Winter – 2017 Examinations
Model Answer **Subject Code: 17331 (ETG)**

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 (A) **Attempt any SIX of the following:** 12

1 (A) (a) Define node and loop in a network.

Ans:

Node: A point or junction where two or more than two elements of network are connected together is called node. 1 Mark

Loop: A closed path for flow of current in an electrical circuit is called loop. 1 Mark

1 (A) (b) State Ohm's Law.

Ans:

Ohm's Law:

As long as physical conditions (such as dimensions, pressure and temperature) are constant, the potential difference or voltage applied across the conductor is directly proportional to current flowing through it. 2 Marks

OR

As long as physical conditions (such as dimensions, pressure and temperature) are constant, the current flowing through the conductor is directly proportional to the potential difference or voltage applied across it.

$V \alpha I$ i. e. $V = R I$ OR $I \alpha V$ i.e $I = V/R$

where, R = constant of proportionality, called as the resistance of the conductor.

1 (A) (c) State the formula to find equivalent resistance of three resistances connected in parallel.

Ans:

Formula to find equivalent resistance of 3 resistances connected in parallel:

$$\frac{1}{R} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$$

2 Marks

Where, R is magnitude of equivalent resistance in Ω,
R1, R2, R3 are the magnitudes of individual resistances in Ω.

1 (A) (d) State Faraday's Laws of Electromagnetic induction.

Ans:

Faraday's Laws of Electromagnetic induction:

First Law:

Whenever a changing magnetic flux links with a conductor, an emf is induced in that conductor. OR

When a conductor cuts across magnetic field, an emf is induced in that conductor. 1 Mark

Second Law:

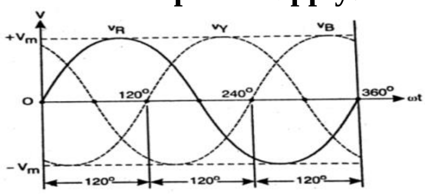
The magnitude of induced emf is directly proportional to the rate of change of flux linking with the conductor or the rate of flux cut by the conductor. 1 Mark

1 (A) (e) Draw the waveform representation of three phase supply with neat labels.

Ans:

Waveform representation of three phase supply:

2 Marks for labeled waveform
1 Mark for unlabeled waveform



1 (A) (f) What is meaning of phase sequence in a 3-phase system? Give the 3-phase sequence used in practice.

Ans:

Meaning of phase sequence in a 3-phase system:

Phase sequence is defined as the order in which the voltages (or any other alternating quantity) of the three phases attain their positive maximum values. — 1 Mark

Phase sequence used in practice is -- R-Y-B. — 1 Mark

1 (A) (g) State the importance of earthing.

Ans:

Importance of earthing:

1) Earthing is grounding the metallic body of the electrical equipment to avoid the hazards due to leakage current. If the leakage current keeps circulating in the body of the equipment, it might result in electrical shocks.
2) Earthing is necessary for better voltage regulation and protection from surges and lightning strikes.
3) To provide safe path to divert lightning and short circuit currents.
4) To provide stable platform for operation of sensitive electronic equipment.

1 Mark for each (any two) = 2 Marks

1 (A) (h) Classify transformer on the basis of (i) Construction (ii) Supply system.

Ans:

Classification of transformer

(i) On the basis of Construction-(any two)**:**

1) Core type transformer
2) Shell type transformer
3) Berry type transformer

1 Mark

(ii) On the basis of Supply system:

1) Single phase transformer
2) Three phase transformer

1 Mark

1 (B) **Attempt any <u>TWO</u> of the following:** **8**

1 (B) (a) State the function of following part of a transformer.

(i) Conservator (ii) Transformer oil (iii) Laminated steel core (iv) Windings

Ans:

1) **Conservator:**
Provides through breather scope for expansion and contraction of insulating oil in the transformer tank due to heating/cooling, thus preventing the buildup of high pressure in the tank.
2) **Transformer oil:**
Provides cooling to transformer and used for insulation purposes.
3) **Laminated steel core:**
Facilitates placement of respective phase windings (primary and secondary) and provides path of low reluctance for the magnetizing flux.
4) **Windings:**
Facilitates production of emf in the windings for transferring the electrical energy from primary circuit to secondary circuit.

1 Mark each = 4 Marks

1 (B) (b) Determine current through 5 ohm resistance in the circuit shown in fig no. 1 using node voltage method.

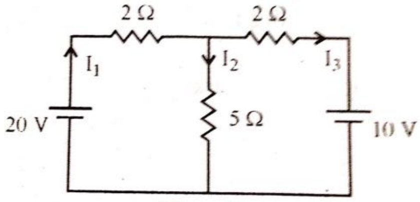
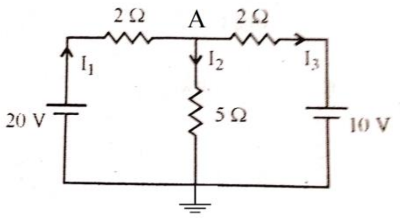


Fig. – 1

Ans:



By applying KCL to Node A

$$I_1 = I_2 + I_3$$

$$\frac{20 - V_A}{2} = \frac{V_A}{5} + \frac{V_A - 10}{2}$$

$$10 = \frac{V_A}{2} + \frac{V_A}{5} + \frac{V_A}{2} - 5$$

$$15 = \frac{12V_A}{10} \qquad 12V_A = 150$$

$$V_A = 12.5 \text{ volts}$$

Current flowing through resistance 5 Ω = $\frac{V_A}{5} = \frac{12.5}{5} = \mathbf{2.5\ Amp}$

1 Mark for equation formulation

2 Mark for stepwise solution of V_A

1 Mark for Current

1 (B) (c) Three identical coils each of (4.2 + j 5.6) ohms are connected in star across 415volt, 3-phase, 50 Hz AC supply.
Determine: (i) Phase voltage (ii) Phase current (iii) Power factor (iv) Power absorbed by the load.

Ans:

Data Given:

Line Voltage V_L = 415V, frequency f = 50 Hz

Impedance per phase Z = 4.2 + j 5.6 Ω,

In star-connected system, phase voltage $V_{ph} = \frac{1}{\sqrt{3}}$ Line voltage

$= \frac{415}{\sqrt{3}} = \mathbf{239.60\ V}$

Impedance per phase Z_{ph} = 4.2 + j 5.6 Ω = 7 ∟53.13^0 Ω

∴ Phase current $I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{239.60}{7} = \mathbf{34.23\ A}$

In star-connected system, Line current = Phase current = 34.23 A

Power factor = $cos\emptyset = \cos 53.13\ OR = cos\frac{4.2}{7}$ = **0.6 lagging**

Total Power absorbed by the circuit,

$$P_{3\emptyset} = \sqrt{3}V_L I_L cos\emptyset = 3V_{ph}I_{ph}cos\emptyset$$

$$= \sqrt{3} \times (415) \times (34.23) \times 0.6$$

= **14762.73 watt = 14.76 kW**

1 Mark for each bit = 4 Marks

2 **Attempt any <u>FOUR</u> of the following:** **16**

2 (a) Three resistances 50 Ω, 40 Ω and 25 Ω are connected in parallel. Determine its

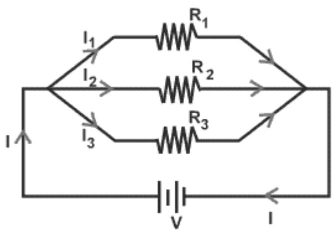
equivalent resistance. If the current in 25 Ω resistance is 8 Amp. Find currents in the other two resistances and total power consumed in the circuit.

Ans:

Data Given:

$R_1 = 50\ \Omega$, $R_2 = 40\ \Omega$, $R_3 = 25\ \Omega$

$I_3 = 8A$



1) **Equivalent Resistance (R_{eq}):**

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R_{eq}} = \frac{1}{50} + \frac{1}{40} + \frac{1}{25} = \frac{4+5+8}{200}$$

$$\frac{1}{R_{eq}} = \frac{17}{200}$$

$$R_{eq} = \frac{200}{17} = \mathbf{11.76\Omega}$$

1 Mark for R_{eq}

2) **Branch Currents:**

Referring to the circuit diagram,

$$V = I_3R_3 = 8 \times 25 = 200V$$

Since $V = I_1R_1 = I_2R_2 = I_3R_3$

$$I_1 = \frac{V}{R_1} = \frac{200}{50} = \mathbf{4A}$$

1 Mark for I_1

$$I_2 = \frac{V}{R_2} = \frac{200}{40} = \mathbf{5A}$$

1 Mark for I_2

3) **Power consumed in the circuit:**

$$P = \frac{V^2}{R_{eq}} = \frac{200^2}{11.76} = \mathbf{3400W}$$

1 Mark for P

$$OR$$

$I = I_1 + I_2 + I_3 = 4+5+8 = 17A$ and $P = VI = 200 \times 17 = 3400$ W

2 (b) Using mesh loop method, find the current in 6 Ω and hence power consumed by 6 Ω resistance for the network shown in fig. no. 2.

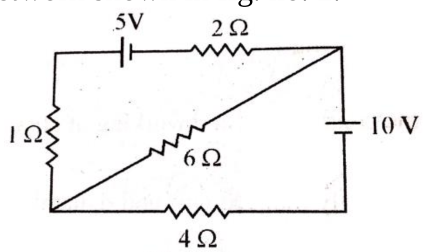
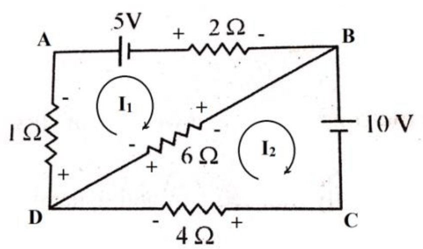


Fig. – 2

Ans:



1 Mark for Circuit diagram with mesh currents

By applying KVL to mesh ABDA

$$-5 - 2I_1 - 6(I_1 - I_2) - 1I_1 = 0$$

$$-9I_1 + 6I_2 = 5 \text{ ------------------- (1)}$$

1Mark for two equations formulation

By applying KVL to mesh BCDB

$$-10 - 4I_2 - 6(I_2 - I_1) = 0$$

$$6I_1 - 10I_2 = 10 \text{ ------------------- (2)}$$

Multiply eq (1) by 6 and eq (2) by 9, we get

$-54I_1 + 36 I_2 = 30$ -------------------------(3)

$54I_1 - 90 I_2 = 90$ ------------------------(4)

Adding eq (3) from eq (4), we get

$54 I_2 = -120$

$\therefore$ $I_2 = \frac{-120}{54}$ = **-2.22 A**

Substituting I_2 in eq. (1), we get

$$-9I_1 + 6(-2.22) = 5$$

$$-9I_1 - 13.32 = 5$$

$$-9I_1 = 18.32$$

$$I_1 = \mathbf{-2.037A}$$

It is seen that the current magnitudes are negative, it means that the assumed directions of currents (both clockwise) are not proper. The actual currents are anti-clockwise with positive magnitudes.

Thus

$$I_1 = \mathbf{2.037A} \text{ (anticlockwise)}$$

$$I_2 = \mathbf{2.22A} \text{ (anticlockwise)}$$

1 Mark for mesh currents

The net current through 6 Ω is given by $I = I_2 - I_1$ (from B to D)

$\therefore$ I = 2.22 – 2.037 = **0.183A**

Power consumed by 6 Ω is given by,

$P = I^2 R = (0.183)^2 (6) =$ **0.2W**

1 Mark for power

2 (c) Define the following terms w.r.to A.C. system :

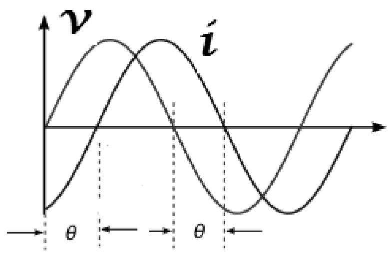
(i) Phase difference (ii) Phase angle (iii) Leading (iv) Lagging

Ans:

i) Phase difference:-

Phase difference between two alternating quantities is the angular distance between their respective zero or maximum values.

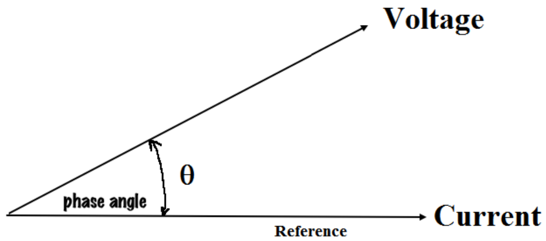
In the following figure, it is seen that the angular distance between corresponding zero values is θ, hence phase difference between them is θ.



1 Mark for each bit = 4 Marks

ii) Phase angle:

It is the angle made by a phasor with respect to the reference. In the following phasor diagram, the phase angle of voltage is θ, whereas the phase angle of current is 0°, considering +x-axis as reference.



iii) Leading:

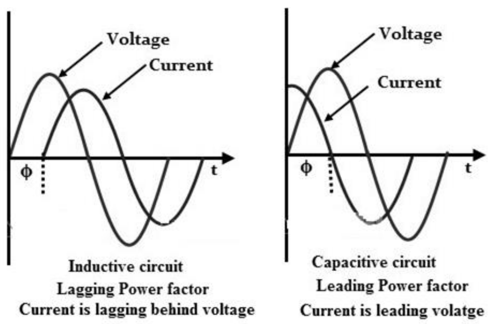
When two quantities do not attain their respective zero or peak values simultaneously, then the quantities are said to be out-of-phase quantities. The quantity which attains the respective zero or peak value first, is called 'Leading Quantity'.

In the following first diagram, the voltage attains its zero or positive peak first and after an angle of ϕ, the current attains its respective zero or positive peak value, hence voltage is said to be leading the current by an angle of ϕ. Similarly, in the second diagram, the current is said to be leading the voltage by ϕ.

iv) Lagging:

The quantity which attains the respective zero or peak value later, is called 'Lagging Quantity'.

In the following first diagram, the current attains its zero or positive peak later than the voltage after an angle of ϕ, hence current is said to be lagging the voltage by an angle of ϕ. Similarly, in the second diagram, the voltage is said to be lagging the current by ϕ.



2 (d) An alternating voltage is mathematically expressed as

$$v = 141.42\sin\left(157.08t + \frac{\pi}{12}\right)\ volt$$

Find its maximum value, RMS value, frequency and time period.

Ans:

Standard equation of sinusoidal quantity is $v = V_m \sin(\omega t \pm \emptyset)\ volt$

On comparing the given voltage with standard equation, we get

1 Mark for each bit = 4 Marks

(i) Maximum Value $V_m = \mathbf{141.42\ V}$

(ii) RMS value of voltage (V_{rms}):

$$V_{rms} = \frac{V_m}{\sqrt{2}} = \frac{141.42}{\sqrt{2}} = \mathbf{100\ V}$$

(iii) Angular frequency ω = 157.08 rad/sec = $2\pi f$

$\therefore$ frequency $f = \frac{157.08}{2\pi} = \mathbf{25\ Hz}$

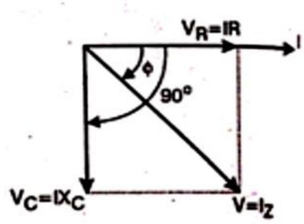
(iv) Time period T = 1/f = 1/25 = **0.04 sec = 40 millisecond**

2(e) Draw phasor diagram for R-C series circuit. Write the voltage and current equations for it.

Ans:

1) Phasor diagram for R-C series circuit:

2 Marks for phasor diagram



Phasor Diagram

2) Voltage and current Equations

2 Marks for equations

$v = V_m \sin(\omega t)$ volt

$i = I_m \sin(\omega t + \phi)$ amp

2(f) A coil of resistance 10 Ω and an inductance 0.1 H is connected in series with a capacitor of 150 μF across 200 volts, 50Hz supply. Find

(i) Inductive reactance
(ii) Capacitive reactance
(iii) Impedance
(iv) Current

Ans:

Data Given:

Resistance R = 10Ω, Inductance L = 0.1H, Capacitance C = 150μF =150×10^{-6} F

Supply Voltage V = 200V and f = 50Hz.

1 Mark for each bit = 4 Marks

(i) Inductive reactance $X_L = 2\pi fL = 2\pi(50)(0.1) = \mathbf{31.416\Omega}$

(ii) Capacitive reactance $X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi(50)(150\times10^{-6})} = \mathbf{21.22\Omega}$

(iii) Impedance of series circuit

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{10^2 + (31.416 - 21.22)^2}$$
$$= \mathbf{14.28\,\Omega}$$

(iv) Current $I = \frac{V}{Z} = \frac{200}{14.28} = \mathbf{14}$ **A**.

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

3(a) Define fuse. Explain the construction and working of HRC fuse.

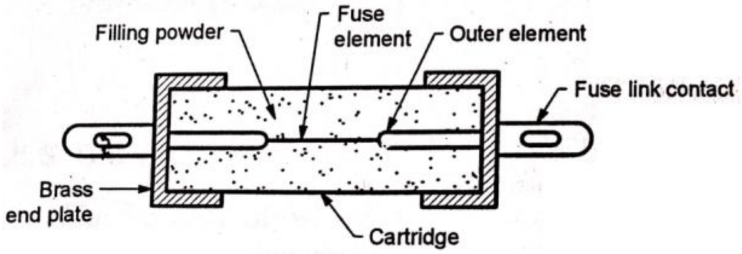
Ans:

Fuse:

A fuse is a short piece of metel, insered in series with circuit which melts when exessive current flows through it and thus breaks the circuit. 1 Mark for definition

Construction of HRC fuse:

HRC fuse mainly consists of heat resisting ceramic body. The current carrying element is compactly surrounded by the filling powder. Filling material acts as 1 Mark for construction an arc quenching and cooling medium when the fuse element blows off due to excessive heat generated under abnormal conditions.



H.R.C. fuse

1 Mark for diagram

Working of HRC fuse:

Under normal conditions, the fuse element is at a temperature below its melting point. Therefore, it carries the normal current without overheating. 1 Mark for working

When a fault occurs, the current increases and the heat produced is sufficient to melt the element and ultimately breaking the circuit current, it protects the load.

3(b) Distinguish between statically induced emf and dynamically induced emf with examples.

Ans:

Comparison between statically & dynamically induced emf:

Statically induced emf	Dynamically induced emf
Emf is induced without any relative motion between conductor and magnetic field.	Emf is induced due to relative motion between conductor and magnetic field.
Emf is induced when changing magnetic field links with a conductor.	Emf is induced when conductor cuts the magnetic field due to relative motion between them.
Direction of statically induced emf is given by Lenz's law.	Direction of dynamically induced emf is given by Fleming's Right hand rule.
Two types: Self-induced emf, Mutually induced emf	No such further classification
e.g. emf induced in transformer windings	e.g emf induced in Generator, Alternator armature windings

1 Mark for each of any three points excluding examples = 3 Marks

1 Mark for examples

3(c) Draw the labelled diagram for balanced three phase delta connected system. State the relationship between :

(i) Line voltage and phase voltage

(ii) Line current and phase current

(iii) Power in terms of phase voltage and phase current

Ans:

Balanced three phase delta connected system:

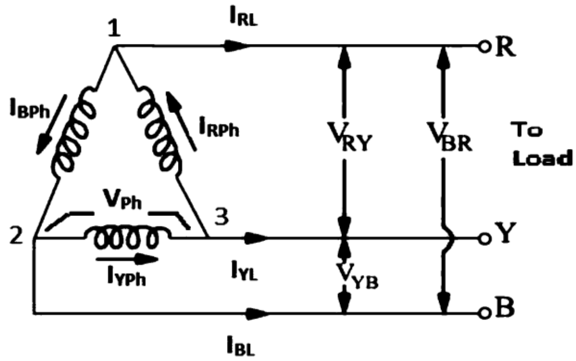
For balanced delta connected system shown in the diagram below,

Line Currents: I_{RL}, I_{YL}, I_{BL}

Phase Currents: I_{RPh}, I_{YPh}, I_{BPh}

Line Voltages: V_{RY}, V_{YB}, V_{BR}

Phase Voltage: V_{12}, V_{23}, V_{31}



3 Phase Delta Connected Supply System

2 Marks for labeled diagram

The relationship in delta connection :

(i) Line voltage = Phase voltage OR ($\therefore V_L = V_{ph}$)
(ii) Line current = √3 x Phase current OR ($\therefore I_L = \sqrt{3}\, I_{ph}$)
(iii) Power in each phase $P_{ph} = V_{ph} I_{ph} \cos\phi$
(iv) Total three-phase power $P_T = 3\, V_{ph}\, I_{ph} \cos\phi = \sqrt{3}\, V_L\, I_L \cos\phi$

½ Mark for each equation = 2 Marks

3(d) Define the following term :
(i) Power factor
(ii) Active power
(iii) Apparent power
(iv) Reactive power

Ans:

(i) Power factor:

It is the cosine of the angle between the applied voltage and the resulting current.

Power factor = $\cos\phi$

where, ϕ is the phase angle between applied voltage and current.

OR

It is the ratio of true or effective or real power to the apparent power.

$$\text{Power factor} = \frac{\text{True Or Effective Or Real Power}}{\text{Apparent Power}} = \frac{VI\cos\emptyset}{VI} = \cos\emptyset$$

OR

It is the ratio of circuit resistance to the circuit impedance.

$$\text{Power factor} = \frac{\text{Circuit Resistance}}{\text{Circuit Impedance}} = \frac{R}{Z} = \cos\emptyset$$

1 Mark for any definition

(ii) Active power: It is the product of voltage, current and the cosine of the phase angle between voltage and current. OR

It is the power actually utilized in the circuit.

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

1 Mark for any definition

(iii)Apparent Power :

This is simply the product of RMS voltage and RMS current.

$S = VI = I^2Z$ volt-amp.

1 Mark for any definition

(iv)Reactive Power:

Reactive power (Q) is the product of voltage, current and the sine of the phase angle between voltage and current.

$Q = VI\sin\emptyset = I^2X$ volt-amp-reactive.

1 Mark for any definition

3(e) Write any four safety precautions to be taken while working with an electrical system.

Ans:

Safety precautions to be taken while working with an electrical system:

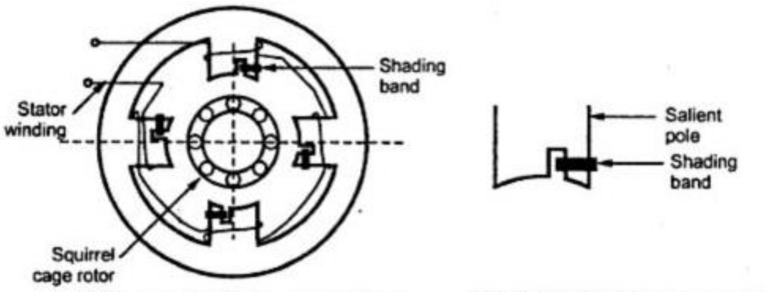
1. Avoid working on live parts.
2. Switch off the supply before starting the work.
3. Never touch a wire till you are sure that no currents are flowing.
4. Do not guess, whether electric current is flowing through a circuit by touching.
5. Insulate yourself on the insulating material like wood, plastic etc. before starting the work on live circuit.
6. Your hand & feet must be dry (not wet) while working on live circuit.
7. Rubber mats must be placed in front of electrical switchgears/ panels.
8. Use hand gloves, Safety devices & proper insulated tools.
9. Ground all metallic parts of machine body, and structure of equipment.
10. Earthing should be checked frequently.
11. Do not use aluminum ladders but use wooden ladders while working with electrical circuits.
12. Do not operate the switches without knowledge.
13. Do not use defective material for repairing.
14. While working on live equipment, obey proper instructions.
15. Do not work on defective equipment.
16. Use safe clothing.
17. Use shoes with rubber soles to avoid shock.
18. Do not wear suspected necklace, arm bands, finger ring, key chain, and watch with metal parts while working.
19. Do not work if there is improper illumination such as in sufficient light or unsuitable location producing glare or shadows.
20. Do not work if there is an unfavorable condition such as rain fall, fog or high wind.
21. Do not sacrifice safety rules for speed.
22. Do not allot work to untrained person (worker) to handle electrical equipment.
23. Make habit to look out for danger notice, caution board, flags, and tags.
24. Warn others when they found to be in danger near live conductors or apparatus.
25. Inspect all electrical equipment & devices to ensure there is no damage or exposed wires that may causes a fire or shock.
26. Avoid using electrical equipment near wet, damp areas.
27. Use approved discharge earth rod for before working.
28. Never speak to any person working upon live mains.
29. Do not do the work if you are not sure.

1 Mark for each(any four) = 4 Marks

3 (f) Explain the construction and operation of shaded pole single phase induction motor.

Ans:

Construction and operation of Shaded pole Single phase Induction Motor:



(a) 4 - pole shaded pole construction (b) Salient pole with shading band

2 Marks

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.

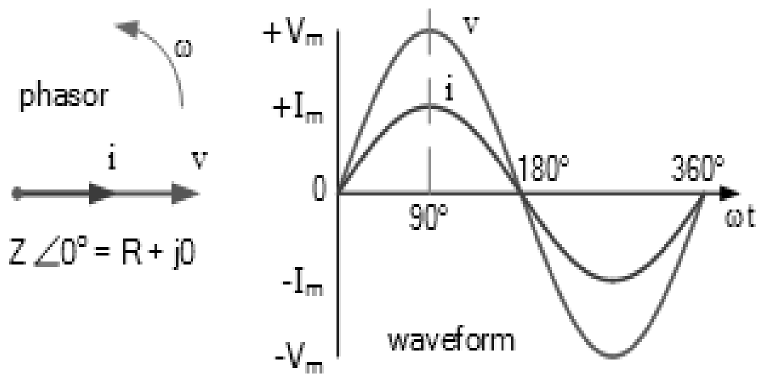
When a single phase supply is fed to the main winding, an alternating flux is produced in the pole. A portion of this flux links with the shading band and induces a voltage in it. As shading band is short-circuited, a large current flows in it. The current in the shading band causes the flux in the shaded portion of the pole to lag the flux in the un shaded portion of the pole. Thus the flux in the shaded portion reaches its maximum value after the flux in the un shaded 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. 2 Marks

4 **Attempt any <u>FOUR</u> of the following**: **16**

4 (a) Draw the waveforms for current, voltage and phasor diagram of a simple resistive circuit when an A.C. voltage is applied across it.

Ans:

Waveforms for current, voltage and phasor diagram of a single resistive circuit when an A.C. voltage is applied across it:



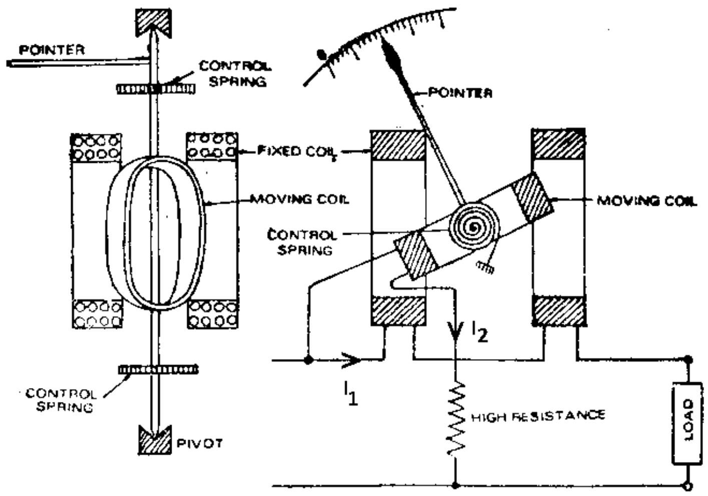
2 Marks for waveform

2 Marks for phasor diagram = 4 Marks

4 (b) Explain the construction and working of dynamometer type wattmeter.

Ans:

Construction and working of 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". 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.

1 Mark for construction

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.

1 Mark for working

4 (c) State any four advantages of three phase system over single phase system.

Ans:

Advantages of three phase system over single phase system:

1) Three phase transmission line requires less conductor material for same power transfer at same voltage.
2) For same frame size, three phase machine gives more output.
3) For same rating, three phase machines have small size.
4) Three phase motors produce uniform torque.
5) Three phase induction motors are self-starting.
6) For same rating, three phase motors have better power factor.
7) Three phase transformers are more economical. Power capacity to weight ratio is more.
8) Three phase machines have higher efficiencies.
9) Three phase system is more economical with regards to generation, transmission and distribution of power.
10) Three phase machines require less maintenance.

1 Mark for each(any four) = 4 Marks

4 (d) State any four merits of MCB over fuse.

Ans:

Merits of MCB over fuse:

1) Safety disconnecting features for circuit isolation.
2) It is reusable, hence very little maintenance costs.
3) Instant re-closing of the circuit after a fault has been cleared.
4) Terminal insulation for operator safety.
5) Lower power losses.
6) Simplicity of mounting and wiring.
7) Lower space requirements.
8) Stable arc interruption.
9) Discrimination can be achieved either based on current or based on time.
10) Closed overload protection compared to HRC fuses.
11) Stable tripping characteristics.
12) MCB is more sensitive to current than fuse. It detects any abnormality in the current flow and automatically switches off the electrical circuit.
13) In case of MCB, the faulty zone of electrical circuit can be easily identified.
14) MCB provides a better interface with the help of knob than a fuse.

1 Mark for each of any four points = 4 Marks

4 (e) Define efficiency and voltage regulation of single phase transformer.

Ans:

Efficiency:

It is defined as the ratio of the output power to the input power of transformer. 2 Marks

OR % Efficiency = (output power/input power) x 100

OR % Efficiency = (output power/(output power+ losses)) x 100

Regulation:

The change in secondary voltage of transformer from no load to full load expressed as a fraction or percentage of no load voltage (or Full load voltage), keeping primary voltage constant, is called as regulation. 2 Marks

OR % $Regulation_{dowm} = \{(V_{NL}-V_{FL})/V_{NL}\}$x 100 OR

% $Regulation_{up} = \{(V_{NL}-V_{FL})/V_{FL}\}$x 100

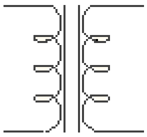
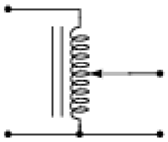
4 (f) Compare a two winding transformer with auto transformer (any four points).

Ans:

Comparison of two winding transformer with auto transformer:

Sr. No.	Two winding Transformer	Autotransformer
1	There are two separate windings, one for primary and one for secondary.	Only one winding, part of the winding is common for primary and secondary.
2	No movable contact between primary and secondary	Movable contact exist
3	Electrical isolation between primary and secondary windings.	Electrical connection between primary and secondary.
4	Comparatively more losses	Comparatively lower losses.
5	Efficiency is less as compared to autotransformer.	Efficiency is more as compared to two winding transformer.
6	Copper required is more.	Copper required is less, thus

1 Mark for each of any four points = 4 Marks

		copper is saved.
7	Core type or shell type construction	Spiral core construction
8	Generally used where fixed voltage is required.	Special applications where variable voltage is required.
9	Cost is more	Cost is less
10	Poor voltage regulation	Better voltage regulation
11	 Symbol of Two winding transformer	 Symbol of Auto transformer

5 **Attempt any <u>FOUR</u> of the following** 16

5 (a) State and explain Lenz's law.

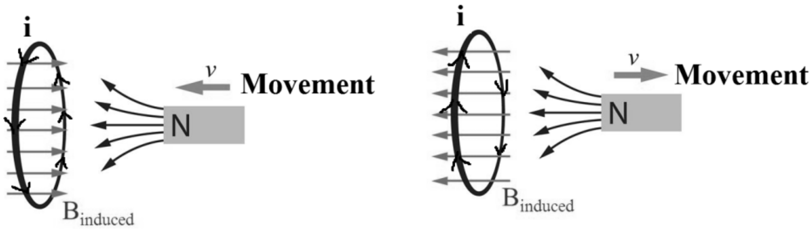
Ans:

Lenz's law:

Lenz's law states that the direction of induced emf is such that it always opposes the cause of its production. 1Mark

Explanation :

Consider a loop made of conducting material facing perpendicular to the magnet, as shown in the diagram. If the magnet is moved towards the loop, the loop experiences increase in the magnetic field of the permanent magnet. Since the changing magnetic flux is linking with the loop, emf is induced in the loop. The cause of production of the emf is the increasing magnetic field. According to Lenz's law, the direction of emf is such that it always opposes the cause of its production. Here the emf produces current in the loop in such direction that the magnetic field produced by this current ($B_{induced}$) opposes the increasing flux of magnet. Therefore the direction of $B_{induced}$ is opposite to the direction of the flux of magnet. To have the opposite $B_{induced}$, the emf circulates anticlockwise current in the loop, as shown in the figure (a). 3 Marks for explanation



(a) (b)

If the direction of movement of magnet is reversed to take it away from the loop, the loop experiences decrease in the flux. The emf now acts to oppose the decay in the flux. So the emf circulates loop current in such direction that the flux produced by loop current lies in the same direction as the flux of magnet. For this the emf circulates current in clockwise direction as shown in the figure (b). Thus the emf always acts to oppose the cause of its production.

5 b) Define inductive reactance of coil. Write its unit. State the factors on which it depends.

Ans:

Inductive reactance of coil:

The opposition offered by coil to the alternating current due to its inductance is called the inductive reactance of the coil. It is the imaginary part of the impedance of the coil. — 1 Mark for definition

Unit: Being an opposition to the current, it is measured in ohm (Ω). — 1 Mark for unit

Factors on which Inductive Reactance depends:

Inductive reactance is given by,

$X_L = 2\,\pi\,f\,L\,\Omega$

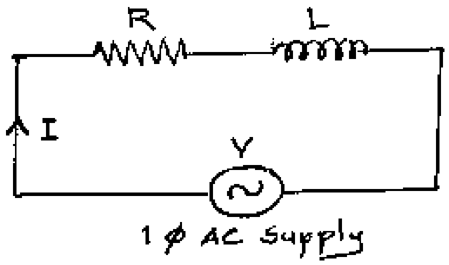
It depends upon: — 2 Marks for two factors

i) **L - Inductance** of the coil
ii) **F - Frequency** of the current in coil

5 c) Draw a series R-L circuit. Write its expression for impedance. Draw the impedance triangle.

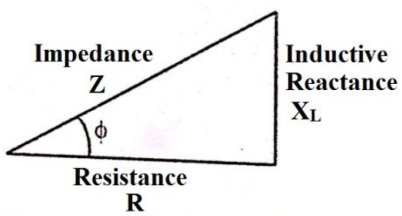
Ans:

Series R-L circuit:



1 Mark for R-L circuit

Impedance triangle:



Impedance triangle for R-L series circuit

2 Marks for Impedance triangle

Expression for impedance:

$$Z = R + jX_L \quad OR \quad Z = |Z|\angle\emptyset \;;$$

$$Z = \sqrt{R^2 + (X_L)^{\,2}} \qquad \emptyset = tan^{-1}\frac{X_L}{R}$$

1 Mark for expression

5d) Explain the concept of power factor and its significance..

Ans:

Concept of power factor:

Power factor is cosine of angle between voltage and current.

$\cos\phi = R / Z$ **OR** 1 Mark

Power factor is the ratio of active power to the apparent power

pf = KW/ KVA

Significance of Power factor:

1. If pf increases, current reduces, so the cross- section of conductor decreases and hence its cost reduces.
2. As the cross- section of conductor decreases hence weight decreases. So design of supporting structure becomes lighter.
3. Copper losses decreases, hence transmission efficiency increases.
4. Voltage drop reduces, hence voltage regulation becomes better.
5. Handling capacity (KW) of each equipment increases as p.f. increases.
6. Less capacity (KVA) rating of equipment are required so capital cost decreases.
7. Cost per unit (KWH) decreases.

1 Mark for each of any three points = 3 Marks

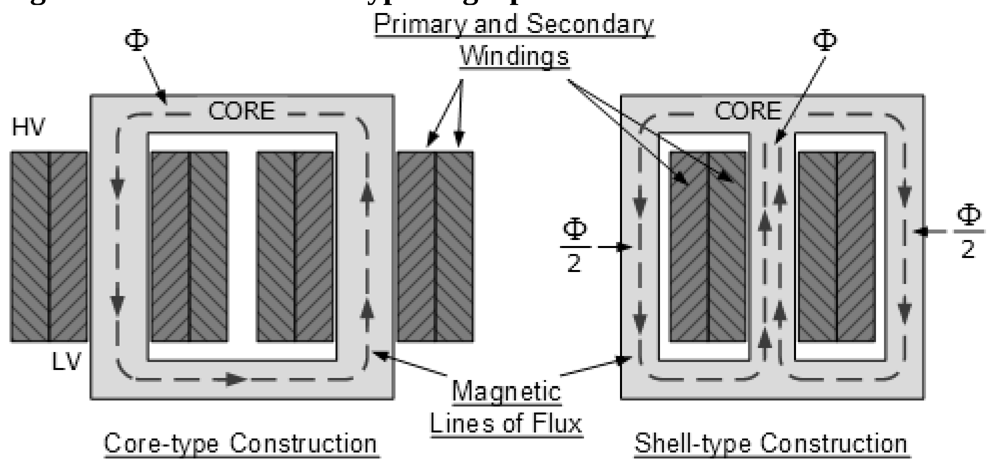
5e) Draw a neat labeled diagram for

(i) Core type

(ii) Shell type single phase transformer.

Ans:

Diagram for core and shell type single phase transformer:



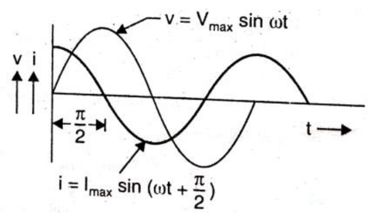
2 Marks each =4 Marks

5f) Draw waveform, write voltage, current equations and draw phasor diagram for an ac circuit containing capacitance only.

Ans:

For Purely Capacitive Circuit:

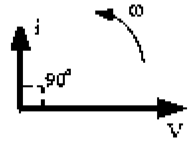
i) Waveform of voltage and current:



1 Mark

(i) **Equation for voltage and current:**
$v = V_m \sin(\omega t)$
$i = I_m \sin(\omega t+90°)$ or $I_m \sin(\omega t+\pi/2)$ — 2 Marks

(ii) **Phasor diagram:**



1 Mark

6 Attempt any FOUR of the following **16**

6 a) Define the following terms :
(i) RMS value (ii) Peak factor (iii) Form factor (iv) Angular velocity

Ans:

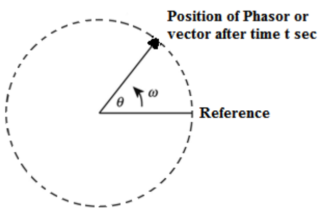
i) RMS value:
For an alternating current, the RMS value is defined as that value of steady current (DC) which produces the same heat or power as is produced by the alternating current during the same time under the same conditions.

ii) Peak factor:
The peak factor of an alternating quantity is defined as the ratio of its maximum value to the rms value.

iii) Form factor:
The form factor of an alternating quantity is defined as the ratio of the RMS value to the average value.

1 Mark for each definition = 4 Marks

iv) Angular velocity:
The angular velocity is defined as the rate of change of the angular displacement of a phasor or vector during its rotation about a point.



(Figure optional)

Angular velocity $\omega = \frac{\theta}{t}$ rad/sec OR
$\omega = 2\pi f \ rad/sec$

6 b) The equation of an alternating current is represented as, i = 62.35 sin 628 t. Determine (i) Frequency (ii) Time period (iii) Maximum value (iv) Angular velocity.

Ans:
Standard equation of sinusoidal quantity is $i = I_m \sin(\omega t)\ A$.
On comparing the given current with standard equation, we get
Angular frequency ω = 628 rad/sec = $2\pi f$

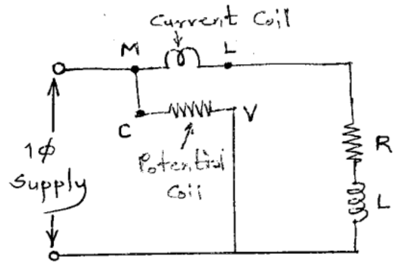
(i) $\therefore$ frequency $f = \frac{628}{2\pi} = 99.95 \cong$ **100Hz**
(ii) Time period T = 1/f = 1/100 = **0.01 sec = 10 millisecond**
(iii) Maximum Value $I_m = \mathbf{62.35\ A}$
(iv) Angular velocity, ω = **628 rad/sec**

1 Mark for each bit = 4 Marks

6 c) Draw a neat circuit diagram for the measurement of single phase power using dynamometer type wattmeter.

Ans:

Circuit diagram for the measurement of single phase power using dynamometer type wattmeter:



4 Marks for labeled diagram

3 Marks for partially labeled diagram

2 marks for unlabeled diagram

6 d) Three identical coils, each of R =.4 Ω and C = 100 microfarad are connected in star across 415 volt, 3-phase, 50 Hz supply.
Find (i) V_{ph} (ii) I_{ph} (iii) Power factor (iv) Total power absorbed

Ans:

Data Given:

Line Voltage V_L = 415V, frequency f = 50 Hz

Resistance per phase R = 4 Ω,

Capacitance per phase C = 100μF = 100×10^{-6} F

Capacitive reactance per phase $X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi(50)(100\times10^{-6})} = 31.83\Omega$ — ½ Mark for X_c

Impedance per phase $Z_{ph} = \sqrt{R^2 + (X_C)^2} = \sqrt{4^2 + (31.83)^2} = 32.08\Omega$ — ½ Mark for Z

In star-connected system, phase voltage $V_{ph} = \frac{1}{\sqrt{3}}$ Line voltage

$= \frac{415}{\sqrt{3}} = \mathbf{239.60\ V}$ — ½ Mark for V_{ph}

∴ Phase current $I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{239.60}{32.08} = \mathbf{7.468\ A}$ — ½ Mark for Iph

In star-connected system, Line current = Phase current = 7.468 A — ½ Mark for I_L

Power factor = $cos\emptyset = \frac{R_{ph}}{Z_{ph}} = \frac{4}{32.08}$ = **0.1246 leading** — ½ mark for pf

Total Power absorbed by the circuit,

$$P_{3\emptyset} = \sqrt{3}V_L I_L cos\emptyset = 3V_{ph}I_{ph}cos\emptyset$$

$$= \sqrt{3} \times (415) \times (7.468) \times 0.1246$$

= **668.85 watt** — 1 Mark for P

6 e) Explain why single-phase induction motors are not self-starting.

Ans:

Reason of why single phase induction motors are not self-starting: When single phase AC supply is given to main winding it produces alternating flux. According to double field revolving theory, alternating flux can be represented by two oppositely rotating fluxes of half magnitude. These oppositely rotating fluxes induce current in rotor & there interaction produces two equal but opposite torques, hence the net torque is Zero and the rotor remains standstill. Hence Single-phase induction motor is not self-starting.

4 Marks for answer with logical reasoning

OR

Single phase induction motor has distributed stator winding and a squirrel-cage rotor. When fed from a single-phase supply, its stator winding produces a

flux (or field) which is only alternating i.e. one which alternates along one space axis only. It is not a synchronously revolving (or rotating) flux as in the case of a two or a three phase stator winding fed from a 2 of 3 phase supply. Now, alternating or pulsating flux acting on a stationary squirrel-cage rotor cannot produce rotation (only a revolving flux can produce rotation).
That is why a single phase motor is not self-starting**.**

6 f) State the working principle of Capacitor-start single-phase I. M. with necessary diagrams.

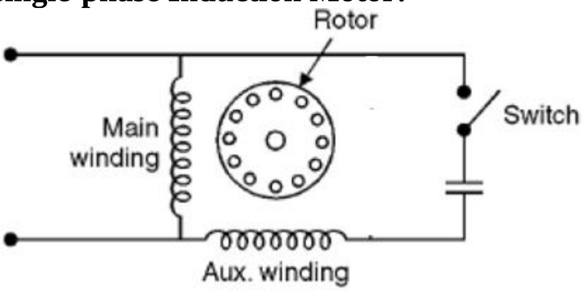
Ans:

[NOTE: Following are the types of Capacitor-start single-phase induction motors:

- **i) Capacitor-start, Induction-run Induction Motor**
- **ii) Capacitor-start, Capacitor-run Induction Motor**
- **iii) Permanent Split Capacitor motor**

Examiner is requested to allot the marks for any one of above type]

Capacitor-start single-phase Induction Motor:



2 Marks for circuit diagram

-In this motor, auxiliary winding is in series with a capacitor and remains in the circuit only during starting.

-Due to capacitor, the phase difference of approximately 90° is obtained between main and auxiliary winding currents.

-This 90° phase displaced currents flowing through two windings displaced in space results in production of rotating magnetic field.

-The rotating magnetic field is cut by stationary rotor conductors, emf is induced in them, current flows and force is produced on rotor conductors causing the rotor to rotate.

-After attaining 75-80% of rated speed, centrifugal switch in series with auxiliary winding get opened and auxiliary winding gets disconnected. The motor then continues to run without capacitor & only with main winding in the circuit.

2 Marks for explanation