brushes are further externally connected to three phase star connected rheostat.

2. Constructional detail of Squirrel cage induction motor:



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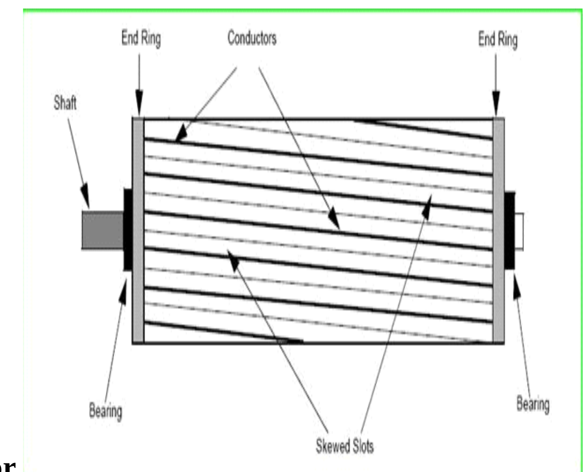


or equivalent figure

Explanation:

- It consist laminated cylindrical core having slots on its outer periphery.
- One copper or aluminum bar is placed in each slot. All the bars are joined at each end by metal rings called end rings.
- Rotor bars are brazed or electrically welded or bolted to the end rings.
- This form permanently short circuited winding which is non breakable.
- The rotor slots are not parallel to the shaft but they are skewed at certain angle with the shaft.

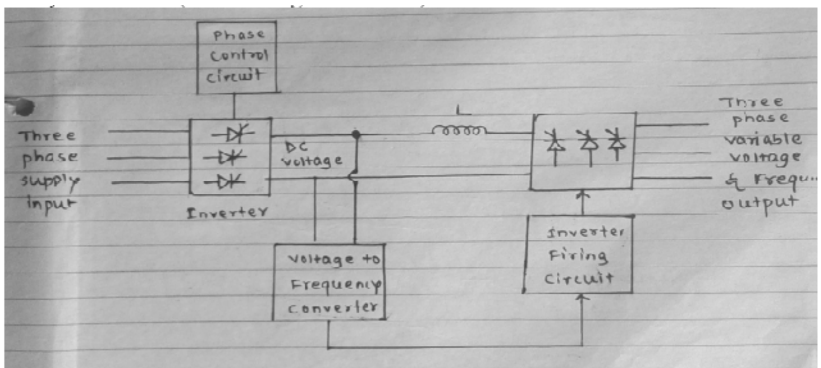
e)	**List out speed control methods for 3-phase induction motor. Explain any one in brief.**

Ans: **(List : 2 Marks & 2 Marks for any one method explanation)**

Following methods to control the speed of 3 phase induction motor: (Explanation of any one method is expected)

1) By Varying applied frequency (Frequency control)
2) By varying applied voltage (Stator voltage control)
3) Rotor resistance control.
4) By varying number of poles of the stator winding (Pole Changing)
5) By Voltage/ frequency control (V/f) method

1. by varying applied Frequency (Frequency control):



Frequency control method block diagram.

- The synchronous speed of an induction motor is given by $N_S = \frac{120 \times f}{P}$.
- It is clear from the equation that the speed of the induction motor can be changed by changing the frequency of the supply.
- The speed of the motor will increase if frequency increases and vice versa.
- Changing the frequency of supply to the motor is difficult. Therefore this method is only employed where the variable frequency alternator is available for the above purpose.

2. By varying applied voltage (Stator voltage control):

- This method is very easy but rarely used in commercial practice because a large variation of voltage produces a very small change in speed and much energy is wasted.
- In this method three resistances are inserted in series with the stator winding of the motor and the value of these resistances is varied by a common handle, so that equal resistances come in the stator circuit.
- For a particular load when voltage increases, speed of the motor also increases and vice-versa.

3. By rotor rheostatic control (Rotor Resistance control): For slip ring I.M. only

- In this method star connected external resistances (of continuous rating) are connected in the rotor circuit.
- The speed of the motor increases with the decrease of resistance in the rotor circuit.
- The change in speed is approximately inversely proportional to the external resistance connected in the rotor circuit.
- This method of the speed control is applied where a small variation of speed is required and the power wasted is not having great importance.

4. Pole Changing :

a) Speed control using two separate winding-

An induction motor stator is wound for fixed number of poles. The speed of the induction motor depends upon the number of poles for which stator is wound. If instead of one stator winding two independent windings are wound for a different number of poles then two definite speeds can be obtained. e.g. one winding for 4- pole and another winding for 8-poles them speeds can be achieved. Two windings are insulated from one another when any one of the winding is used, the other should be kept open circuited by the switch or kept star connected.

$$N_S = \frac{120 \times f}{P}$$

b) Speed control using consequent pole technique-

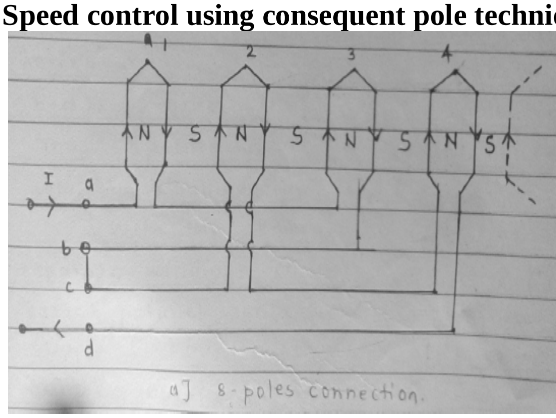


Fig (a)

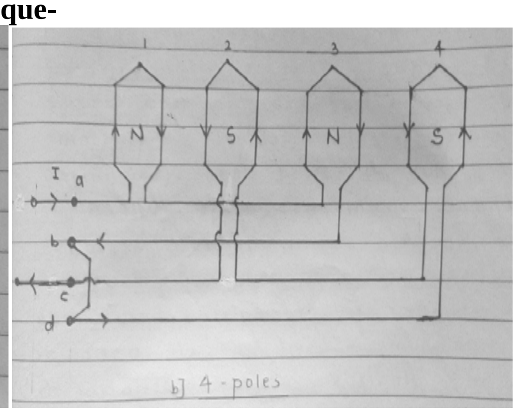


Fig (b)

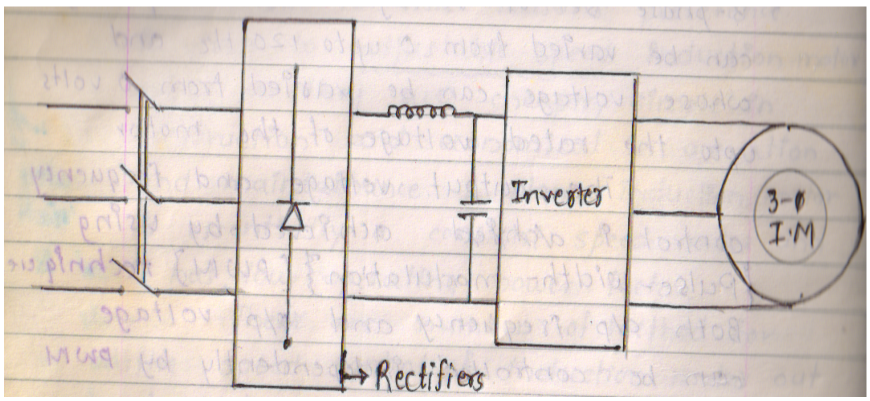
This method is used for obtaining multispeed in squirrel cage induction motor. In this method only one winding is used and it is provided with some simple switching means (device), so that connections of coils with supply are changed and different number of poles is formed. This is explained as below-

- Above fig (a) shows developed winding diagram for one phase of balanced three phase winding.
- Coil-1 & c oil-3 are in series and they form one coil group while coil-2 & coil-4 connected

in series to form another coil group. These two coil groups are connected in series such that all coils are magnetized in the same direction.

- Hence these coils form 4-North poles and 4-South poles. Thus this arrangement gives total 8-poles.
- If two coil groups are connected in series as shown in fig (b), there will be only 4- poles formed. Thus synchronous speed in this case will be doubled than first case.

5. By Voltage/ frequency control (V/f) method:

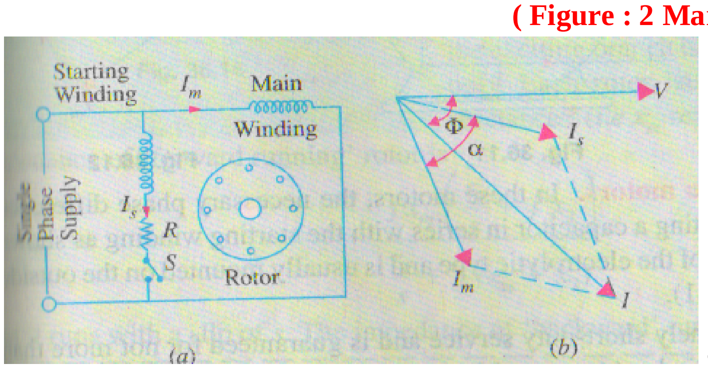


- If the ratio of voltage to frequency is kept constant, the flux remains constant.
- The maximum torque which is independent of frequency can be maintained approximately constant.
- However at a low frequency, the air gap flux is reduced due to drop in the stator impedance and the voltage has to be increased to maintain the torque level.
- This type of control is usually known as Volts/ Hertz or V/f control.
- A simple circuit arrangement for obtaining variable voltage and frequency is as shown in the above figure.

f) **Draw the schematic representation and state the principle of working of split phase single phase induction motor.**

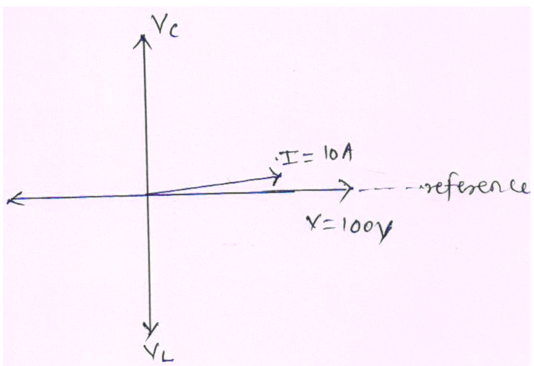
Ans: **Circuit diagram of resistance split single phase induction motor:**

(Figure : 2 Marks & Working : 2 Marks)



or equivalent figure

	Working of resistors split single phase induction motor: ➢ In resistors split phase I.M. shown in above figure ‘a’, the main winding has low resistance but high reactance whereas the starting winding has a high resistance, but low reactance. ➢ The resistance of the starting winding may be increased either by connecting a high resistance ‘R’ in series with it or by choosing a high-resistance fine copper wire for winding purpose. ➢ A centrifugal switch S is connected in series with the starting winding and is located inside the motor. It function is to automatically disconnected the starting winding from the supply when the motor has reached 70 to 80 per cent of its full load speed.
Q.5	**Attempt any FOUR of the following : 16 Marks**
a)	**A resistance of 10 ohm, inductance of 0.1 H and capacitance of 100 microfarad are connected in series across 100 volts, 50 Hz, AC supply. Find : (i) current (ii) power factor (iii) power (iv) draw phasor diagram.**
Ans:	**I= V/Z** $X_L = 2\pi f L = 2\pi \times 50 \times 0.1$ $X_L = 31.4159\ \Omega$ ---------------- **(1/2 Mark)** $X_C = \frac{1}{2\pi f C}$ $= \frac{1}{2\pi \times 50 \times 100 \times 10^{-6}}$ $X_C = 31.8309\ ohm$ ---------------- **(1/2 Mark)** $\text{Im}pedance\ Z = \sqrt{(R)^2 + (X_l - Xc)^2}$ $\text{Im}pedance\ Z = \sqrt{(10)^2 + (31.4159 - 31.8309)^2}$ $\text{Im}pedance\ Z = 10.0035\ ohm$ ---------------- **(1/2 Mark)** **i) To Find Current=** $I = \frac{V}{Z}, = \frac{100}{10.0035}$ $I = 9.9964\ Amp$ ---------------- **(1/2 Mark)**

	ii) To Power Factor = $$Cos\ \phi = \frac{R}{Z}, = \frac{10}{10.0035}$$ $$Cos\phi = 0.9996$$ ---------- **(1/2 Mark)** **iii) Power =** $$P\ = V\ I\ Cos\ \phi$$ ---------- **(1/2 Mark)** $$P\ = 100 \times 10 \times 0.9996$$ $$P\ = 999.6426\ Watt$$ ---------- **(1/2 Mark)** **iv) Phasor diagram:** ---------- **(1/2 Mark)**  or equivalent figure	
b)	**Three identical coils each having a resistance of 15 ohm and an inductance of 0.03 H are in delta across 400 V, 50 Hz supply. Determine (i) impedance per phase (ii) phase current (iii) line current (iv) power consumed.**	
Ans:	**To Find Reactance :** $$X_L = 2\pi\ f\ L, \quad X_L = 2 \times \pi \times 50 \times 0.03$$ $$X_L = 9.4247\ ohm$$ ---------- **(1/2 Mark)** **i) Find Phase Impedance :** $$Impedance\ \ Z\ = \sqrt{(15)^2 + (9.4247)^2}$$ ---------- **(1/2 Mark)** $$Impedance\ \ Z\ = 17.7151\ \Omega$$ ---------- **(1/2 Mark)**	

	ii) To Find Phase Current : $$I_{Ph} = \frac{V_{Ph}}{Z_{Ph}}, = \frac{400}{17.7151}$$ $$I_{Ph} = 22.5796\ Amp$$ --- **(1/2 Mark)** **iii) To Find Line Current :** $$I_L = \sqrt{3} \times I_{Ph} = \sqrt{3} \times 22.5796$$ $$I_L = 39.1090\ Amp$$ --- **(1/2 Mark)** **To Find Power Factor :** $$Cos\ \phi = \frac{R}{Z}, = \frac{15}{17.7151}$$ $$Cos\phi = 0.8467$$ -- **(1/2 Mark)** **(iv) power consumed :** $$P = \sqrt{3}\ V_L I_L\ Cos\ \phi$$ --- **(1/2 Mark)** $$P = \sqrt{3} \times 400 \times 39.1090 \times 0.8467$$ $$P = 22941.76833\,Watt \approx 2.2\text{kw}$$ ---------------------------------- **(1/2 Mark)**
c)	**A 200 kVA, 3300/240 V, 50 Hz single phase transformer has 80 turns on secondary winding. Calculate (i) Primary current and secondary current on full load. (ii) Maximum value of flux (iii) Number of primary winding turns.**
Ans:	$V_I = 3300\,V$ $V_2 = 240\,V$ $N_I = ?$ $N_2 = 80$ $I_1 = ?$ $I_2 = ?$ **i) To Find full load Primary current I_1:-** $$I_1 = \frac{KVA \times 10^3}{V_1\ volt}$$ --- **(1/2 Mark)**

$$I_1 = \frac{200 \times 10^3}{3300}$$

$I_1 = 60.6060\ Amp$ -- **(1/2 Mark)**

To Find full load Secondary I_2:

$I_2 = \frac{KVA \times 10^3}{V_2\ volt}$ ……………………………………….. **(1/2 Mark)**

$$I_2 = \frac{200 \times 10^3}{240}$$

$I_2 = 833.333\ Amp$ -- **(1/2 Mark)**

ii) Number of primary winding turns N_1:

$$\frac{V_2}{V_1} = \frac{N_2}{N_1} \quad \text{OR} \quad \frac{V_1}{V_2} = \frac{N_1}{N_2} ,$$

$N_1 = \frac{V_1}{V_2} \times N_2$ -- **(1/2 Mark)**

$$N_1 = \frac{3300}{240} \times 80$$

$N_1 = 1100\ \ turns$ -- **(1/2 Mark)**

iii) Maximum flux:

$E_1 = 4.44\, \phi_m\ f\ N_1$ -- **(1/2 Mark)**

$$\phi_m = \frac{E_1}{4.44 \times f \times N_1}$$

$$\phi_m = \frac{3300}{4.44 \times 50 \times 1100}$$

$\phi_m = 0.01351 Wb$ -- **(1/2 Mark)**

d) **Compare squirrel cage and slip ring induction motor on the basis of : (i) rotor construction (ii) starting torque (iii) efficiency (iv) application.**

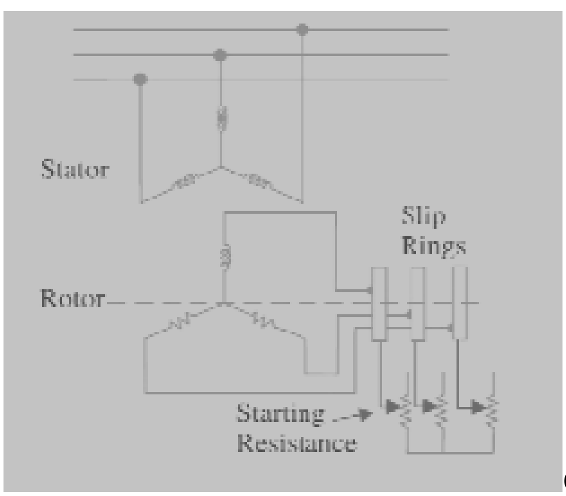
Ans: **(Each Point -1 Mark)**

S.No	Points	Squirrel Cage Induction Motor	Slip Ring Induction Motor
i)	Rotor construction	Simple and robust, Rotor is permantaly short circuited	Complicated and bulkily, Rotor one end is connected to slip rings.
ii)	Starting torque	Poor	Higher
iii)	Efficiency	Better	Lower
iv)	Applications.	For driving somehow constant load e.g. Lathe Machine, Workshop Machine and water pump and constant speed applications	For driving heavy load where high starting torque is required e.g. Lift, Crane, Elevators, conveyor belts etc and variable speed applications

e) **Explain in brief constructional detail of slip ring induction motor.**

Ans: **Constructional detail of slip ring induction motor:**

(Figure : 2 Mark & Construction: 2 Mark)



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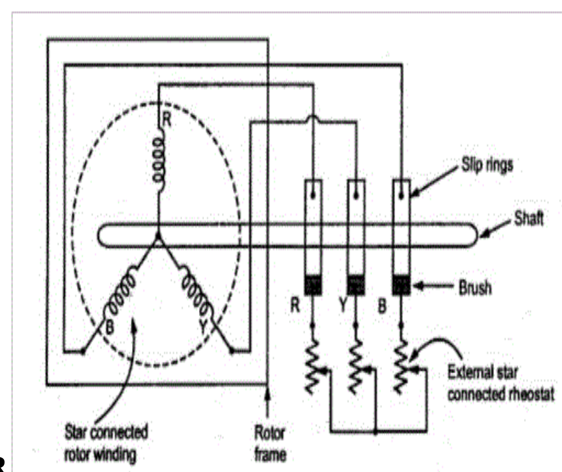


Explanation:

- It consist laminated cylindrical core and it carries three phase windings.

	➢ The rotor winding may be single layer or double layer. ➢ The rotor winding is uniformly distributed in slots and it is always star connected. ➢ Rotor is wound for same number of poles as that of the stator winding. ➢ Three phases of rotor winding is are shorted internally to form star point and other three winding terminals are brought out and joined to three insulated slip rings mounted on the rotor shaft. ➢ One brush is resting on each slip ring. These three brushes are further externally connected to three phase star connected rheostat.
f)	**Write four applications of stepper motor.**
Ans:	**Following are the applications of stepper motor: (Any Four Applications expected: 1Mark each)** 1.Suitable for use with computer controlled system 2. Widely used in numerical control of machine tools. 3. Tape drives 4. Floppy disc drives 5. Computer printers 6. X-Y plotters 7. Robotics 8. Textile industries 9. Integrated circuit fabrication 10. Electric watches 11. In space craft's launched for scientific explorations of planets. 12. In the production of science friction movies 13 Automotive 14. Food processing 15. Packaging
Q.6	**Attempt any FOUR of the following : 16 Marks**
a)	**Three impedances each of 3 ohm resistance and 4 ohm inductive reactance in series are connected in star across 3-phase, 400 V, 50 Hz, AC supply. Determine : (i) Phase current (ii) Line current (iii) Power factor (iv) Total power.**
Ans:	$X_L = 4\ ohm$ **Impedance Find Impedance =** $\text{Impedance}\ Z = \sqrt{(R)^2 + (X_L)^2}$ --- **(1/2 Mark)** $\text{Impedance}\ Z = \sqrt{(3)^2 + (4)^2}$

$Impedance\ Z = 5\,\Omega$ -- **(1/2 Mark)**

Phase voltage:

$$V_{Ph} = \frac{V_L}{\sqrt{3}} = \frac{400}{\sqrt{3}}$$

$V_{Ph} = 230.94\ Volt$ --- **(1/2 Mark)**

(i) Phase current :

$$I_{Ph} = \frac{V_{Ph}}{Z_{Ph}}, = \frac{230.94}{5}$$

$I_{Ph} = 46.188\ Amp$ -- **(1/2 Mark)**

(ii) Line current :

$$I_L = I_{Ph}$$

$I_L = 46.188\ Amp$ -- **(1/2 Mark)**

(iii) Power factor :

$$Cos\,\phi = \frac{R}{Z}, = \frac{3}{5}$$

$Cos\phi = 0.6$ --- **(1/2 Mark)**

(iv) Total power.

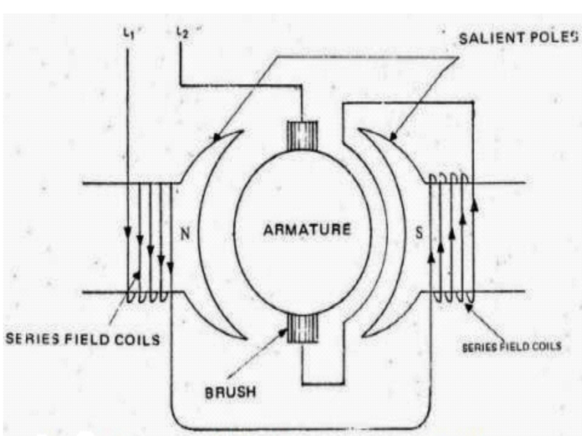
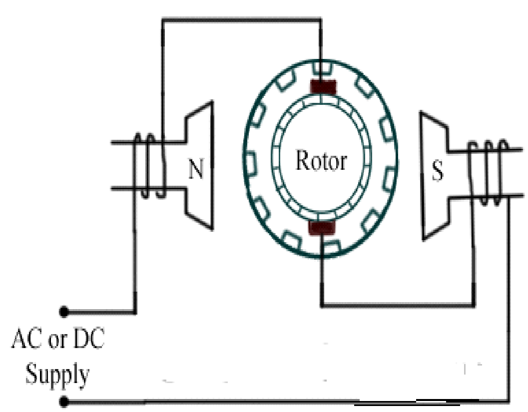
$P = \sqrt{3}\ V_L I_L\ Cos\,\phi$ -- **(1/2 Mark)**

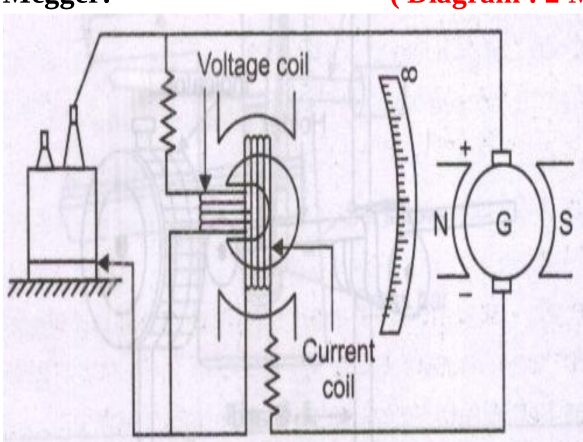
$$P = \sqrt{3} \times 400 \times 46.188 \times 0.6$$

$P = 19199.99105\,Watt$ -- **(1/2 Mark)**

$$P = 19.1999\ KWatt$$

b)	**A 100 kVA, single phase transformer has a full load Cu loss of 3 kW and iron loss of 2 kW. Find the efficiency of the transformer at half and full load at unity power factor.**
Ans:	**Efficiency at half Load** $\eta_{HL} = \frac{1/2 \times KVA \times Cos\phi}{1/2 \times KVA \times Cos\phi + Iron\ losses + (1/2)^2\ copper\ losses} \times 100$ --- **(1 Mark)** $\eta_{HL} = \frac{1/2 \times 100 \times 1}{1/2 \times 100 \times 1 + 2 + 0.75} \times 100$ $\eta_{HL} = 94.79\ \%$ -- **(1 Mark)** **Efficiency at Full Load** $\eta_{FLL} = \frac{KVA \times Cos\phi}{KVA \times Cos\phi + Iron\ losses + copper\ losses} \times 100$ -- **(1 Mark)** $\eta_{FLL} = \frac{100 \times 1}{100 \times 1 + 2 + 3} \times 100$ $\eta_{FL} = 95.23\ \%$ --- **(1 Mark)**
c)	**A single phase transformer delivers 10 A at 220 V to a resistive load while the primary draws 6 A at 0.9 lagging power factor from 450 V, 50 Hz supply. The turns ratio of the transformer is 2. Calculate the percentage efficiency and percentage regulation in this condition.**
Ans:	$W_1 = V_1\ I_1\ Cos\phi_1$ --- **(1/2 Mark)** $W_1 = 450 \times 6 \times 0.9$ $W_1 = 2430\ Watt$ $W_2 = V_2\ I_2\ Cos\phi_2$ --- **(1/2 Mark)** $W_2 = 220 \times 10 \times 1$ $W_2 = 2200\ Watt$ **Percentage efficiency:** **%** $\eta = \frac{W_2}{W_1} \times 100$ --- **(1/2 Mark)** **%** $\eta = \frac{2200}{2430} \times 100$ **%** $\eta = 90.5349\ \%$ -- **(1/2Mark)**

	% Regulation $\frac{N1}{N2} = 2Given$ $K = \frac{N2}{N1} = 0.5$ $K = \frac{V2}{V1} = 0.5$ ---------------------------------------**(1/2 Mark)** No load secondary voltage V2= 0.5x V1 = 0.5x450 =225 volt ---------------------------------**(1/2 Mark)** $\% \text{ Regulation} = \frac{No\ load\ secondary\ voltage - full\ load\ secondary voltgae}{full\ load\ secondary voltgae} \times 100$ ------ **(1/2 Mark)** $\% \text{ Regulation} = \frac{225-220}{225} \times 100$ **% Regulation =2.22 %**--------------------------- **(1/2 Mark)**
d)	**Explain the principle of working of universal motor.**
Ans:	**Figure of Universal motor:** **(Figure : 2 Marks & Explanation : 2 Marks)** OR 

	OR Equivalent figure **Working of universal motor:** ➢ A universal motor works on either DC or single phase AC supply. When the universal motor is fed with a DC supply, it works as a DC series motor. When current flows in the field winding, it produces an electromagnetic field. The same current also flows from the armature conductors. When a current carrying conductor is placed in an electromagnetic field, it experiences a mechanical force. Due to this mechanical force, or torque, the rotor starts to rotate. The direction of this force is given by Fleming's left hand rule. When fed with AC supply, it still produces unidirectional torque. Because, armature winding and field winding are connected in series, they are in same phase. Hence, as polarity of AC changes periodically, the direction of current in armature and field winding reverses at the same time. Thus, direction of magnetic field and the direction of armature current reverses in such a way that the direction of force experienced by armature conductors remains same. Thus, regardless of AC or DC supply, universal motor works on the same principle that DC series motor works.
e)	**Draw and explain working of megger.**
Ans:	**Diagram of Megger:** **(Diagram : 2 Mark & Working : 2 Marks)**  **or equivalent figure** **Working of Megger:** ➢ The voltage for testing is supplied by a hand generator incorporated in the instrument or by battery or electronic voltage charger. It is usually 250V or 500V and is smaller in size.

	➢ A test volt of 500V D.C is suitable for testing ship's equipment operating at 440V A.C. Test voltage of 1000V to 5000V is used onboard for high voltage system onboard. ➢ The current carrying coil (deflecting coil) is connected in series and carries the current taken by the circuit under test. The pressure coil (control coil) is connected across the circuit. ➢ Current limiting resistor – CCR and PCR are connected in series with pressure and current coil to prevent damage in case of low resistance in external source. ➢ In hand generator, the armature is moving in the field of permanent magnet or vice versa, to generate a test voltage by electromagnetic induction effect. ➢ With an increase of potential voltage across the external circuit, the deflection of the pointer increases; and with an increase of current, the deflection of pointer decrease so the resultant torque on the movement is directly proportional to the potential difference and inversely proportional to the resistance. ➢ When the external circuit is open, torque due to voltage coil will be maximum and the pointer will read "infinity". When there is short circuit the pointer will read "0".
f)	**What is ELCB and MCCB? State its function.**
Ans:	**ELCB Means:** **(1 Marks)** Earth Leakage circuit breaker **Function of ELCB :** **(1 Marks)** ➢ An Earth Leakage Circuit Breaker (ELCB) is a device used to directly detect currents leaking to earth from an installation and cut the power and avoid the person getting shock. **MCCB Means:** **(1 Marks)** Moulded Case circuit breaker **Function of MCCB :** **(1 Marks)** ➢ MCCB is a protective device which disconnected the system under abnormal condition.such as over current due to short circuit or over load.

---END---