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	Attempt any FIVE of the following : 10 Marks
a)	**State Faraday's law of Electromagnetic Induction**
Ans	**First Law: - ----------(1 Mark)** Whenever change in the magnetic flux linked with a coil or conductor, an EMF is induced in it. **OR** Whenever a conductor cuts magnetic flux, an EMF is induced in conductor. **Second Law: ---------- (1 Mark)** The Magnitude of induced EMF is directly proportional to (equal to) the rate of change of flux linkages. $e = \frac{-N}{dt} d\varphi$
b)	**Define following terms with respect to A.C. quantity. (i) Time period (ii) Frequency**
Ans	**i) Time Period: ----------(1 Mark)** The time (in sec) required by an alternating quantity to complete its one cycle is known as time period. **ii) Frequency: (1 Mark)** It is the number of cycles completed by an alternating quantity in one second.
c)	**State the relationship between line current and phase current for star and delta connection.**
Ans	**(i) Star connected: (1 Mark)**

a) The relation between line current and phase current in star connected load.

$$I_L = I_{ph}$$

b)The relation between line voltage and phase voltage in star connected Load

$$V_L = \sqrt{3}\, V_{Ph}$$

(ii) Delta connected load: **(1 Mark)**

a) The relation between line current and phase current in delta connected circuit.

$I_L = \sqrt{3}\ \ I_{ph}$ *OR* $I_{ph} = I_L / \sqrt{3}$ *where* I_L *is line Current and* I_{ph} *is phase Currnts*

b) The relation between line voltage and phase voltage in delta connected circuit

$V_{ph} = V_L$ *where* V_L *= line voltage &* Vph *= Phase volatge*

d) State the working principle of transformer.

Ans **Working Principle: - ---------- (2 Marks)**

- The primary winding is connected to single phase AC supply. an ac current starts flowing through primary winding.
- The AC primary current produces an alternating flux in the magnetic core.
- This Changes flux gets linked with the secondary winding through the magnetic core
- The varying flux will induce voltage into the secondary winding according to the faraday's laws of electromagnetic induction.

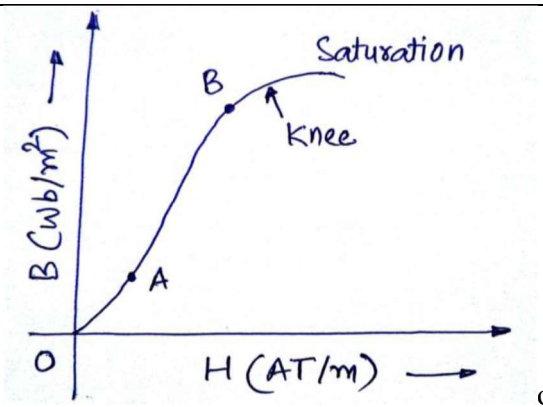
OR

A Transformer works on the principle of Faradays law of electromagnetic induction. When their primary winding is connected to a.c supply, applied alternating voltage circulates an alternating current through it.

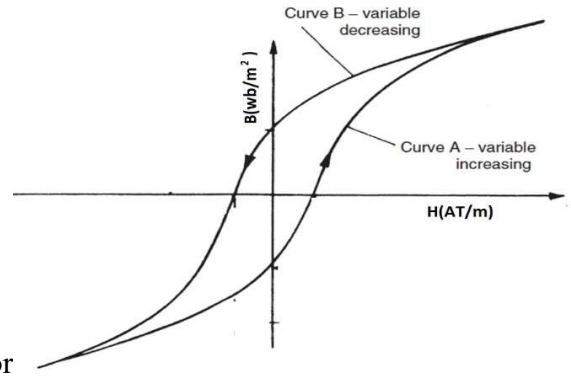
This current flowing through the primary winding produces an alternating magenetic flux (Ø).This flux links with secondary winding through the magenetic core & induces an emf in it according to the faraday's laws of electromagnetic induction.

e)	**Write any four main parts of d.c. motor.**
Ans	**Parts of DC Motor:----------(Any four parts expected: 1/2 Marks each, Total 2 Marks)** 1) Yoke: 2) Pole Cores & Pole shoe: 3) Armature core: 4) Armature winding: 5) Commentator: 6) Brush: 7) Cooling Fan: 8) End covers 9) Field winding
f)	**Write any two applications of each motor. (i) Universal motor (ii) Stepper motor**
Ans	**(Any two applications are accepted from following or equivalent 1 Mark each point)** **i) Application of Universal Motor :** 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 **ii) Applications of stepper motor-** **(Any two applications are accepted from following or equivalent 1 Mark each point)** 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 Automotive 13. Food processing 14. Packaging
g)	**State any two methods of reducing earth resistance.**
Ans	**(Any Two methods expected: 1 Marks for each, Total 2 Marks)** **Methods of reducing earth resistance:** Earth resistance can be minimized using any of the following measures 1. By increasing length of the earth electrode 2. By increasing no of earthing rods 3. By treatment of the soil. Soil treatment involve treating the soil with a salt, such as copper sulfate, magnesium sulfate, or sodium chloride. Combined with moisture, the salts leach into the soil to reduce earth resistivity.
Q.2	**Attempt any THREE of the following : 12 Marks**
a)	**Draw and explain B-H curve of magnetic material.**
Ans:	**B-H curve: (Diagram ; 2 Marks & Explanation: 2 Marks)** The B-H curve is the graphical representation of relation between flux density (B) and applied field strength (H), with H plotted on the x-axis and B plotted on the y-axis. Typical B-H curve is as shown in figure below:



or



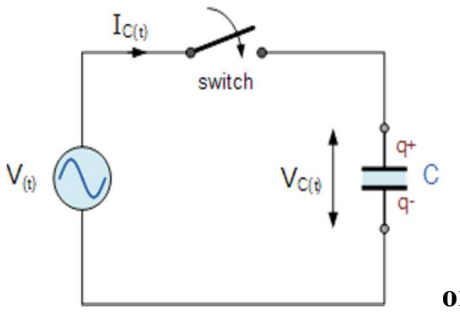
OR Equivalent Figure

The B-H curve can be described by dividing it into 3 regions.

- **Region OA:** For zero current, H = 0 and B is also zero. The flux density B then increases gradually as the value of H is increased. However B changes slowly in this region.
- **Region AB:** In this region, for small change in H, there is large change in B. The B-H curve is almost linear in this region.
- **Region beyond B:** After point B, the change in B is small even for a large change in H. Finally, the B-H curve will tend to be parallel to X axis. This region is called as saturation region.

b) **Draw purely capacitive circuit. Show vector diagram and waveform and write formula for capacitive reactance.**

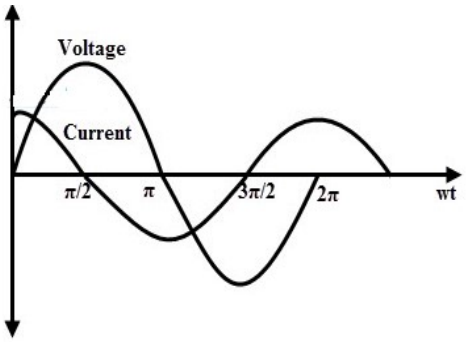
Ans: **Schematic diagram of purely capacitive circuit:** **(1 Mark)**



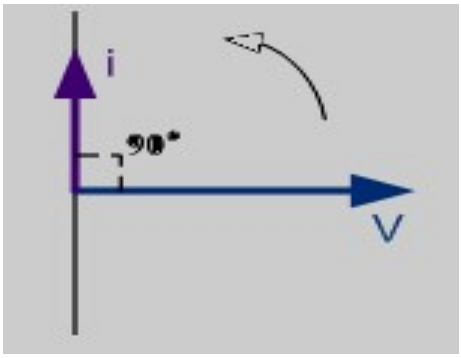
or equivalent Diagram

Pure capacitive circuit: **(Waveform: 1 Mark & Vector Diagram 1 Mark)**

Waveform:



Vector Diagram :



Formula for capacitive reactance: **(1 Mark)**

$$X_C = \frac{1}{2\pi \times f\ C}$$

Where:

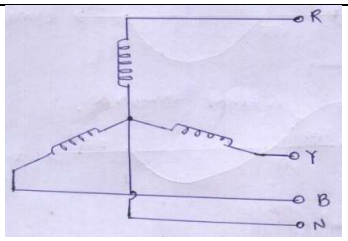
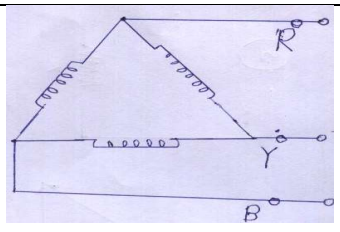
X_C = Capacitive reactance in ohm

f = Frequency in Hz

C = Capacitance in farad

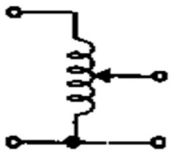
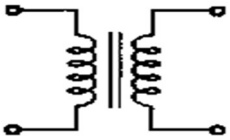
c) Compare star and delta connection on basis : (i) Connection diagram (ii) Neutral (iii) Line and phase current (iv) Line and phase voltage.

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

Sr no	Parameter	Star connection	Delta connection
1.	connection diagram		
2.	Neutral	Neutral point formed	No neutral point formed
3.	Line & Phase current	$I_L = I_{Ph}$	$I_L = \sqrt{3}\ I_{Ph}$
4.	Line & phase voltage	$V_L = \sqrt{3}\ V_{Ph}$	$V_L = V_{Ph}$

d) Compare auto transformer with two winding transformer on following basis: (i) Symbol (ii) Copper saving (iii) Isolation (iv) Application

Ans: **(1 Mark each point, total 4 Marks)**

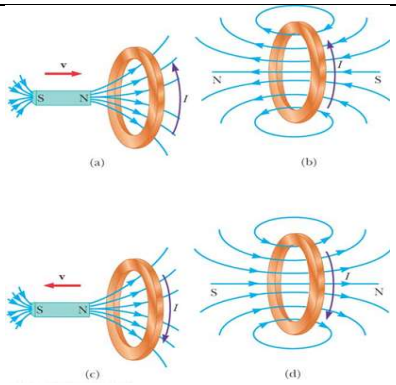
S.No.	Points	Autotransformer	Two winding transformer
1.	**Symbol**		
2.	**Copper saving**	Copper saving takes more as compared to two winding	Copper saving is less
3.	**Isolation**	There is no electrical isolation	Electrical isolation is present in between primary and secondary winding
4.	**Application**	Variac, starting of ac motors, dimmerstat.	Mains transformer, power supply, welding, isolation transformer

Q.3 Attempt any THREE of the following : 12 Marks

a) Explain with neat diagram Lenz's law. State its any two applications.

Ans: **(1 Marks for explanation and 2 marks for figure, 1 for application)**

Lenz's law of electromagnetic induction states that the direction of the current induced in a conductor by a changing magnetic field (as per Faraday's law of electromagnetic induction) is such that the magnetic field created by the induced current *opposes* the initial changing magnetic field which produced it. The direction of this current flow is given by Fleming's right hand rule.



As the magnet moves to the right toward the loop, the external magnetic flux through the loop increases with time. As the result, the induced current set up in the loop which produces magnetic field, as illustrated in figure (b).Knowing that like magnetic poles repel each other, we conclude that the left face of the current loop acts like a north pole and that the right face acts like a south pole.

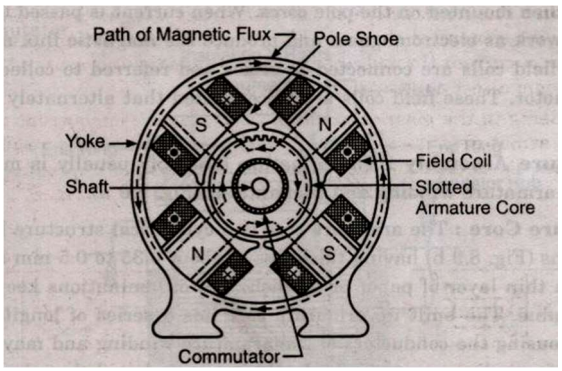
If the magnet moves to the left, as in figure (c), its flux through the area enclosed by the loop decreases in time. Now the induced current in the loop produces the magnetic field as shown in figure (d).In this case, the left of the loop is a south pole and the right face is a north pole.

Lenz law applications are plenty. Some of them are listed below-

1. Eddy current balances
2. Metal detectors
3. Eddy current dynamometers
4. Braking systems on train
5. AC generators
6. Card readers
7. Microphones

b) Explain the working principle of d.c. motor with neat sketch.

Ans: **(Figure-2, & Working principle : 2 Mark, Total 4 Mark)**



OR Equivalent Fig

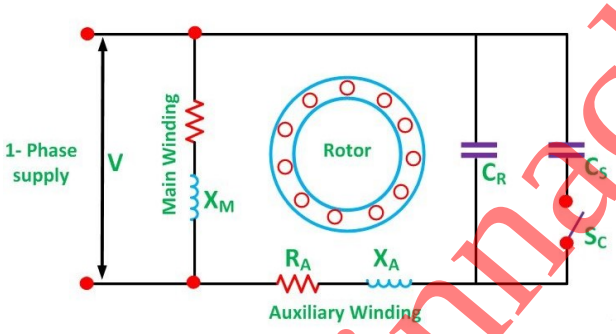
Working Principle of D.C Motor :- **(2 Marks)**

It works on Faradays law of electromagnetic induction -If a current carrying conductor is placed in a magnetic field, mechanical force is experienced on the conductor, the direction of which is given by Fleming's left-hand rule (also called motor rule) and hence the conductor moves in the direction of force.

c) Explain the principle of operation of capacitor start capacitor run motor.

Ans: **Schematic representation of capacitor start capacitor run induction motor:**

(Diagram-2 Marks & Operation-2 Marks)



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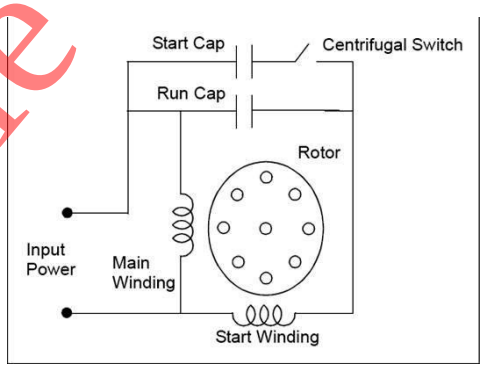


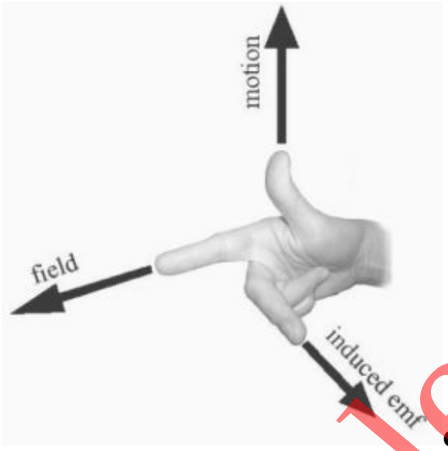
operation of capacitor start capacitor run motor:

In these motors one capacitor is connected in series with the auxiliary winding. There is no centrifugal switch. Thus this winding along with the capacitor remains energized for both starting and running conditions. **Capacitor serves the purpose of obtaining necessary phase displacement at the time of starting and also improves the power factor of the motor.**

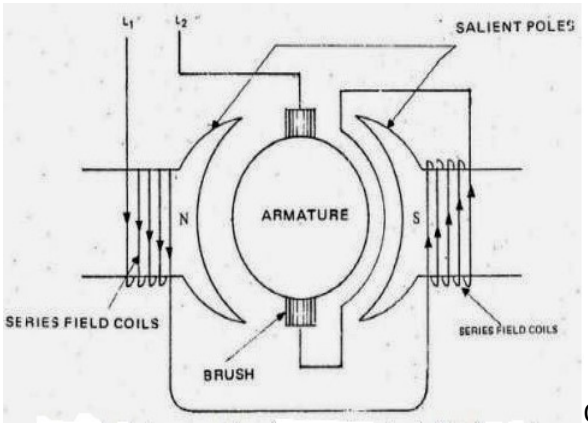
d) Explain the importance of earthing.

Ans: Importance of Earthing: **(Any Four point are expected: 1 Mark each, Total 4 Marks)**

1. To provide an alternative path for the leakage current to flow towards earth.
2. To save human life from danger of electrical shock due to leakage current.
3. To protect high rise buildings structure against lightening stroke.
4. To provide safe path to dissipate lightning and short circuit currents.
5. To provide stable platform for operation of sensitive electronic equipment's.

Q.4	Attempt any THREE of the following : 12 Marks
a)	**Explain how Fleming's right hand rule helps to deciding direction of induced EMF.**
Ans:	**Fleming's Right Hand Rule: (Figure: 2 Marks & Explanation: 2 Marks, Total 4 Marks)**  **or equivalent figure** Stretch out the first three fingers of your right hand such that they are mutually perpendicular to each other, align first finger in direction of magnetic field, thumb in direction of motion of conductor with respect to magnetic field, then the middle finger will give the direction of induced emf in conductor.
b)	**Write any two applications of each of the following: (i) DC Shunt motor (ii) DC series motor.**
Ans:	**i) Applications of DC shunt motor: (Any Two applications expected: 1 Mark each)** 1. Line shafts 2. Lathes 3. Vacuum cleaners 4. Pressure blowers 5. Reciprocating pumps 6. Wood working machines **ii) DC Series Motor : (Any Two applications expected: 1 Mark each)** 1. Electric traction 2. Cranes, 3. Passenger elevators, 4. Continuous conveyors, 5. Grinders, 6. Polishers,

c)	**Explain principle of operation of universal motor with neat diagram.**
Ans:	**Figure of Universal motor:** **(Figure : 2 Marks & Explanation : 2 Marks)**



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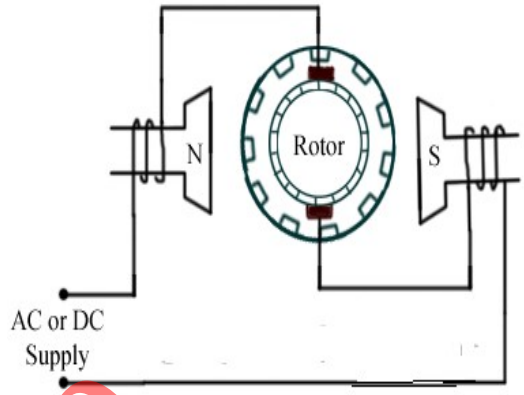


OR Equivalent figure

Working of universal motor: **(Following or equivalent working is to be accepted)**

- 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 t
- o this mechanical force, or torque, the rotor starts to rotate. The direction of this force is given by Fleming's left hand rule.

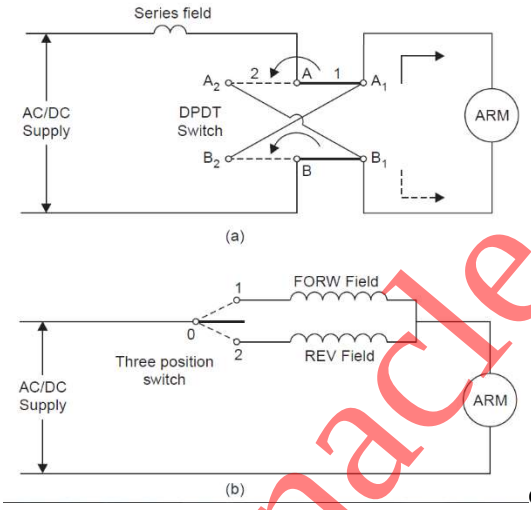
  When fed with AC supply, it still produces unidirectional torque. Because, armature winding and field winding are connected in series, they are in same phase. Hence, as polarity of AC changes periodically, the direction of current in armature and field winding reverses at the same time. Thus, direction 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.

d)	**Explain how direction of rotation of universal motor is reversed.**
Ans:	**(2 Marks for explanation and 2 marks for figure)**

The direction of rotation of a universal motor can be changed by either: (i) Reversing the field connection with respect to those of armature; or (ii) By using two field windings wound

on the core in opposite directions so that the one connected in series with armature gives clockwise rotation, while the other in series with the armature gives counterclockwise rotation.

The second method, i.e., the two-field method is used in applications such as motor operated rheostats and servo systems. This method has somewhat simpler connections than the first method.



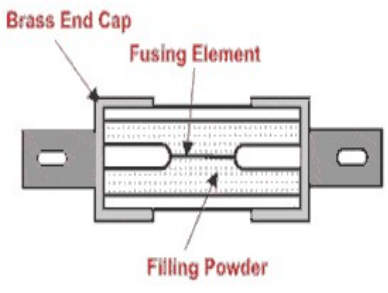
or equivalent Figure

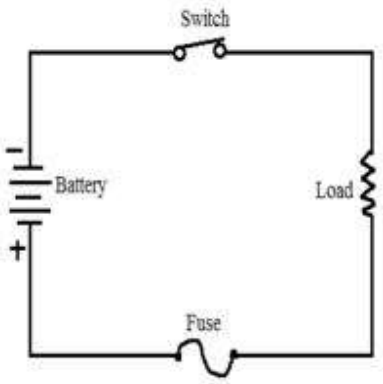
e) Explain the working of fuse with neat diagram.

Ans: **Working of fuse** **(2 Marks for explanation and 2 marks for figure)**

Fuse is an overcurrent/short circuit protection. The working principle of the fuse is based upon "heating effect of the electric current". It is fabricated in a form of strip or thread of metallic wire. The connection of the Fuse in an electrical circuit is always in series with device that is to be protected. Due to the heavy flow of current in the electrical circuit, the fuse gets melted soften and it opens the circuit. The extreme flow of current may direct to the collapse of the wire and disconnection of the circuit that is protected

Diagram of Fuse:





Q.5	Attempt any TWO of the following : 12 Marks
(a)	**A sinusoidal voltage with equation, V = 200 sin (314 t + n/3) volt is applied to a load. Calculate (i) Maximum voltage (ii) RMS voltage (iii) Frequency (iv) Time period (v) Phase angle (vi) Angular frequency.**
Ans:	**Given data :** **v = 200 sin (314 t +** $\frac{\pi}{3}$ **)** **Maximum Value V_m :** 200 V **i) Maximum voltage V_m** = 200 volt ---------- **(1 Mark)** **ii) RMS value Vrms =** 0.707 x Vm---------- **(1/2 Mark)** = 0.707 x 200 = 141.4 Volt ---------- **(1/2 Mark)** **iii) Frequency** = $\frac{\omega}{2\pi}$ ---------- **(1/2 Mark)** $= \frac{314}{2\pi}$ $F = 49.97 \cong 50\ H_z$ ---------- **(1/2 Mark)** **iv) Time Period (T) :** $T = \frac{1}{F} = \frac{1}{49.97}$ ---------- **(1/2 Mark)** $T = 0.02$ sec - ---------- **(1/2 Mark)** **v)Phase angle** ϕ = $\frac{\pi}{3} = 60^0$ ---------- **(1/2 Mark)** $\phi = 60^0$ ---------- **(1/2 Mark)** **vi) Angular Frequency:** $\omega = 314$ rad/sec ----------**(1 Marks)**
b)	**Three similar coils each of resistance 20 ohm and on inductance 0.1 H are connected in delta to a 3-Ph, 440V, 50 Hz supply system. Calculate the phase current, line current, phase voltage, line voltage, active power and reactive power.**
Ans:	**Given Data:**

$R_{ph} = 20\,\Omega \qquad V_L = 440\,V \quad L = 0.1\,H \qquad F = 50Hz$

$$Z_{ph} = R_{ph} + X_{Lph}$$

$$X_L = 2\,\pi\,F\,L$$

$$X_L = 2\,\pi \times 50 \times 0.1$$

$$X_L = 31.41\ \Omega$$ ---------- **(1/2 Mark)**

$$Z_{ph} = R_{ph} + X_{Lph}$$

$$Z_{ph} = 20 + j\,31.41\,\Omega$$

$$Z_{ph} = 37.23 \angle 57.51\ \Omega$$

i) Line Voltage $= V_L = 440\,V$ ---------- **(1/2 Mark)**

ii) In Delta connection Line voltage = Phase voltage (V_{ph}):

$$V_L = V_{ph}$$

$$V_{ph} = 440\ volts$$ ---------- **(1/2 Mark)**

iii) Phase Current (I_{ph}) :

$$I_{ph} = \frac{V_{ph}}{Z_{ph}}$$ ---------- **(1/2 Mark)**

$$I_{ph} = \frac{440}{20 + j\,31.41}$$

$$I_{ph} = \frac{440}{37.23}$$

$$I_{ph} = 11.81\ Amps$$ ---------- **(1/2 Mark)**

iv) Line Current (I_L) :

$$I_L = \sqrt{3} \times I_{ph}$$

$$I_L = \sqrt{3} \times 11.81$$

$I_L = 20.54$ Amps ---------- **(1 Mark)**

Power Factor (P.F) :

$$Cos\phi = \frac{R}{Z}$$ ---------- (1/2 Mark)

$$Cos\phi = \frac{20}{37.23}$$

$Cos\phi = 0.5372\ lag$ OR $P.F = Cos\phi\ 57.51 = 0.5372\ lag$ --- (1/2 Mark)

v) Active Power (P_A) :

$$P_A = \sqrt{3}\ V_L\ I_L\ Cos\phi$$

$$P_A = \sqrt{3} \times 440 \times 20.45 \times 0.5372$$

$P_A = 8371.51\ watt$ ---------- (1/2 Mark)

vi) Reactive Power ($P_{reactive}$) :

$P_{reactive} = \sqrt{3}\ V_L\ I_L\ Sin\phi$ ---------- (1/2 Mark)

$P_{reacttive} = \sqrt{3} \times 440 \times 20.45 \times \sin 57.51$

$P_{reactive} = 13145.71\ VAR$ ---------- (1/2 Mark)

c) **A 1-ph 1.5 KVA. 230/110 V transformer used in a laboratory. Calculate primary winding current.**
(i) Secondary winding current (ii) Turns ratio. (iii) Current ratio

Ans:

i) Primary current (I_1):

$$I_1 = \frac{KVA}{V_1}$$ ---------- (1/2 Mark)

$$I_1 = \frac{1.5 \times 10^3}{230}$$

$I_1 = 6.5217\ \ Amp$

---------- (1/2 Marks)

ii) Secondary current (I_2):

$$I_2 = \frac{KVA}{V_2}$$ ---------- (1/2 Mark)

$$I_2 = \frac{1.5 \times 10^3}{110}$$

$$I_2 = 13.6364 \ \ Amp$$

---------- (1/2 Marks)

iii) Turns ratio:

$$K = \frac{N_1}{N_2} = \frac{V_1}{V_2} = \frac{230}{100} = 2.0909 \quad \textbf{or}$$

$$= \frac{N_1}{N_2} = \frac{I_2}{I_1} = \frac{13.6364}{6.5217} = 2.0909$$ ----------(02 Mark)

iv) Current ratio:

$$K = \frac{I1}{I2} = \frac{6.5217}{13.6364} = 0.4782$$

$$K = 0.4782$$ ----------(02 Mark)

Q.6	**Attempt any TWO of the following : 12 Marks**
a)	**Explain the principle of working of stepper motor with a neat diagram.**

Ans:

Working Principle of stepper Motor- **(1 Mark)**

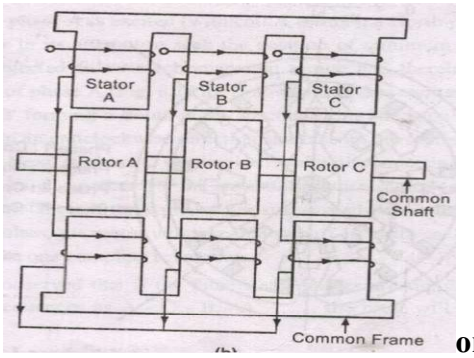
A stepper motor rotates through a fixed angular step in response to each input current pulse received by its controller.

Types of Stepper Motor :- **(1 Mark)**

1) Variable Reluctance Motor
2) Permanent Magnet Motor

1) Variable Reluctance Motors:-

(Any One method explanation expected: Diagram : 2 Marks and Working: 2 Mark)



or equivalent dia.

Working:-

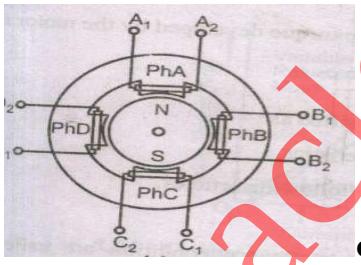
When phase A is excited rotor attempts minimum reluctance between stator and rotor and is subjected to an electromagnetic torque and there by rotor rotates until its axis coincides with the axis of phase A.

Then phase 'B' is excited disconnecting supply of phase 'A' then rotor will move 30 anticlockwise directions. The Same process is repeated for phase 'C'

In this way chain of signals can be passed to get one revolution and direction can be also changed.

OR

2) Permanent Magnet Motor:-



or equivalent dia.

Working :-

If the phase is excited in ABCD, due to electromagnetic torque is developed by interaction between the magnetic field set up by exciting winding and permanent magnet.

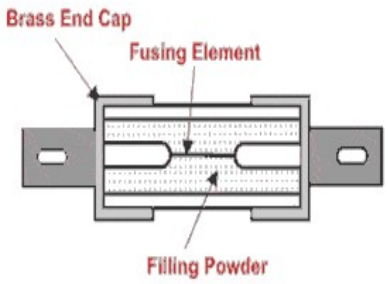
Rotor will be driven in clockwise direction.

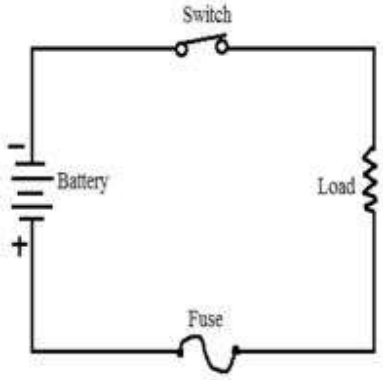
b) Explain the operation of each of the following : (i) Fuse (ii) ELCB

Ans: **i) Working of fuse :** **(2 Marks for explanation and 1 Marks for figure)**

Fuse is an overcurrent/short circuit protection. The working principle of the fuse is based upon "heating effect of the electric current". It is fabricated in a form of strip or thread of metallic wire. The connection of the Fuse in an electrical circuit is always in series with device that is to be protected. Due to the heavy flow of current in the electrical circuit, the fuse gets melted soften and it opens the circuit. The extreme flow of current may direct to the collapse of the wire and disconnection of the circuit that is protected

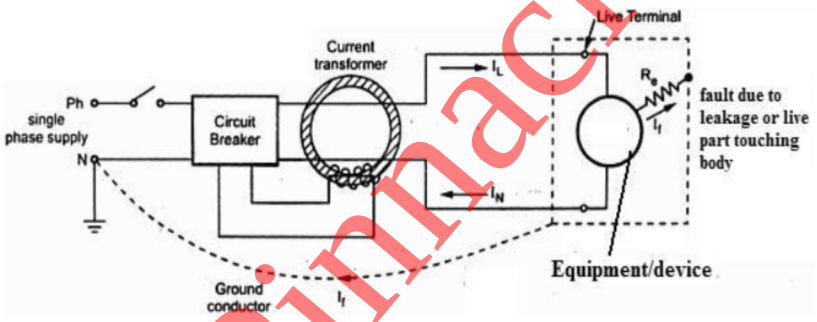
Diagram of Fuse:





or equivalent figure

ii) Diagram of ELCB (Earth Leakage Circuit Breaker) : **(1 Marks)**



OR

Equivalent Figure

Operation of ELCB (Earth Leakage Circuit Breaker) : **(2 Marks)**

- It works on principle of relaying when the current in the earth path exceeds a set value.
- Under normal conditions (I_L–I_N) = I_f is very low or nearly zero. The CT surrounding the phase and neutral senses the differential current under earth fault and actuates the CB to operate (open). The difference current I_f through fault path resistance R_e is the leakage to earth. If this value exceeds a preset value, then the ELCB opens.

OR

The ELCB detects fault currents from live to the Earth (ground) wire within the installation it protects. If sufficient voltage appears across the ELCB's sense coil, it will switch off the power, and remain off until manually reset. A voltage-sensing ELCB does not sense fault currents from live to any other earthed body.

c)	Write any two applications of each of the following : (i) ELCB (ii) MCCB (iii) MCB (iv) Fuse

Ans:

i) Applications of ELCB : **(2 Marks)**

1. It is used for safety of the operator
2. It is used to detect presence of leakage current in a device

ii) Applications of MCCB : **(2 Marks)**

1. It is used as a protective device in low voltage distribution
2. It is used to protect secondary side of power distribution transformer
3. It is used for short circuit protection of motors

iii) Applications of MCB : **(1 Marks)**

1. It is used as an alternative to fuse in domestic and commercial applications
2. It is used in industrial control panels as overload protection and disconnection of supply
3. It is used in industrial heating systems.

iv) Applications of Fuse: **(1 Marks)**

1. Protection against overload and short circuit.
2. Electrical Appliances, like ACs (Air Conditioners), TV, Washing Machines, Music Systems, and
3. Many more.
4. Electrical Cabling in Home
5. Motor starters
6. Cameras, Scanners, Printers, and Photocopiers
7. Automobiles, electronic devices and Gaming's

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