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 should assess the understanding level of the candidate.

3) The language errors such as grammatical, spelling errors should not be given 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 should give credit for any equivalent figure/figures drawn.

5) Credits to 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 (as long as the assumptions are not incorrect).

6) In case of some questions credit may be given by judgment 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

**1** Attempt **any ten** of the following: **20**

1 a) Give the difference between AC and DC supply (any two).

**Ans:**

**Difference between AC and DC supply:**

| Sr. No | AC Supply | DC Supply |
|---|---|---|
| 1 | The voltage polarity changes alternately with time. | The voltage polarity is fixed and does not change with time. |
| 2 | The current continuously changes its magnitude with respect to time and the direction also gets reversed alternately. | The current magnitude and direction are fixed and do not change with time. |
| 3 | The frequency i.e cycles per sec is non-zero and finite. | The frequency is zero. |
| 4 | It is produced by rotary machines which convert mechanical energy into electrical energy. | It is produced by stationary device which converts chemical energy into electrical energy. |

1 mark for each of any two = 2 marks

1 b) Define: i) Frequency ii) Form factor.

**Ans:**

**i) Frequency:**

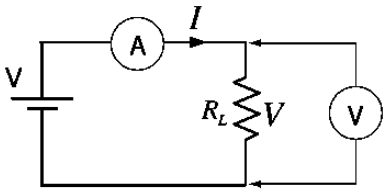
The number of cycles completed by an alternating quantity in one second is called as frequency. Its unit is cycles/second or hertz. 1 mark

**ii) Form factor:**

It is defined as the ratio of RMS value to the Average value of an alternating quantity. 1 mark

1 c) Draw connection diagram for ammeter and voltmeter.

**Ans:**




1 mark for ammeter connection
1 mark for voltmeter connection

1 d) Give different ratings of energy meter.

**Ans:**

**Ratings of Energy meter:**

1) Current rating
2) Voltage rating
3) Temperature
4) Meter constant
5) Frequency
6) No. of phases

1 mark for each of any two ratings = 2 marks

1 e) State any two parts of D. C. motor along with function.

**Ans:**

**Parts of DC Motor and their functions:**

| Sr. No | Part | Function |
|---|---|---|
| 1 | Yoke | i) It supports the other components such as poles and provides mechanical protection for whole machine.<br>ii) It forms a part of the magnetic circuit & provides the path of low reluctance for the magnetic flux. |
| 2 | Pole Core | It supports the exciting coils or field winding. |
| 3 | Pole Shoe | It spreads out flux in the air gap & its large cross section reduces the reluctance of the magnetic path. |
| 4 | Armature Core | i) Houses the armature conductors or coils and causes them to rotate, hence cut the magnetic flux<br>ii) Provides a low reluctance path to the flux through armature. |
| 5 | Armature Winding | i) To produce emf by cutting the flux, OR<br>ii) To produce force and cause rotation when it carries the current. |
| 6 | Commutator | To reverse the current in each conductor of the armature as it passes from influence of one pole to another and thus to help the motor to develop a continuous and unidirectional torque |
| 7 | Brush | To facilitate the electrical connection between stationary part and rotating part (commutator) |
| 8 | Cooling Fan | To provide better ventilation for effective cooling. |
| 9 | End Covers | To provide protection and support to the shaft. |

1 mark for each of any two parts = 2 marks

1 f) Define kVA rating of transformer.

**Ans:**

**kVA rating of transformer:**

The 'kVA rating' of a transformer is the apparent power in “kilo volt ampere” that can flow through a transformer without exceeding the limit of temperature rise. 2 marks

**OR**

**Any other valid definition**

1 g) State any two important applications of auto transformer.

**Ans:**

**Important applications of auto transformer:**

1) Variac
2) Dimmerstat
3) Starter for AC motor
4) Power transformer

1 mark for each of any two application s = 2 marks

1 h) List the applications of universal motor (any four).

**Ans:**

**Applications of universal motor:**

(i) Vacuum cleaners

½ mark for each of any four = 2 marks

(ii) Drink and food mixers
(iii) Domestic sewing machine
(iv) Portable drills
(v) Blenders
(vi) Dryers
(vii) Small water pumps

1 i) How the direction of rotation of 3-phase induction motor is reversed?

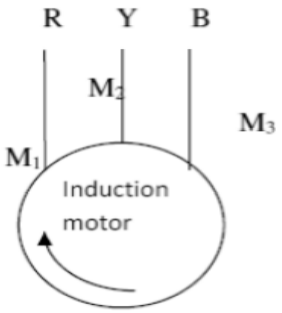
**Ans:**

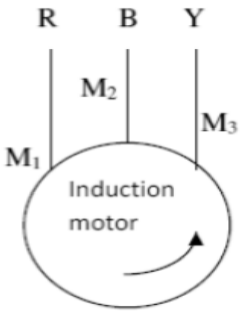
**Reversal of rotation of 3-phase induction motor:**

The direction of rotation of 3-phase induction motor is reversed by interchanging any two phases of motor terminals with supply terminals. 1 mark

The direction of rotation of 3-phase induction motor is reversed by changing the phase sequence of supply.

e.g. R-Y-B ---- clockwise direction
B-Y-R or Y-R-B or R-B-Y --- anticlockwise direction 1 mark for example




1 j) State two limitations of individual drive.

**Ans:**

**Limitations of individual drive:**

i) Cost is more
ii) Investment wasted if drive remains idle for longer time
iii) Power loss is more
iv) Space required will be more
v) More maintenance
vi) More cost of maintenance

1 mark for each of any two limitations

1 k) Name any two electrical machines used in electro-agro system.

**Ans:**

**Electrical machines used in electro-agro system:** 1 mark for each of any two = 2 marks

1. Induction motor in mono block and centrifugal pumps.
2. Electrical dryers (harvesting and for partial drying of grains) use single phase induction motor and shaded pole motor
3. Small portable battery operated DC motor are used in sprayers.
4. Cutting machines for crops uses high speed electric motors.

1 l) Compare MCB and kitkat fuse on basis of (1) operation (2) cost.

**Ans:**

**Comparison between MCB and Kitkat fuse:**

| Particulars | MCB | Kitkat Fuse |
|---|---|---|

| | | | |
|---|---|---|---|
| Operation | i) Provide short circuit protection & over load protection to electrical loads<br>ii) Its operation under fault condition is faster than kitkat fuse<br>iii) Operation is by tripping. | i) Provides short circuit & occasionally over current protection depending on its size & related circuit rating.<br>ii) Its operation under fault condition is slower than MCB<br>iii) Operation is by melting of fuse element. | 1 mark for each point = 2 marks |
| Cost | Cost is more than kitkat fuse | Cost is less than MCB | |

**2** Attempt **any four** of the following: **16**

2 a) Compare two winding transformer with autotransformer.

**Ans:**

**Comparison between two winding transformer and autotransformer:**

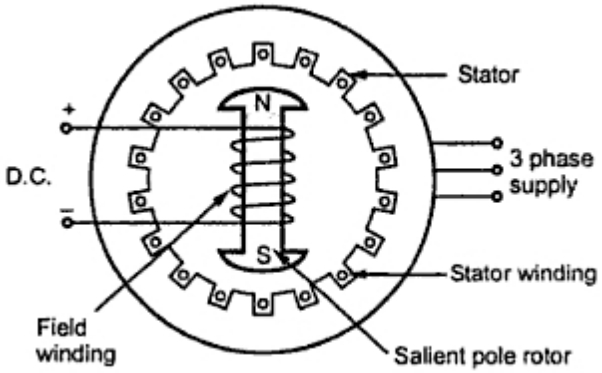
| Particulars | Two winding transformer | Autotransformer |
|---|---|---|
| Construction | It has two windings | It has one winding |
| Principle | Principle of mutual induction | Principle of Self-induction. |
| Copper requirement | Being two-winding, copper requirement is more | Being one-winding, Copper is saved. |
| Losses | More losses | Less losses |
| Efficiency | Efficiency is lower than autotransformer | Efficiency is high |
| Transformation Ratio | Fixed | Variable |
| Electrical connection | No electrical connection between primary and secondary | Primary and secondary are electrically connected. |
| Power transfer | Entirely by induction | Partially by induction and conduction |
| Size | Size is bigger than autotransformer | Size is small |
| Application | Power / Distribution transformer, power supply, welding, isolation transformer etc. | Variac, starter for ac motors, dimmerstat, power transformer. |

1 mark for each of any four points = 4 marks

2 b) Describe the construction of rotating field type alternator with neat sketch.

**Ans:**

**Rotating field type alternator:**




2 marks for diagram

**OR**

**Any other equivalent diagram**

An alternator consists of stator and rotor. The stator is in the form of hollow cylinder, slotted on the inner periphery. The stator core is made up of steel laminations to reduce the iron losses. In the stator slots, three-phase winding is uniformly distributed. 2 marks for description

The rotor carries magnetic poles and field winding. Two types of rotor constructions are available:

i) Salient pole construction

ii) Cylindrical rotor construction

The figure shows salient pole construction. In salient pole construction, the field poles appear projected on the rotor. Therefore, there is uneven air gap between stator and rotor. At projected poles, the gap is minimum and at the space between the poles, the air gap is maximum. The field winding is place round the poles as shown in the figure. In case of cylindrical rotor construction, the rotor surface appears smooth with uniform air gap between stator and rotor, as the field winding is placed in rotor slots. The field winding is connected to an external DC supply using slip ring – brush arrangement.

2 c) A 50 Hz, 4 pole, 3 phase induction motor runs at 1450 rpm at full load. Calculate :

i) Synchronous speed

ii) Full load slip of motor

**Ans:**

**Data given:**

Frequency f = 50 Hz

Poles P = 4

Speed N = 1450 rpm at full load

**i) Synchronous speed ($N_S$):**

$Ns = (120\ f)/ P$ 1 mark

$= (120 \times 50)/4 =$ **1500 rpm** 1 mark

**ii) Full load slip of motor (%$s_{FL}$):**

$slip = (Ns – N) / Ns$ 1 mark

$= (1500 – 1450)/1500$

$= 0.0333$

% slip at full load $\%s_{FL} =$ **3.33**% 1 mark

2 d) Explain the factors for the selection of motor for different drives.

**Ans:**

1) Type of drive:- Individual or group
2) Electrical supply:-Whether it is AC or DC, 1phase or 3 Phase
3) Nature of the load: Constant or variable.
4) Speed Requirement: Constant speed or variable speed operation.
5) Environmental condition: The condition of surroundings in plant - Explosive etc.
6) Efficiency: For precise output requirement high efficient motors are used.
7) Cost:- Cost is one of the factor which is considered in motor selection.
8) Motor Duty Cycle: Continuous or intermittent operation.

1 mark for each of any four = 4 marks

**OR**

**Any other valid points**

2 e) State the principle of dielectric heating. State its applications.

**Ans:**

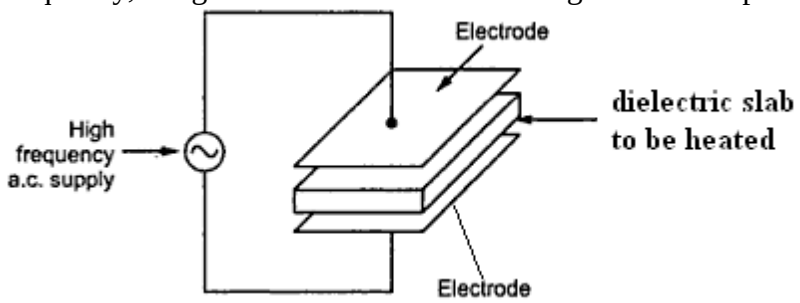
**Principle of Dielectric heating:**

When non-metallic material with extremely poor conductivity is subjected to high frequency electric field of ac supply, heat losses take place due to the leakage current and heat is produced. The frequency is normally between 12 kHz to 30 kHz.

**OR**

Dielectric heating (also known as Capacitance heating) is the method of heating non-conductive materials. The material to be heated is placed between two electrodes, to which a high-frequency energy source is connected. The oscillating field passes through the material and as the field direction changes, the polarization of individual molecules reverses rapidly, causing friction and hence heat. The higher the frequency, the greater the movement and large is the heat production.

2 marks for principle




1 mark for diagram

**Applications:**

1) Drying of industrial products such as textiles, agricultural products such as tobacco etc.
2) Rubber vulcanizing
3) Curing of rubber and plastics
4) Sterilization

½ mark for each of any two application = 1 mark

2 f) Why earthing is essential in electric installation? State its different types.

**Ans:**

**The earthing is essential:** 3 marks

1) To provide protection and safety to the operator and the equipment.
2) To facilitate the balanced supply conditions.
3) To provide safe path to discharge lightning and short circuit currents.

**Types of Earthing:**

i) Pipe earthing 1 mark

ii) Plate earthing

**3** Attempt **any four** of the following: **16**

3 a) Current flowing through the circuit is I = 141.4 Sin (314t – $\pi$/2) amp.
Calculate: i) Frequency ii) Rms value iii) Phase difference iv) Amplitude

**Ans:-**

**Data Given:**

$$\mathbf{i = 141.4 \sin(314t - \pi/2)}$$

On comparing the given equation of current with standard form of sinusoidal current, $\mathbf{I = I_m \sin(\omega t \pm \phi)}$

1 mark for each bit

i) **Frequency :**
$\omega t = 314t$
$\omega = 2\pi f = 314$
$f = 314/(2\pi f) = 49.97$ hz = **50 Hz**

ii) **Rms value:**
$I_{rms} = I_m \times 0.707 =$ **99.96 amp**

iii) **Phases difference:**
Since $\phi =$ **$\pi$/2 rad = 90°**

iv) **Amplitude:**
Maximum value = $I_m =$ **141.4 amp**

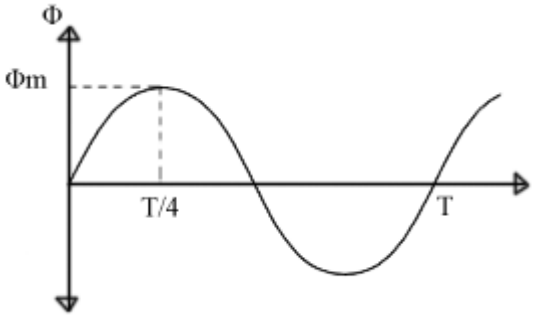
3 b) Derive EMF equation of transformer.

**Ans:-**

Let,
$N_1$ = Number of turns of primary winding
$N_2$ = Number of turns of secondary winding
$\Phi_m$ = Maximum flux in the core (in wb) = ($B_m$ x A)
$B_m$ = Maximum flux density in the core in wb/$m^2$
A = Area of core in $m^2$
f = frequency of the AC supply (in Hz)

**First Method:**

When the sinusoidal voltage is supplied to primary, sinusoidal current flows and sinusoidal flux is set up in the core, given by,
$\Phi_m = \Phi_m \sin(\omega t)$ wb
As shown in the fig., the flux rises sinusoidally to its maximum value $\Phi_m$ from 0. It reaches to the maximum value in one quarter of the cycle i.e in T/4 sec (where, T is time period of the sin wave of the supply = 1/f).




1 mark for diagram

Therefore, average rate of change of flux = $\Phi_m/(T/4)$ = $\Phi_m/(1/4f)$
Therefore,
average rate of change of flux = $4f\Phi_m$ wb/s
Now, Induced emf per turn = rate of change of flux per turn 1 mark
Therefore, average emf per turn = $4f\Phi_m$ volts
Now, we know, Form factor = RMS value / average value
Therefore, RMS value of emf per turn = Form factor X average emf per turn.
For sinusoidal quantity, form factor is 1.11 1 mark
Therefore, RMS value of emf per turn = 1.11 x 4f $\Phi_m$ = 4.44f $\Phi_m$
RMS value of induced emf in whole primary winding ($E_1$)
= RMS value of emf per turn ×Number of turns in primary winding
$E_1$ = 4.44f $N_1$ $\Phi_m$ 1 mark
Similarly, RMS induced emf in secondary winding ($E_2$) can be given as
$E_2 = 4.44fN_2\Phi_m$.

**OR** **OR**

**Second Method:**
The alternating magnetic flux in the core is given by,

$$\emptyset = \emptyset_m sin(\omega t)$$

According to Faraday's law of electromagnetic induction, 1 mark

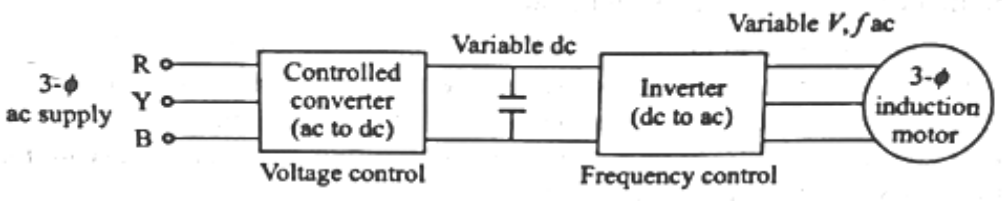
Instantaneous value of emf/turn $= e = -\frac{d\emptyset}{dt}$

$$= -\frac{d}{dt}[\emptyset_m sin(\omega t)]$$
$$= -\omega\emptyset_m cos(\omega t)$$
$$= \omega\emptyset_m sin\left(\omega t - \frac{\pi}{2}\right) \quad \text{volt}$$

1 mark

Maximum value of emf/turn $= \omega\emptyset_m = 2\pi f\emptyset_m$ 1 mark
RMS value of emf/turn $= 0.707 \times 2\pi f\emptyset_m = 4.44\,\emptyset_m f$ volt
$\therefore$ RMS value of emf in primary winding = RMS value of emf/turn $\times N_1$
$E_1 = 4.44\,\emptyset_m f N_1$ volt 1 mark
Similarly,
RMS value of emf in secondary winding $E_2 = 4.44\,\emptyset_m f N_2$ volt

3 c) With diagram, explain the speed control of induction motor by VFD method.
**Ans :**




2 marks for block diagram

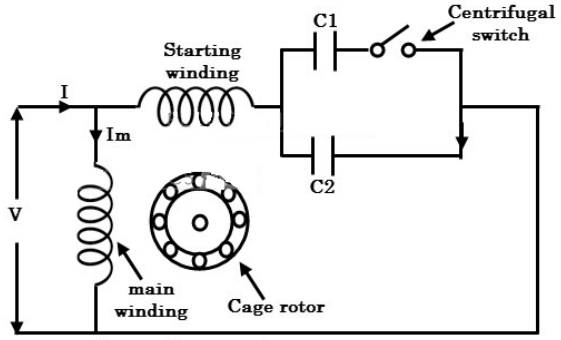
The synchronous speed of the induction motor can be varied smoothly over a wide range by changing the supply frequency. In order to maintain the air gap flux at its normal value under varying frequency conditions, it is necessary to keep V/f ratio constant. Therefore if speed controls to be achieved by changing frequency, the supply voltage is also to be changed simultaneously. Since the commercial power systems operate at constant frequency, variation of frequency for speed control purpose is necessarily achieved by using rotary (e.g. motor generator sets) or solid state frequency conversion equipment. 2 marks for explanation

Variable frequency can be obtained from solid state equipment or (i.e. VFD drives). A basic block diagram of speed control of induction motor using variable frequency source is shown in above fig. Three phase supply at input is first converted into controlled DC. This DC voltage is applied to inverter circuit whose frequency is controlled by pulses from voltage to frequency controller unit. A smoothing reactor, L is connected in the circuit to filter the controlled DC.

3 d) Draw and explain capacitor start and run single phase induction motor.

**Ans:**

**Capacitor start Capacitor run single phase induction motor:**




Circuit diagram of capacitor start capacitor run motor

2 marks for circuit diagram

- In this motor, auxiliary (starting) winding is in series with parallel combination of capacitors $C_1$ and $C_2$. The capacitor $C_1$ remains in circuit only during starting.
- The main winding is highly inductive in nature and carries current $I_m$ that lags behind the applied voltage by some angle.
- Due to capacitor in series with auxiliary winding, the auxiliary winding circuit carries leading current $I_s$.
- The phase difference between $I_m$ and $I_s$ is approximately 90°.
- This 90° phase difference causes the two currents to produce the rotating magnetic field.

2 marks for explanation

- The rotating magnetic field is cut by rotor conductors and emf is induced in it. Then current flows in rotor conductors. The interaction between rotor currents and rotating magnetic field causes force on rotor conductors and rotor rotates.
- After attaining 75-80% of synchronous speed, centrifugal switch in series with the capacitor $C_1$ get opened and it is disconnected.
- The auxiliary winding continues to carry the current through $C_2$ and motor runs with only one capacitor $C_2$.
- Since capacitors $C_1$ and $C_2$ are used for starting and capacitor $C_2$ is used

under running condition, this motor is called "Capacitor-start, Capacitor-run induction motor

3 e) List four types of electric motor enclosures and state advantages of each.

**Ans :**

**Electric motor enclosures and their advantages:**

| Sr. No. | Types | Advantages |
|---|---|---|
| 1 | Open type | Allows free ventilation |
| 2 | Protected type | Provides complete protection with ventilation |
| 3 | Drip-proof type | Provides protection from liquid or moisture |
| 4 | Splash-proof type | Provides complete protection from dust, dirt etc. |
| 5 | Totally-enclosed type | Provides complete protection without ventilation |
| 6 | Pipe ventilated type | Provides cool air to motor |
| 7 | Flame-proof type | Provides protection to the motor from sparking, explosive environment etc. |

1 mark for each of any four = 4 marks

3 f) Explain in short different fire extinguishing methods.

**Ans:**

**Different fire extinguishing methods:**

Normally only two types of fire extinguishers are used for electrical fires: CO2 & Dry chemical powder.

**(i) Carbon Dioxide Extinguishing Systems:**

This type is the most suitable & widely recommended one for electrical fires. Carbon dioxide (CO2) extinguishers are normally Class C extinguishers. Before using it, switch off the supply immediately so that the source for the fire to get sustained is isolated using proper insulated hand gear/foot gear. To use the extinguisher, pull the pin near the handle, point the horn at the base of the fire, and hold down the handle. As the flames shrink, continue spraying until the fire is fully extinguished.

2 marks for each of any two methods = 4 marks

**(ii) Dry chemical extinguisher:**

The Dry Powder (or Dry Chemical) charged fire extinguisher is a multipurpose fire extinguisher and can be used on wide variety of fires. They are used on electrical fires but leave a residue that may be harmful to sensitive electronics. They work by chemical reaction with the fire causing the particles to expand chemically inhibiting combustion and expelling the oxygen thereby smothering the flames.

**iii) Sand buckets -**

A bucket filled with sand is used to prevent the spread of or extinguish fire. Typically, fire buckets are painted bright red and have the word 'FIRE' stenciled on them. They are preferred for fighting small fires in certain situations. The main advantages of fire buckets are that they are cheap, reliable, easy to use and can be quickly refilled and reinstated. Normally, they are hung on dedicated fire bucket stands.

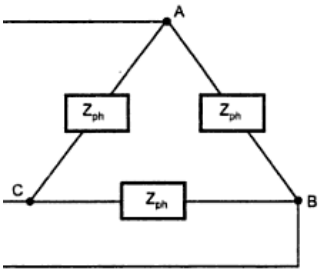
**iv)** In addition to above for fires other than in electrical reasons/areas pressurized water hose, water mist can be used.

**4** Attempt **any four** of the following: **16**

4 a) Draw delta connected load. State the relationship between line and phase values for the same.

**Ans:**

**Delta connected load**




2 marks for circuit diagram

**Relationship between line and phase values for delta connection:**

Line Voltage = Phase Voltage

$V_L = V_{ph}$ 1 mark

Line current = $\sqrt{3}$ Phase current

$I_L = \sqrt{3}\ I_{ph}$ 1 mark

4 b) Explain construction and working of transformer.

**Ans:**

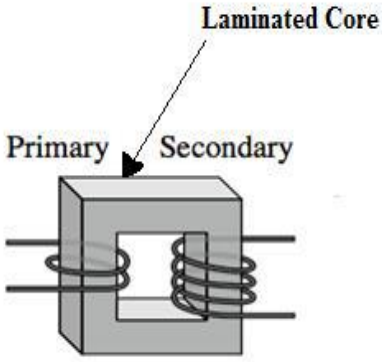
**Construction of transformer:**

Transformer essentially consists of following components:

i) **Windings:** Two windings of aluminium or copper are placed round the core and are insulated from each other and also from the core.

ii) **Core:** Magnetic core is made up of thin silicon steel laminations.

For big size transformers, tank is used to accommodate the core-winding assembly. In fact, the core-winding assembly is kept immersed in oil in the tank. The oil acts as a cooling medium and also the insulating medium. The terminals are taken out of the tank using bushings. 2 marks for construction




There are two types of core constructions:

i) Core type construction

ii) Shell type construction

In core type construction, the winding surrounds the core, whereas in shell type construction, the core surrounds the winding. The vertical portion of core is called 'Limb' or 'leg'. The horizontal portion of the core is called 'yoke'. The core is made from the E and I or L type laminations stacked together.

The low-voltage winding has few turns; hence it is usually helical winding. The high voltage winding has large no. of turns, hence it is usually disc type winding.

**Working of transformer:**

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

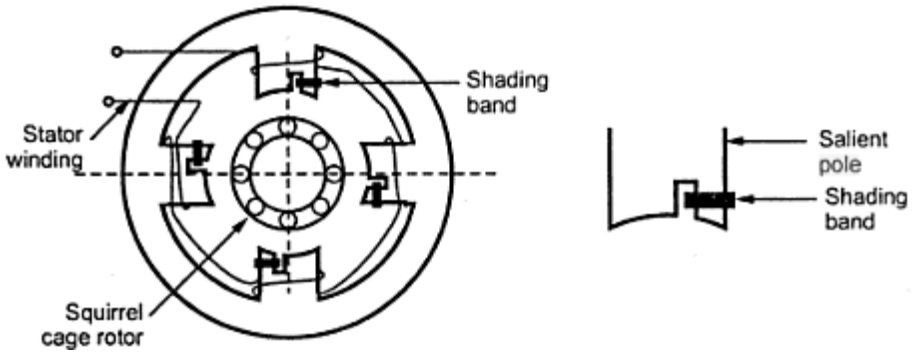
ii) The AC primary current produces an alternating flux $\phi$ in the core. 2 marks for working

iii) The changing flux ϕ links with both the primary and secondary windings and according to Faraday's laws of electromagnetic induction, emfs are induced in both the windings.
iv) The emf is induced in primary due to self-induction, whereas the emf is induced in secondary due to mutual induction,
v) If the load is connected to secondary winding, the secondary emf delivers current through load and the power is ultimately transferred from source on primary side to load on secondary side without electrical connection between primary winding and secondary winding.
vi) The power is transferred through magnetic coupling.

4 c) Explain shaded pole induction motor with sketch.

**Ans:**

**Shaded pole induction motor:**




2 marks for diagram

It has squirrel cage rotor and salient pole stator. The stator poles are shaded partially by short circuited conductor band to create the phase difference between the fluxes emerging from shaded and un-shaded portion. These phase differing fluxes produce the required torque on the rotor for motion.

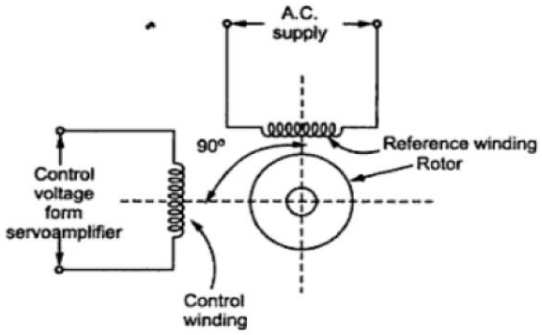
2 marks for explanation

When a single phase supply is fed to the main winding, an alternating flux is produced in the pole. A portion of this flux links with the shading band and induces a voltage in it. As shading band is short-circuited, a large current flows in it. The current in the shading band causes the flux in the shaded portion of the pole to lag the flux in the unshaded portion of the pole. Thus the flux in the shaded portion reaches its maximum value after the flux in the unshaded portion reaches its maximum. The phase difference in fluxes causes equivalent rotating magnetic field in the air-gap and torque is exerted on the squirrel cage rotor.

4 d) Describe working of AC servo motor with sketch. State its two applications.

**Ans:**

**Principle of working of AC servo motor:**




1 mark for diagram

There are some special applications 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. These motors are used for position control or in servo mechanisms, hence are termed as servomotors. The AC servomotor consists of main and control winding and squirrel cage / drag cup type rotors. $V_r$ is the voltage applied to the main or reference winding while $V_c$ 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 force or torque is exerted on rotor and is set in motion.

2 marks for explanation

**Applications:**

(i) CNC machine
(ii) Precision control
(iii) Process controller
(iv) Robotics
(v) Sewing machine
(vi) Aeronautical application
(vii) Conveyor etc.

½ mark for each of any two application = 1 mark

4 e) **What is electroplating? Give its two applications.**

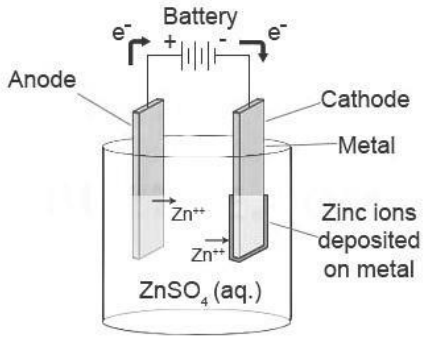
**Ans:**

**Electroplating:**

Electroplating is a process of depositing a layer of some material for some useful purposes on the articles of other metals

**OR**

Electroplating is carried out with a desire to coat particular metal on the surface of other metal.




2 marks for meaning

**OR**

**Any other equivalent diagram** 1 mark for each of any two application = 2 marks

**Applications of Electroplating:**

i) Gold or silver plating for ornaments.
ii) Zinc nickel plating on cost iron or steel parts to prevent corrosion.
iii) Surface plating for giving extra shining etc.

4 f) Explain how energy conservation is done in homes and industry.

**Ans:**

**Energy conservation in homes and industry:**

It can be done by following ways:

1) By switching off the appliances when not in use or required.
2) By making use of energy efficient luminaries, like CFL, LED.
3) By using energy efficient home appliances like AC, Fridge.
4) By using energy efficient motors.
5) By using energy efficient transformers.
6) By demand side management.
7) By using p.f. improvement device.

1 mark for each of any four ways = 4 marks

**5** Attempt **any four** of the following: **16**

5 a) Calculate voltage across individual element for the circuit shown in Figure 5 (a).

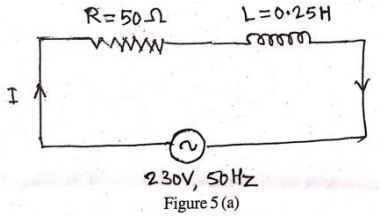


Figure 5 (a)

**Ans:**

**Data Given:**

RL-series circuit has R = 50 Ω, L= 0.25 H, V = 230V, f = 50 Hz

$X_L = 2\pi fL = 2 \times \pi \times 50 \times 0.25 = 78.54\ \Omega$

$Z = \sqrt{R^2 + X_L^2} = \sqrt{50^2 + 78.54^2} = 93.10\ \Omega$

$I = V/Z = 230/93.10 = 2.47$ Amp

$V_R = I \times R = 2.47 \times 50 =$ **123.5 V**

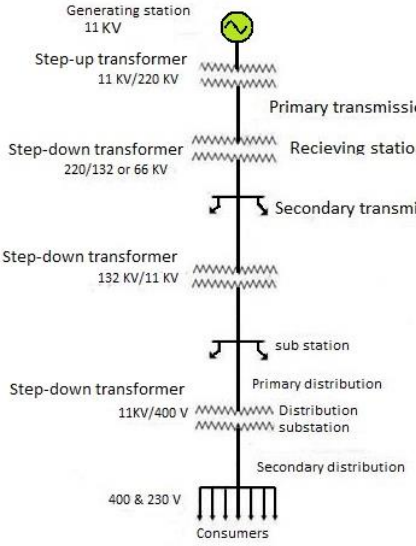
$V_L = I \times X_L = 2.47 \times 78.54 =$ **194 V**

½ mark for $X_L$
½ mark for Z
1 mark for I
1 mark for $V_R$
1 mark for $V_L$

5 b) Draw single line diagram of electrical power system and show different stages.

**Ans:**

**Single line diagram of electrical power system with different stages:**




4 marks for labeled diagram

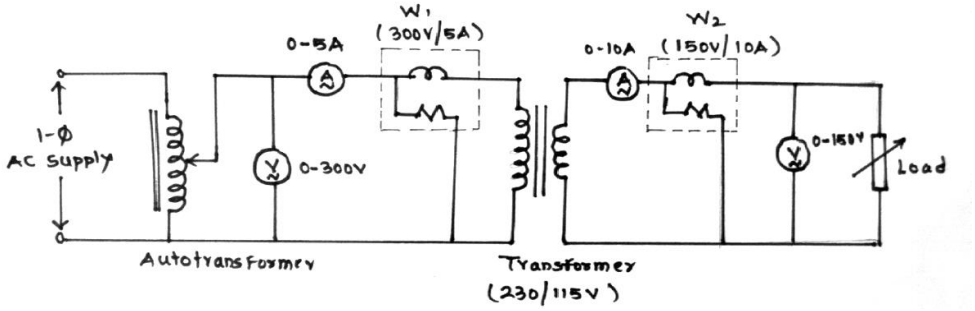
2 to 3 marks for partially labeled diagram

1 mark for unlabeled diagram

5 c) Explain direct loading test on single phase transformer with neat circuit diagram.

**Ans:**

**Circuit diagram for direct loading test on single phase transformer:**




2 marks for circuit diagram

Direct loading test on transformer is carried out to calculate the losses, efficiency and voltage regulation of the transformer. The circuit diagram is as shown in figure above. Single phase supply is given to the primary of the transformer and load is connected to the secondary side.

2 marks for explanation

1) No load Operation:
   The rated voltage is supplied to primary winding and load is switched off. The secondary current & power is then zero. This is no load operation. The readings of voltmeter, ammeter and wattmeters are taken. The input power read by primary side wattmeter then represents the constant loss of the transformer. The secondary voltage under no-load will be the secondary emf $E_{20}$.
2) On-load operation:
   Few more sets of readings are taken for different loading conditions on secondary side keeping rated supply voltage.

Efficiency and regulation can be calculated by using following formulae:

Efficiency = output power/Input power = $W_2/W_1$
Regulation = $(V_{NL}-V_{FL})/V_{NL}) * 100$ OR
$= (V_{NL}-V_{FL})/V_{FL}) * 100$

5 d) Why starters are required? Draw neat sketch of DOL starter.

**Ans:**

**1) For 3-phase Induction Motor:**

Three-phase induction motor is electrically a rotating transformer with short-circuited secondary. At the time of starting, the relative speed between rotating magnetic field and rotor is large, producing high emf and currents in rotor conductors. The rotor currents reflected on stator side causes high starting current of motor.

2 marks for correct reason for any motor

- The starters are required for 3-phase induction motor to limit the heavy or large starting current drawn by the induction motor when directly switched on.
- The large starting current produces large copper losses in motor that generates heat which can damage insulation of motor.
- The large starting current produces heavy dip in supply voltage that can affect other equipment operating on it.

**2) For of D.C. motors:**

The current drawn by DC motor is given by,

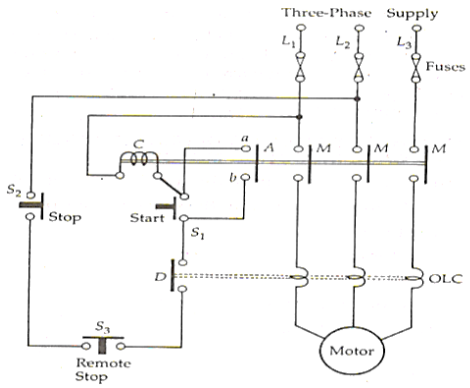
$$I_a = \frac{V - E_b}{R_a}$$

At start, speed N = 0 rpm and back emf is therefore zero. i.e $E_b$ = 0 volt
Therefore,

$$I_a = \frac{V}{R_a}$$

As $R_a$ is very small, $I_a$ will be dangerously high at the time of starting. This high starting current may damage the motor armature (and series field winding in case of DC series motor). Hence to limit the starting current, suitable resistance is inserted in series with armature which is called as starter. This starting resistance is cut-off in steps with increase in speed.

**Direct-On-line (DOL) Starter:**




2 marks for circuit diagram of DOL

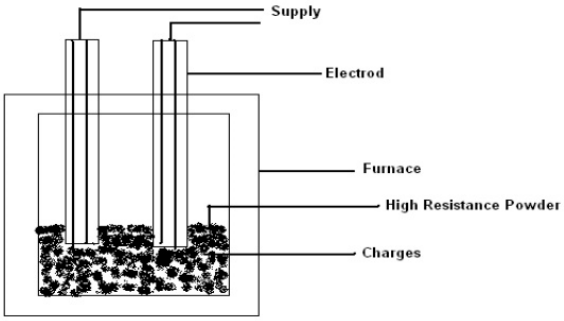
**OR**

**Any other equivalent diagram**

5 e) Explain with sketch, direct resistance heating.

**Ans:**

**Direct Resistance Heating:**



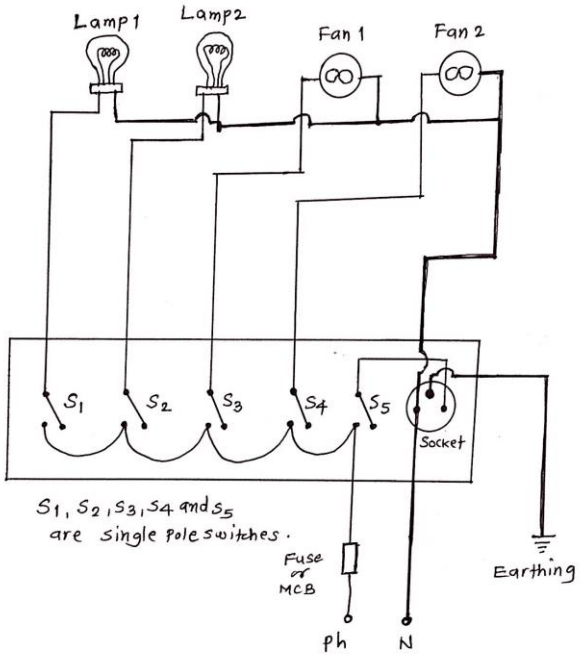

2 marks for diagram

It is based on the heating effect of electric current: When current I flows through resistance R, the power loss ($I^2R$) takes place and heat is produced in the resistance. In this method, the material to be heated is treated as a resistance and current is passed through it. The material, here called as charge, may be in the form of powder, small solid pieces or liquid. The two electrodes are inserted in the charge and connected to either AC or DC supply. When the charge is in the form of small pieces, a powder of high resistivity material is sprinkled over the surface of the charge to avoid direct short-circuit. Heat is produced when current passes through it. This method of heating has high efficiency because the heat is produced in the charge itself.

2 marks for explanation

5 f) Draw neat wiring diagram of control 2 lamps, 2 fans and 1 socket.

**Ans:**




4 marks for labeled diagram

3 marks for partially labeled diagram

2 mark for unlabeled diagram

**6** Attempt **any four** of the following: **16**

6 a) Explain for series RC circuit.

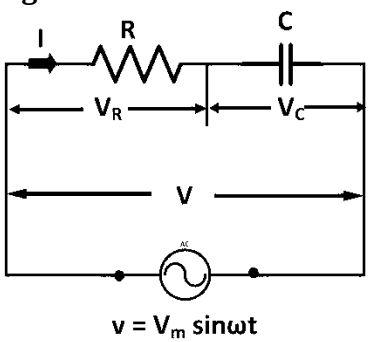
i) Circuit diagram

ii) Voltage equation

iii) Current equation
iv) Power

**Ans:**

**(i) Series RC circuit diagram:**




1 mark

**(ii) Voltage equation:**

If the voltage is taken as reference the instantaneous voltage is given by equation, $v = V_m \sin(\omega t)$ 1 mark

**(iii) Current equation:**

In RC series circuit the current leads the applied voltage by an angle $\phi$ and the instantaneous value of current is given by equation, 1 mark

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

**(iv) Power:**

In RC series circuit the power is given by equation

$$P = V I \cos \phi$$ 1 mark

where, V and I are the rms values of voltage and current respectively.

6 b) State the advantages of polyphase (3-phase) system over single phase system (any four).

**Ans:**

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

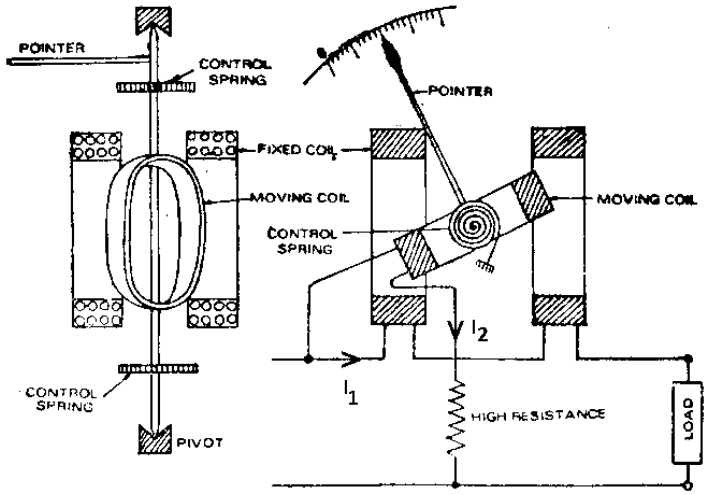
1. **More output:** For the same size, output of poly-phase machines is always higher than single phase machines.
2. **Smaller size:** For producing same output, the size of three phase machines is always smaller than that of single phase machines.
3. **More power is transmitted:** It is possible to transmit more power using a three phase system than single phase system.
4. **Smaller cross-sectional area of conductors:** If the same amount of power is to be transmitted then the cross-sectional area of the conductors used for three phase system is small as compared to 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:** The three phase ac motors are self-starting, while single phase induction motors are not.
7. **Horse power rating:** Horse power rating of three phase motors is greater than that of single phase motor of same size.
8. **Smooth Power:** Power delivered by a single phase system fluctuates whereas for three phase system power delivered to the load is the same at any instant.

1 mark for each of any four = 4 marks

6 c) Explain with neat diagram working of dynamometer type wattmeter.

**Ans:**

**Dynamometer type wattmeter:**




2 marks for diagram

**OR**

**Any other equivalent diagram**

It works on very simple principle and this principle can be stated as "when any current carrying conductor is placed inside a magnetic field, it experiences a mechanical force and due this mechanical force deflection of conductor takes place". 2 marks for explanation

Figure shows the dynamometer wattmeter for measuring the power. It consists of two stationary coils, called current coils and one moving coil, called voltage or potential coil. The moving coil is mounted on the spindle, in the gap between two stationary coils, as shown. The current coils are connected such that they carry the current proportional to (or equal to) the load current and the voltage coil is connected in such a way that it carries the current proportional to the load voltage. The interaction between two magnetic fields causes the production of force on moving system, which is proportional to the product of voltage and current i.e power. The meter can be calibrated directly to indicate the power in watt.

6 d) Draw speed-torque characteristics of DC shunt and series motors and explain in brief.

**Ans:**

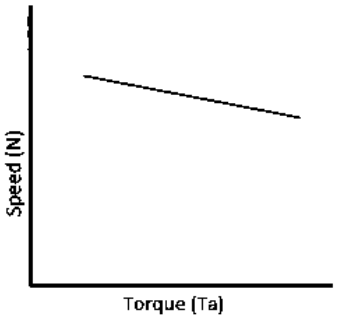
**Speed-Torque characteristics of DC shunt motor:**

From the curve it is clear that the speed reduces when the load torque increases. When the shunt motor runs from no load to full load there is slight change in speed. Thus, it is essentially a constant speed motor. Since the armature torque is directly proportional to the armature current, the starting torque is not high. 1 mark

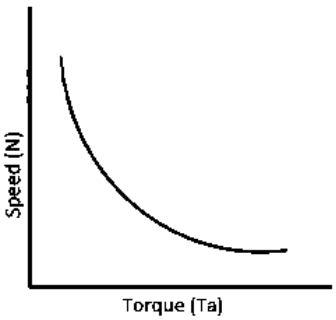
**Speed-Torque characteristics of DC series motor:**

In case of dc series motor, the flux is directly proportional to the armature current at light loads. Thus the torque is directly proportional to the square of armature current. At light loads, the value of the armature current and hence flux, will be quite low and the speed of the dc series motor may become quite high. As the load on the motor increases, the armature current and flux will increase and the speed 1 mark

would decrease rapidly. Therefore this characteristic clearly indicates that a dc series motor should never be started without load.




DC SHUNT MOTOR




DC SERIES MOTOR

1 mark each = 2 marks

6 e) Give any two applications of
i) Stepper motor and
ii) Servo motor

**Ans:**

**i) Applications of stepper motor**

1. Floppy disc drives.
2. Computer printers.
3. Image scanners.
4. Compact Disc drives, etc.

1 mark for each of any two application = 2 marks

**ii) Applications of Servo motor**

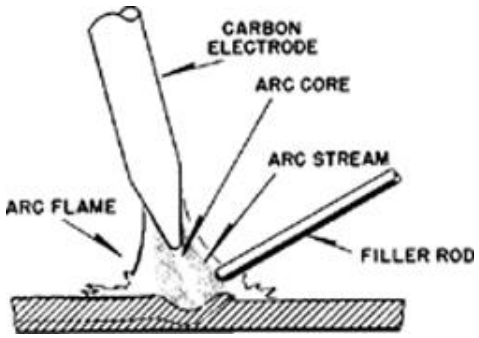
1) CNC machines
2) Machine Tool (Metal Cutting)
3) Machine Tool (Metal forming)
4) Antenna Positioning
5) Packaging
6) Woodworking
7) Textiles
8) Printing etc.

1 mark for each of any two application = 2 marks

6 f) Explain carbon arc welding with neat diagram.

**Ans:**

**Carbon Arc Welding:**




2 marks for diagram

Arc is an electric discharge between one electrode and another which may be a work piece. The arc current while flowing through air in the form of electrons bombards the atoms in air and produces ions. Such state of matter is almost plasma state and the temperature in the vicinity is around 3000 to 4000°C, which is

2 marks for explanation

generally 2 to 3 times the melting point of general metals such as copper, iron etc. The electric arc effectively concentrates heat on the surfaces it is desired to join.
The process in which two metal parts to be welded are brought to a molten state and then allowed to solidify is called as arc welding. Melting of metal is obtained due to heat developed by an arc struck between carbon electrode and metal to be welded (Job) and the additional metal is deposited in the weld from a filler rod.