Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.

2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.

3) The language errors such as grammatical, spelling errors should not be given importance (Not applicable for subject English and Communication Skills).

4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure/figures 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 (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: **20**

1 a) Define w. r. t. sinusoidal a. c. cycle
i) Waveform
ii) Instantaneous value

Ans:

1) **Waveform :** The graph of instantaneous values of an alternating quantity with respect to time is called wave form.
OR
The shape of the curve obtained by plotting the instantaneous values of an alternating quantity as ordinate against time as abscissa is called its wave form or wave shape.
2) **Instantaneous value**: The value of an alternating quantity at any instant is called Instantaneous value of the quantity at that instant.

1 marks for each definition

1 b) What are the advantages of AC over DC any two?

Ans:

Advantages of AC over DC

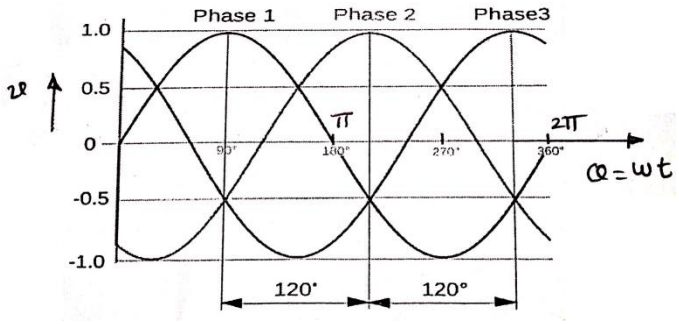
1) AC can be generated at high voltages. But DC can not be be generated at high voltages because sparking starts to occur at commutator at high voltages, due to which commutator may gets damaged.
2) High voltage AC generators are much simpler and economical than DC generators of the same range. It is because in AC generators there is no commutator which is costly part.
3) Alternating current can be stepped down with a static device called transformer . When voltage is stepped up current decreses to a small value. Small current produces less heat losses and power can be trasmitted through a thin conductor.
4) AC transmission and distribution is more economical as line material (say copper, Alluminium etc.) can be saved by transmitting power at higher voltages.
5) At receiving station, voltages can be stepped down to the required value by using step down transformer. This is most important reason for generating and using electrical energy as AC.
6) For the same horse power as of DC motors, AC motors are economical, lighter in weight, require less space and require lesser attention in operation and maintenance.
7) AC can be converted to DC easily when and where required but DC can not be converted to AC so easily and is not economical.
8) AC distribution efficiency is high.
9) Design of AC machine is easy and installation is less costly.

1 Mark each
Any two advantages 2 marks

1 c) Draw the voltage wave form of three phase AC supply for 0 to 2π.

Ans:

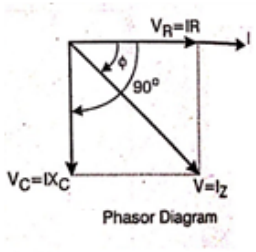
Voltage wave form of three phase AC supply:

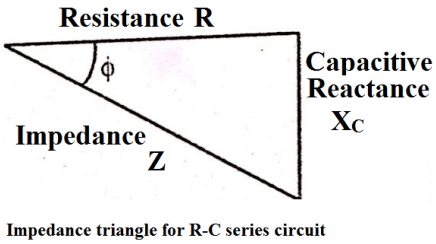


2 marks

1 d) Draw the vector diagram and impedance triangle for R-C series circuit.

Ans:





Impedance triangle for R-C series circuit

1 mark for each

1 e) Give any two applications of squirrel cage induction motor.

Ans:

Applications of squirrel cage induction motor:

i) Flour mills
ii) Lathe machine
iii) Water pump
iv) Printing machinery
v) Drill Machines
vi) Grinding machines
vii) Blowers
viii) Fans
ix) Other shaft drives of small power etc.
x) Wood working machines
xi) Textile machines

Any two valid applications
2 Marks

1 f) State E.M. F. equation of transformer and write meaning of each term in the formula.

Ans:

E.M. F. equation of transformer:

$E_1 = 4.44\ f\ \emptyset_{max}\ N_1$ OR
$E_1 = 4.44\ B_{max}\ A\ N_1$ OR
$E_2 = 4.44\ f\ \emptyset_{max}\ N_2$ OR
$E_2 = 4.44\ B_{max}\ A\ N_2$

where,

N_1 = number of turns in primary
N_2 = number of turns in secondary
$\emptyset_{max}$ = maximum flux in core in weber
B_{max} = maximum flux density in core in Wb/m^2
A = core area in $(meter)^2$

Any emf equation and accordingly meaning of each term
2 marks

E_1 = R. M. S. value of induced emf in primary
E_2 = R. M. S. value of induced emf in secondary

1 g) State Faraday's law of electromagnetic induction.

Ans:

Faraday's first law of electromagnetic induction:

It States that whenever magnetic flux linking with a circuit or coil changes an emf is always induced in it. — First law 1 Mark

OR

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

Faraday's second law of electromagnetic induction: — Second law 1 Mark

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

1 h) State two application of permanent capacitor induction motor.

Ans :

Application of permanent capacitor induction motor :

i) Table fans
ii) Ceiling fans
iii) Blowers
iv) Oil burners
v) Room coolers
vi) Portable tools
vii) Domestic & commercial electrical appliances where low starting torque is required
viii) Induction regulators
ix) Furnace controls
x) Valves and arc welding controls
xi) Exhaust fans etc.

Two correct applications 1 mark each

1 i) List any four safety tools used in electrical workshop.

Ans:

1) Hand gloves
2) Goggles
3) Rubber mats
4) Fire extinguishers
5) Danger notice plates
6) Search lights
7) Safety shoes or Gum boots
8) Ear plugs
9) Fall arresters
10) Life line rope
11) Safety helmets
12) Safety belts
13) Safety mask
14) Fire buckets
15) First aid box
16) Insulating stick or discharge rod

1/2 mark for each of any four points = 2 marks

1 j) Define phase sequence in three phase AC supply.

Ans: Correct Definition 2 Marks

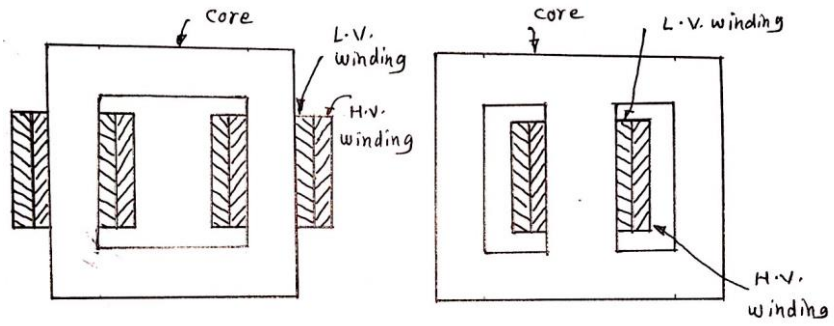
Phase sequence:

The order in which the voltages in three phases reach their respective maximum positive values is called the phase sequence. OR

The order in which the voltages in three phases reach their respective zero values is called the phase sequence.

1 k) Draw only neat sketch of core type and shell type transformer

Ans:



Sketch of core type 1 Mark

Sketch of shell type 1 Mark

1 l) Why should a transformer be never connected to DC supply?

Ans:

With DC supply (of value equal to AC rated voltage) the transformer winding will draw current equal to V_{dc}/R. The winding resistance R being low and X_L being absent for DC, the current I_{dc} would be vary large and transformer will fail within few seconds by overheating of windings. Due to this reason, transformer should never be operated on DC supply. Correct answer 2 Marks

1 m) List speed control methods for three phase Induction Motor

Ans:

Speed control methods for three phase Induction Motor ½ Mark for each of any 4 methods = 2 marks

1) By changing the number of stator poles (P) (pole changing)
2) By changing the line frequency (Frequency control)
3) By changing the applied voltage (stator voltage control)
4) By changing resistance in the rotor circuit (Rotor resistance control)
5) By voltage /frequency (V/F) control method

1 n) Write the equation of V and I in pure capacitive circuit

Ans :

1. Equation of voltage $v = V_m \sin\omega t$ OR $v = V_m \sin \Ø$ 1 mark (any one)

2. Equation current $i = I_m \sin(\omega t + \pi/2)$ OR $i = I_m \sin(\Ø + \pi/2)$ OR $i = I_m \sin(\omega t + 90^0)$ OR $i = I_m \sin(\Ø + 90^0)$ 1 mark (any one)

2 Attempt any four: **16 marks**

2 a) Draw the waveform and phasor diagram for current and voltage when AC flows

through a pure inductive circuit and write the equation for V & I

Ans:

Equation for current and voltage:

$i = I_m \sin(\omega t)\ amp.$

$v = V_m \sin(\omega t + 90°)$

$= V_m \sin\left(\omega t + \frac{\pi}{2}\right)$

OR

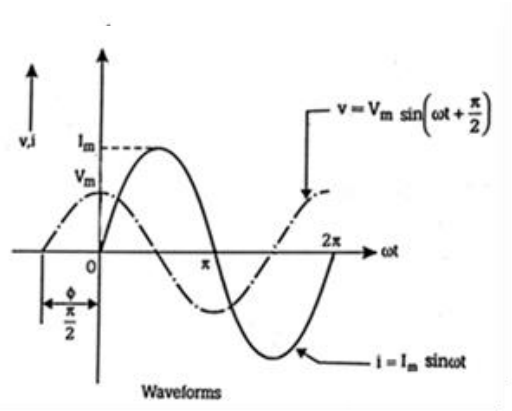
$v = V_m \sin(\omega t)\ amp.$

$i = I_m \sin(\omega t - 90°)$

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

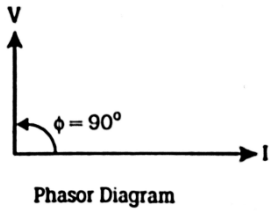
Equation for voltage 1 mark,

Equation for current 1 mark



Phasor diagram 1 mark,

Waveform 1 mark



Phasor Diagram

2 b) An alternating current is represented by i = 70.7sin(520t).
Determine :

i) Frequrncy
ii) I_{RMS}
iii) I_{Avg}
iv) Find the current at t=0.0015 sec. after passing through zero and increasing positively.

Ans:

1 mark for each bit

Given data i = 70.7Sin520t = I_{max} sin(ωt)

i) Freuency
ω=2πf =520 rad/sec.
F =520/(2π) = **82.76 Hz**

ii) I_{RMS} = 0.707I_{max} = 0.707 x 70.7 = **49.99A**

iii) I_{Avg} = 0.637 x 70.7 = **45.03A**

iv) Current at 0.0015 seconds
i =70.7sin(520x0.0015)
=70.7 x 0.703 = **49.72A**

2 c) Explain with diagram how megger is used as earth tester

Ans:

Megger as Earth Tester:

Megger consist of two components in one case as

1) Hand driven d. c. generator and
2) Ohmmeter

Earth tester consist of four main parts as

1) Hand driven d. c. generator
2) Ohmmeter
3) Rectifier
4) Current reverser

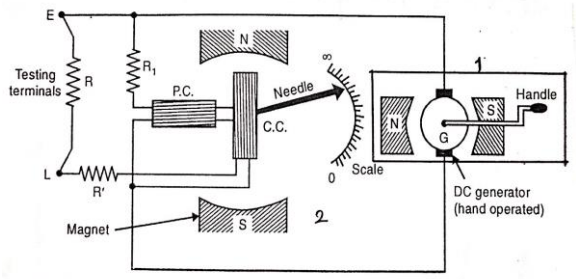


Fig 2(c)-1 Megger

Diagram 2 marks

If we add Rectifier (3) and current reverser (4) with megger with proper connections, the megger is then used as earth tester as shown in fig 2 (c) -2 (Earth Tester)

Explanation 2 marks

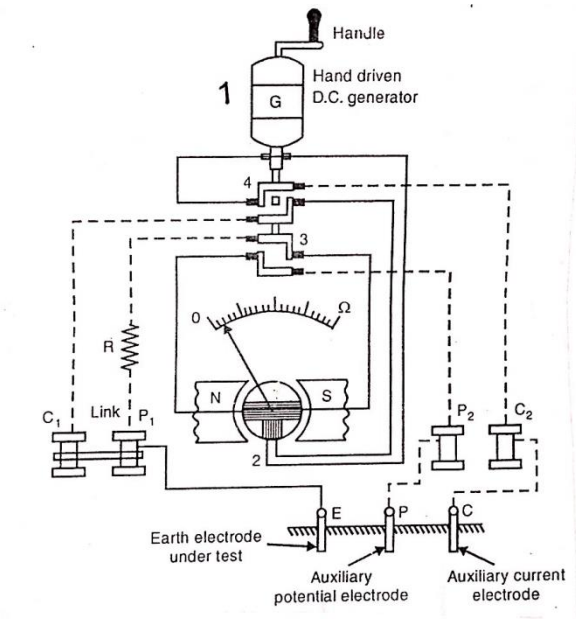
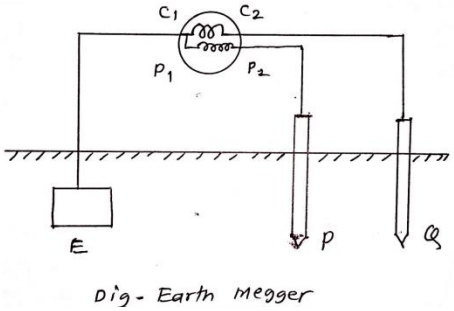


Fig 2(c) 2 Earth tester

OR

Earth Tester

Unlike insulation resistance which is in mega ohms We have to find low resistance of earth for electrical installations An instrument known as earth megger is used for this



Dig- Earth Megger

This is a modification of megger. It has three terminals. The terminal marked E is connected to ground or at any electrode whose earth resistance is to be found and the other two terminals are connected to two spikes as shown in figure. The scale is

calibrated from 0 to 50 ohms suitable for the measurement. When handle of generator is rotated this gives the resistance of ground or earth resistance directly on the scale.

2 d) Define:
i) Zero phase difference ii) Leading phase difference
iii) Lagging phase difference iv) Active power

Ans:

i) Zero phase difference: When two alternating (V and I) quantities of same frequency if attains their respective zero or maximum values simultaneously then such quantities are called in phase quantities or quantities having zero phase difference .

ii) Leading phase difference: When two alternating quantities having same frequency and if first quantity (say I) attains its maximum or zero earlier than second quantity (V), then the angular distance between corresponding zero points (or maximum points) is the leading phase difference for first quantity (I) with respect to second quantity (V).

1 mark for each definition

iii) Lagging phase difference: When two alternating quantities having same frequency and if first quantity (I) attains its maximum or zero earlier than second quantity (V) then the angle of differance between zero points (or maximum points) is the leading phase difference for first quantity (I) with respect to second quantity (V)

iv) Active power: It is defined as the average power consumed by the circuit

OR

The power actually utilized by the circuit is called active power.

OR

The power which is actually dissipated in the circuit resistance is called as active power.

OR

$P = VI \cos \emptyset = I^2R$

2 e) Balanced star connected load supplied from three phase 415V, 50Hz system, current in each phase is $20\angle -30°$, 30° being w. r. t. phase voltage. Determine
i) V_{ph} ii) I_L iii) Cos Ø iv) Power

Ans :

i) In star connection, $V_{ph} = V_L/\sqrt{3}$
$= 415 / \sqrt{3}$
$V_{ph} = 239.6$ volts

1 mark for each bit stepwise solution

ii) In star connection, $I_{ph} = I_L$
$I_{ph} = 20 \angle -30°$ A

iii) Cos Ø = Cos (-30°) = **0.866**

iv) Power
$P = 3V_{ph} I_{ph} \cos\emptyset$ OR $P = \sqrt{3} V_L I_L \cos\emptyset$
$= 3 \times 239.6 \times 20 \times 0.866$

= **124490616 watts** OR

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

$= \sqrt{3} \times 415 \times 20 \times 0.866$

= 124490616 watts

2 f) Compare squirrel cage motor with slip ring three phase I. M. (any four points)

Ans:

Squirrel cage I. M.	Slip ring I. M.
1) Rotor is of Squirrel cage type	Rotor is of phase wound type
2) It has no slip rings on shaft	It has three slip rings on shaft
3) It is economical	It is comparatively expensive
4) It requires very little maintenance.	It requires maintenance more than Squirrel cage I. M.
5) It has small or moderate starting torque.	It has high starting torque.
6) External resistances cannot be inserted in rotor circuit.	External resistances can be inserted in the rotor circuit
7) Simple and robust construction.	Complicated and bulky construction.
8) Rotor is permanently short circuited.	One end of rotor is connected to slip rings
9) Starting torque cannot be adjusted.	Starting torque can be adjusted by varying the external resistance.
10) Speed cannot be controlled from rotor	Speed can be controlled from rotor side
11) Better efficiency	Low efficiency.
12) Power factor is better at running conditions.	Power factor is better at starting conditions.
13) Less rotor 'Cu' losses.	More rotor 'Cu' losses
14) High starting current (5 to 6 times full load)	Starting current is about twice the full load current.
15) Used in workshop for lathe machines, drill machines, grinding machines, blowers, water pumps, printing machines, fans, etc. where constant speed with medium starting torque is required.	Used in cranes, lifts, elevators, compressors, locomotives etc. where high starting torque is required.

1 mark for each of any four point = 4 marks

3 Attempt any four: **16**

3 a) Why transformer rating in terms of KVA, not in KW?

Ans:

1) The output of transformer is limited by heating and by the losses.
   Two types of losses in the transformer: (1) Iron loss, (2) Copper loss
2) Iron loss depends on the transformer voltage (v)

Copper loss is depends on transformer current (I) 4 marks

3) As the losses depends on voltage (V) and Current (I) and almost unaffected by load power factor

Hence transformer output is expressed in VA or KVA not in KW.

3 b) State any two applications of each
(i) Auto transformer (ii) Intermediate frequency transformer

Ans:

Application of Auto transformer:

1. For starting squirrel cage induction motor and synchronous motor.
2. As boosters to raise the voltage in a. c. feeders.
3. As furnace transformer for getting suitable supply voltage
4. As variacs for getting continuously variable ac supply.

1 mark for one application of each

Application of Intermediate frequency transformer:

1. In radio and television transmitters and receivers to facilitate amplification.
2. For coupling at the input & output of each intermediate frequency amplifier stage in radio and television transmitters and receiver.

3 c) What are the different types of powers in AC circuit? State its formula.

Ans :

1. Active power (P) : It is the true power or real power in ac circuit given by the product of voltage and active component of the current. It is given by formula P = VI cosØ watt or kW or MW
2. Reactive power (Q) : It is the product of voltage and reactive component of current. It is given by Q = VI sinØ volt-amp-reactive or kVAr or MVAr
3. Apparent power (S) : It is the product of rms value of voltage and current. It is given by formula S = VI volt-amp or kVA or MVA.

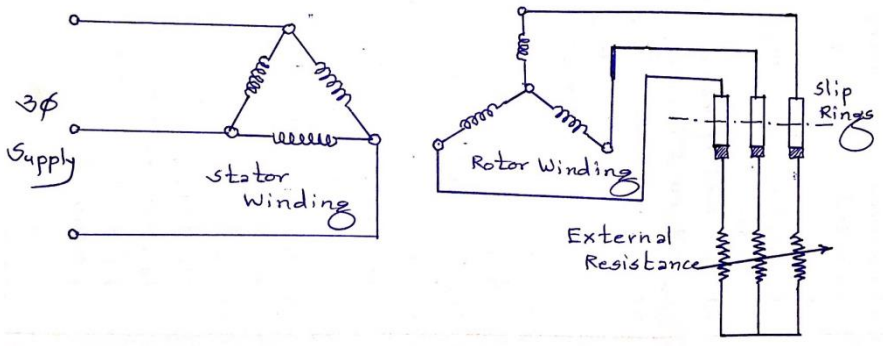
1 mark for each type and formula

1 mark for units of all

3 d) Draw neat sketch and write working principle of slip ring I. M.

Ans :

Working principle of slip ring I. M.:



2 marks for diagram

Working principle :

When 3-phase supply is given to stator winding, it produces constant magnitude rotating magnetic field, which rotates at synchronous speed. In slip ring I.M. the rotor is star connected and three terminals are brought out at slip ring mounted on the shaft. The external resistance can be connected in the rotor circuit, as shown in the figure. The rotating magnetic field produced by stator is cut by the rotor conductors and the emf is induced in the rotor circuit. Since rotor circuit is closed

2 marks

path, the rotor currents flow through the rotor conductors. The interaction between rotating magnetic field and rotor current results in production of force on rotor conductors. Due to this force, the rotor starts rotating in the same direction as the of rotating magnetic field. By reducing the resistance in the rotor circuit the motor speed can be increased. Under normal running condition, the slip rings are short circuited. The external resistance in series with each phase of rotor is used for starting or speed control purpose.

3 e) Compare single phase & three phase system (Any 4 points).

Ans :

Comparison between Single-phase and Three-phase System:

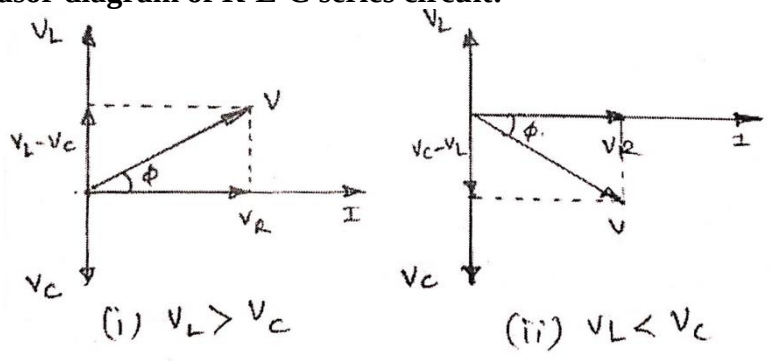
	Single phase system	Three phase system
1	It gives pulsating power	It gives constant power.
2	Output is less for given volume & weight of machine.	Output is greater for given volume & weight of machine.
3	It requires 6 conductors to transmit power equal to 3 phase.	It requires 3 or 4 conductors to transmit power.
4	Cost of 1 – phase machine is higher for same rating.	Cost of 3 – phase machine is less for same rating.
5	Single-phase motor are not self-started.	Three-phase motor are self-started.
6	For rectification filter circuit is required.	No filter circuit is required for rectification since ripples are less.

1 mark for each of any 4 points = 4 marks

3 f) Draw the voltage phasor diagram of R-L-C series circuit when
(i) $V_L > V_C$ (ii) $V_L < V_C$

Ans :

Voltage phasor diagram of R-L-C series circuit:



2 marks for each phasor diagram

4 a) Attempt any four: **16**

4 a) What are the different ways of interconnection phase in a three phase system? Why is it required?

Ans :

Different ways of interconnections in 3-phase system are

(i) Three phase, three wire star connected system. 1 Mark for

(ii) Three phase, three wire delta connected system. each
(iii) Three phase, four wire star connected system.

If each phase of 3-phase system is used separately with separate neutral, for transmission & distribution of power, conductors required will be more and also this will make the system complicated and expensive. Due to this reason, the star or delta connections are used. 1 Mark

4 b) A coil of resistance 15 Ω and inductance of 0.05 H connected in series with 100 μf capacitor across 230 V, 50 Hz ac supply, find (i) current (ii) Power factor of circuit (iii) Voltage drop across coil (iv) Voltage across capacitor.

Ans :

Data Given: R = 15Ω L = 0.05 H C = 100 μF f = 50 Hz V = 230V

$X_L = 2\pi fL = 2\pi(50)(0.05) = 15.71\ \Omega$,

$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi(50)(100\times10^{-6})} = 31.83\ \Omega$

Impedance of circuit $Z = \sqrt{[R^2 + (X_C - X_L)^2]}$

$Z = 22.02\ \Omega$

1 mark for each bit stepwise solution

(i) Current $I = V/Z = (230)/(22.02) =$ **10.44 A**
(ii) Power factor $\cos Ø = R / Z =$ **0.68 leading**
(iii) Impedance of coil $Z_{Coil} = \sqrt{(R^2 + X_L^2)} = 21.72\ \Omega$
Voltage across coil $I \times Z_{Coil} = 10.44 \times 21.72 =$ **226.77 V**
(iv) Voltage across capacitor $V_C = I \times X_C = 10.44 \times 31.83 =$ **332.31V**

4 c) Define (i) Dynamically induced emf & (ii) Statically induced emf.

Ans :

(i) Dynamically induced emf :

When the emf is induced because of relative motion between conductor and magnetic field, then such emf is called dynamically induced emf. In this case the conductor cuts the magnetic field due to relative motion between them. 2 Mark

(ii) Statically induced emf :

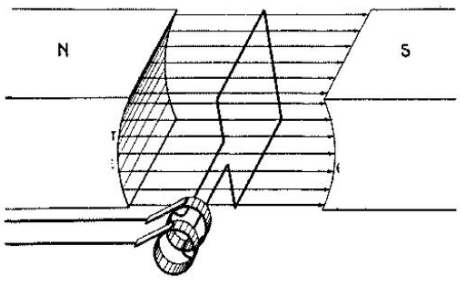
The conductor is stationary and magnetic field is changing, then the emf induced is called statically induced emf. This emf is induced without any relative motion between conductor and magnetic field. 2 Mark

4 d) Explain the process of generation of single phase AC by elementary generator.

Ans:

Generation of single phase AC by elementary generator:

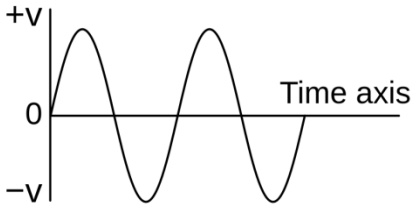
In an elementary generator, a single turn coil is rotated in the gap between two poles as shown in the figure. When the coil is in the vertical plane (shown in the figure), the conductors move along the magnetic lines of force. So no flux is cut and emf induced is zero. However, when conductors attain positions exactly below the poles, their movement is perpendicular to the magnetic lines of force. Therefore, the conductors cut the flux at maximum rate and maximum emf is induced in them. For other positions, the conductors cut the flux,



2 marks for diagrams

2 marks for explanation

but at less rate, hence emf induced is also less. The variation in the emf is just similar to sine wave, hence such emf is called sinusoidal emf.



4 e) What is auto transformer? Write any three applications of auto transformer?

Ans :

Autotransformer:

Auto transformer is single winding transformer.
One winding is wound on a laminated magnetic core. 1 Mark
The part of this winding is common to both primary and secondary circuit.

Applications:

1. For starting squirrel cage I. M. & synchronous motor. Any three
2. As boosters to raise the voltage in a. c. feeder. 3 Mark
3. As furnace transformer for getting suitable supply voltage.
4. As variac for getting required variable a.c. supply.

4 f) Define: (i) Slip (ii) Rotor frequency, (iii) Synchronous Speed, (iv) Slip speed

Ans:

(i) Slip :

The difference between synchronous speed and actual speed of the rotor expressed as fraction or percentage of synchronous speed, is called slip. 1 mark for each bit

$$\% s = \frac{(N_s - N)}{N_s} \times 100$$

(ii) Rotor frequency :

The frequency of rotor emf is proportional to relative speed ($N_S - N$) of rotating stator field with respect to the rotor. It is given by

f_r = slip x supply frequency = s.f

(iii) Synchronous speed :

The speed of rotating magnetic field produced by stator winding is called as synchronous speed. It is given by

$N_S = 120\ f / P$

(iv) Slip speed :

The relative speed between rotor and rotating magnetic field is called as slip-speed. It is given by $(N_S - N)$

5 Attempt any four: 16

5 a) Name various types of statically induced emf. Give the mathematical equation for energy stored in magnetic field.

Ans:

Types of statically induced emf:

i) Self-induced emf 1 mark

ii) Mutually induced emf — each

Mathematical equation for energy stored in magnetic field:

The energy stored in magnetic field at instant of time t is given by, — 1 mark for equation

$$E = ½ (L i^2) \text{ joule}$$

where, E is the energy is joule,

L is the inductance of coil in H — 1 mark for terms

i is the current flowing through the coil at instant of time t sec.

5 b) For AC sinusoidal waveform define:
(i) Cycle, (ii) Frequency, (iii) Phase, (iv) Amplitude

Ans:

i) Cycle:

A complete set of variation of an alternating quantity which is repeated at regular interval of time is called as a cycle. — 1 mark for each definition

OR

Each repetition of an alternating quantity recurring at equal intervals is known as a cycle.

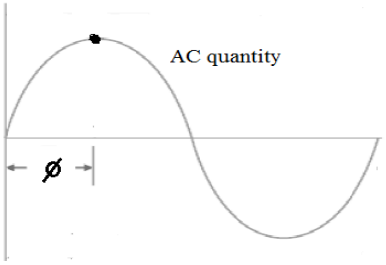
ii) Frequency:

Number of cycles completed by an alternating quantity in one second is called 'Frequency'.

iii) Phase:-

It is the angular distance covered by an alternating quantity since it passed through its last zero value while increasing towards positive maximum value.

In the following figure the phase of quantity at positive maximum value is Ø = 90°.



iv) Amplitude:

The maximum or peak value attained by an alternating quantity in a cycle during positive or negative half cycles is called as amplitude.

5 c) $v = 150 \sin(314t)$ and $i = 10 \sin(314t + \pi/4)$, find the circuit component connected in series.

Ans:

Data Given: Referring to the standard form of equation for sinusoidal quantity, we can write, — Stepwise solution

V_m = Maximum value of voltage = 150V

I_m = Maximum value of current = 10A

The voltage and current can be represented in polar form as, — 1 mark for V and I

$V = (150/\sqrt{2})\angle 0° = 106.07\angle 0°$ volt

I = $(10/\sqrt{2})\angle 45° = 7.07\angle 45°$ amp

Impedance of circuit Z = V/I = $\frac{106.07\angle 0°}{7.07\angle 45°} = 15\angle -45° = (10.61 - j10.61)\Omega$

1 mark for Z and X_C

∴ **Resistance R = 10.61Ω**

∴ Capacitive reactance $X_L = 10.61\Omega$

1 mark for R

Since $X_L = \frac{1}{2\pi fC}$ we can write,

$C = \frac{1}{2\pi f X_C} = \frac{1}{2\pi(50)(10.61)} = 300 \times 10^{-6} = \boldsymbol{300\mu F}$

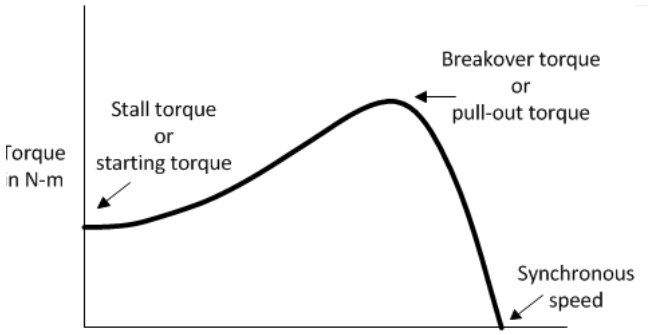
1 mark for C

∴**Capacitance C = 300μF**

5 d) Draw torque-speed characteristic of 3-phase IM and explain it.

Ans:

Torque-Speed characteristics of 3-pahse Induction Motor:



Speed-Torque Curve for a Three-Phase Induction Motor

2 marks for diagram

From the above characteristics:-

- When slip (s) ≈ 0, the rotor speed is equal to synchronous speed (i.e N≈ Ns) torque is almost zero at no load.
- 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 will be obtained at condition $R_2 = sX_2$
- 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.

2 marks for explanation

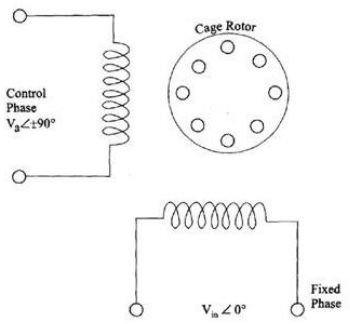
5 e) Explain the working principle of AC servo motor and state its two applications

Ans:

Principle of working of servo motor:

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° space displacement of the two coils/windings and the 90° 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.



1 mark for diagram

2 mark for explanation

Applications :

1 mark for applications

1. Process control equipment.
2. Machine tools.
3. Robotics.
4. Process Controllers.
5. AC position control applications.
6. Portable drilling machine.
7. Sewing machine.

5 f) Give any two applications of following motors.

1. Universal Motor
2. Stepper Motor

Ans:

1. <u>Universal Motor:</u>

Any two 1 mark Each

Washing Machine
Mixer
Grinder
Food Processor
Vaccume Cliner
Hair Drier
Small Drilling Machine
Sewing machine

2. <u>Stepper Motor:</u>

Any two 1 mark each

Robotics
CNC machines
Printer
Radar
Satelite communication system
X-ray Machine
CT scan System
Watch
X-Y recorders and Ploters
Process control System

6 Attempt any four **16**

6 a) Three identitical coils each of impedances (4.2 +j 5.6)Ω are connected in delta across 415 V, 50 Hz, three phase power supply. Determine
i)V_{ph} ii)I_{ph} iii) Power factor iv) Power absorbed by each coil.

Ans:

Given: $Z_{ph} = (4.2 + j\,5.6)\Omega$, $V_L = 415$ V , f = 50 Hz , Delta connection

1 mark for each bit stepwise solution

i) To find V_{ph}:

In delta connection $V_{ph} = V_L$

Hence, **$V_{ph} = V_L = 415$ V**

ii) To find I_{ph}:

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

$$I_{ph} = \frac{415\angle 0°}{4.2 + j\,5.6}$$

$$I_{ph} = \frac{415\angle 0°}{7\angle 53.13°}$$

$I_{ph} = 59.28 \angle -53.13°$ Amp

iii) To find Cos ϕ :

Cos ϕ = cos (-53.13)
= **0.6**

OR

$$\text{Cos } \phi = \frac{R}{Z}$$

$$\text{Cos } \phi = \frac{4.2}{7}$$

= 0.6

iv) To find power consumed by each coil :

Power consumed by each coil = V_{ph} I_{ph} Cos ϕ

= 415 x 59.28 x 0.6

= **14760.72 watt**

= 14.7607 kW

6 b) A 20 KVA 3300/240V, 50 Hz single phase transformer has 80 tuns on secondary winding. Calculate number of primary turns, Full load primary and secondary currents and maximum value of flux in the core.

Ans:

Given: a) kVA=20 b) $V_1 = 3300$V c) $V_2 = 240$ V d) f=50Hz e) N_2 =80 turns
To find : i) N_1 = ? ii) Full load primary current = ?

iii) Full load secondary current = ? iv) Maximum flux ?

i) Number of primary winding turns N_1:

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

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

$$N_1 = \frac{3300}{240} \text{ x } 80$$

$$= \mathbf{1100 \text{ turns}}$$

1 mark for each bit stepwise solution

ii) To Find full load Primary current I_1:

$$I_1 = \frac{KVA \text{ x } 10^3}{V_1}$$

$$I_1 = \frac{20 \text{ x } 10^3}{3300}$$

$$= \mathbf{6.06 \text{ Amp}}$$

iii) To Find full load secondary current I_2:

$$I_2 = \frac{KVA \text{ x } 10^3}{V_2}$$

$$I_2 = \frac{20 \text{ x } 10^3}{240}$$

$$= \mathbf{83.33 \text{ Amp}}$$

iv) Maximum flux:

$$E_1 = 4.44 \, \emptyset_m \, f \, N_1$$

$$\Phi_m = \frac{E_1}{4.44 \ f \ N_1}$$

$$\Phi_m = \frac{3300}{4.44 \text{ x } 50 \text{ x } 1100}$$

$\Phi_m = 0.01351$ weber or

$$= \mathbf{13.51 \text{ mwb}}$$

OR

$$E_2 = 4.44 \, \emptyset_m \, f \, N_2$$

$$\Phi_m = \frac{E_2}{4.44 \ f \ N_2}$$

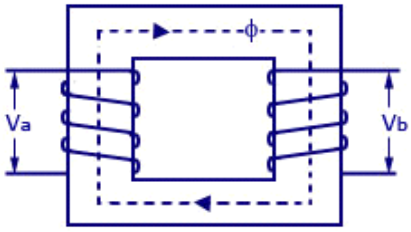
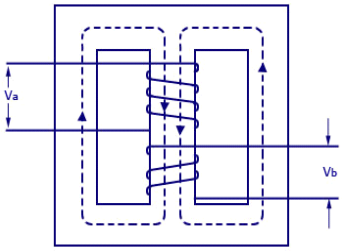
$$\Phi_m = \frac{240}{4.44 \text{ x } 50 \text{ x } 80}$$

$\Phi_m = 0.01351$ weber or

$$= \mathbf{13.51 \text{ mwb}}$$

6 c) Differentiate between core type and shell type transformer.(Any four points)

Ans:

Sr. No.	Core Type Transformer	Shell Type Transformer
1		
2	The Winding surrounds the core	The core surrounds 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
8	Mechanical protection for core is less	Mechanical protection for core is More
9	Cooling is more	Cooling is not effective
10	Cylindrical winding is used	Sandwich type winding

1 mark for each of any 4 points

6 d) State an electric motors suitable for

1. Table fan
2. Blowers
3. Washing machine
4. Centrifugal pumps

Ans:

1. Table fan
   i. Capacitor split phase induction motor

2. Blowers
   i. Split phase induction motor
   ii. Shaded Pole induction motor

3. Washing machine
   i. Universal Motor
   ii. Shaded Pole induction motor

4. Centrifugal pumps
   i. Split phase induction motor
   ii. Single phase Capacitor start induction motor

1 mark for each

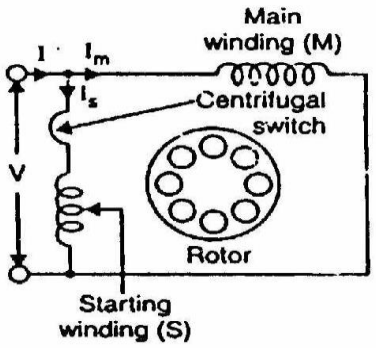
6 e) List the different types of single phase induction motor. Draw neat sketch for any one.

Ans:

Following are the types of single phase induction motor:

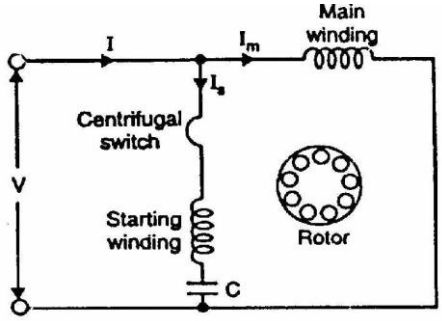
1. Split phase induction motor
2. Capacitor start induction motor
3. Capacitor start capacitor run induction motor
4. Shaded pole induction motor.

1. Split phase induction motor:



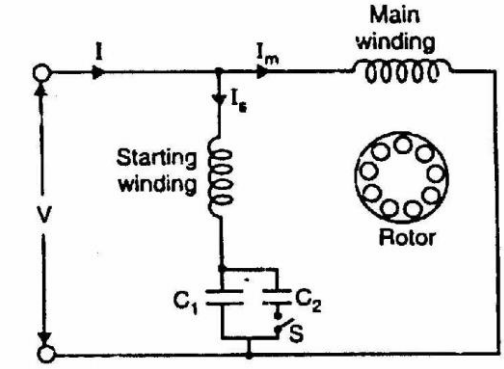
Or equivalent diagram

2. Capacitor start induction motor:



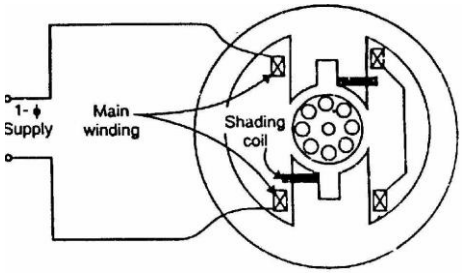
Or equivalent diagram

3. Capacitor start capacitor run induction motor:



Or equivalent diagram

4. Shaded pole induction motor:



Or equivalent diagram

6 f) State the types of earthing. Draw schematic diagram of plate earthing.

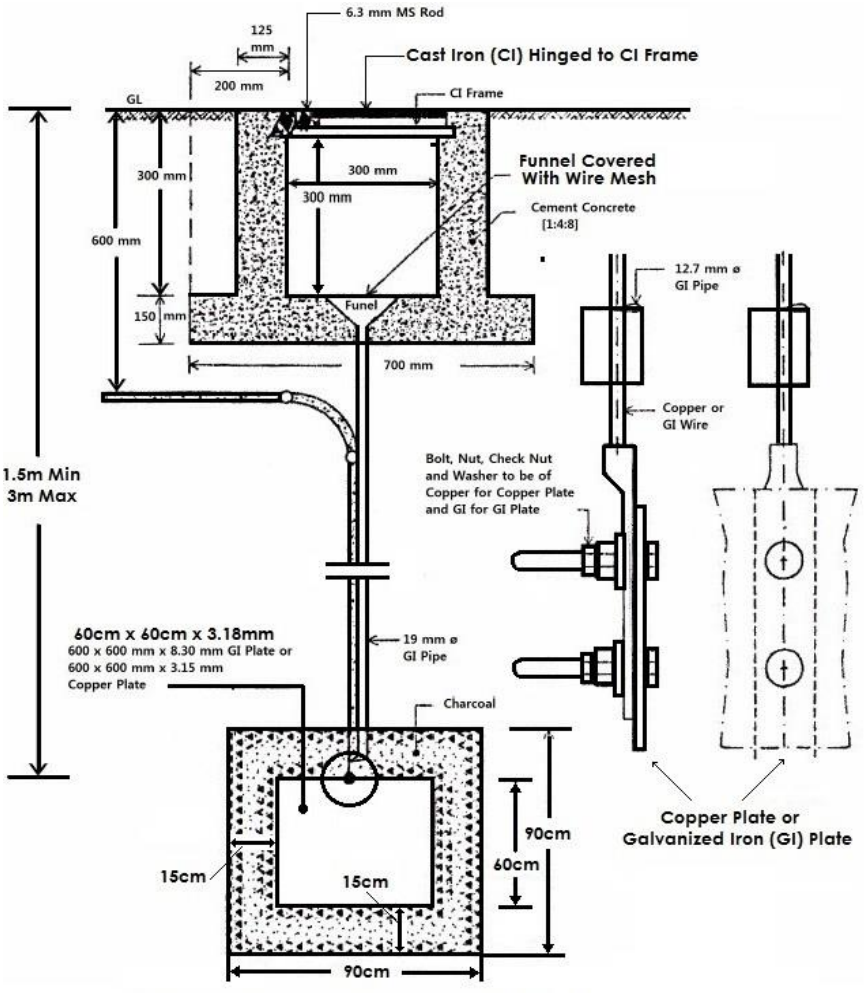
Ans:

Types of earthing:

- Plate earthing.
- Pipe earthing.

Types
1 marks

Schematic diagram of plate earthing:



Labeled
Diagram
3 marks

Or equivalent diagram