SUMMER – 2018 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 <u>SIX</u> of the following: 12

1 (A) (a) Define the term loop and node.

Ans:

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

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

1 (A) (b) State Kirchhoff's voltage law. Also mention the conventions adopted.

Ans:

Kirchhoff's Voltage Law (KVL):

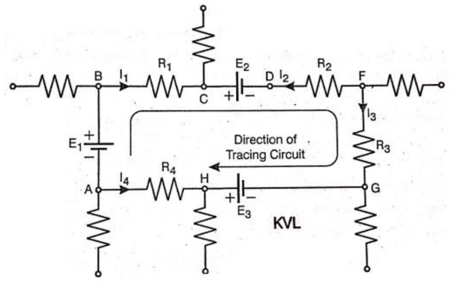
It states that, in any closed path in an electric circuit, the algebraic sum of the emfs and products of the currents and resistances is zero. 1 Mark

i.e $\Sigma E - \Sigma IR = 0$ or $\Sigma E = \Sigma IR$

OR

It states that, in any closed path in an electrical circuit, the total voltage rise is equal to the total voltage drops.

i.e Voltage rise = Voltage drop



Referring to the circuit, by KVL we can write,

$(E_1 - E_2 + E_3) = (I_1R_1 - I_2R_2 + I_3R_3 - I_4R_4)$

Sign convention:

While tracing the loop or mesh, the voltage rise is considered as positive and voltage drop is considered as negative. 1 Mark

1 (A) (c) Three resistances of 10Ω, 15Ω and 20Ω are connected in parallel across 100V.

Find: (i) Total resistance

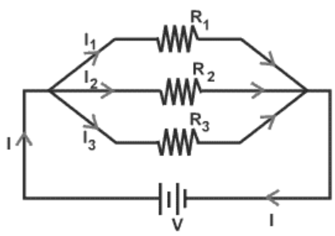
(ii) Current in each resistor.

Ans:

Here $R_1 = 10\Omega$, $R_2 = 15\Omega$, $R_3 = 20\Omega$, $V = 100V$

Equivalent Resistance:

The equivalent resistance of parallel connected resistances is given by,



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

$$= \frac{1}{10} + \frac{1}{15} + \frac{1}{20} = \frac{65}{300}$$

1 Mark for R_{eq}

$$\boldsymbol{R_{eq} = 4.615\Omega}$$

Branch Currents:

$$I_1 = \frac{V}{R_1} = \frac{100}{10} = \mathbf{10A}$$

$$I_2 = \frac{V}{R_2} = \frac{100}{15} = \mathbf{6.67A}$$

$$I_3 = \frac{V}{R_3} = \frac{100}{20} = \mathbf{5A}$$

1 Mark for branch currents

1 (A) (d) State Lenz's Law.

Ans:

Lenz's Law:

It states that the direction of electromagnetically induced emf is such that it always opposes the main cause of its production. 2 Marks

1 (A) (e) Define the following terms:

(i) Amplitude
(ii) Frequency of an AC.

Ans:

i) Amplitude:

It is defined as the maximum or peak value attained by an alternating quantity during its positive or negative half cycle. 1 Mark

ii) Frequency of an AC:

It is defined as the number of cycles completed by an alternating quantity in one second. 1 Mark

1 (A) (f) For star connected load, state numerical relationship between

(i) Line current & phase current
(ii) Line voltage & phase voltage

Ans:

For star connected load,

$$\text{Line current} = \text{Phase current}$$ 1 Mark

$$\text{i.e } I_L = I_{ph}$$

$$\text{Line voltage} = \sqrt{3}\,(\text{Phase Voltage})$$ 1 Mark

$$\text{i.e } V_L = \sqrt{3}V_{ph}$$

1 (A) (g) State necessity of fuse in the circuit.

Ans:

Necessity of fuse in the circuit:

The fuse is provided in an electric circuit to protect the apparatus connected to it from being damaged due to excessive current. If no fuse is provided in the circuit then a dangerous situation would be created on developing of faults such as over load, short-circuit or earth faults. In case of overload, short circuit and heavy earth faults, a heavy current flows through the cables or wires, apparatus etc. So these will get heated and finally damaged. The fire may also take place. Therefore, to prevent the damage from the excessive current, fuse is necessary. The fuse melts when excessive current flows through it and interrupts the current. 2 Marks

1 (A) (h) State any two effects of electric shocks.

Ans:

Effects of electric shocks:

1) **Burns:** Electric shock can result in superficial burns on the surface of the skin, also internal burns leading to organ burns affecting the heart.
2) **Neurological effects:** Electric shock can interfere with the nervous control especially on the heart and lungs.
3) **Effect on the chest:** Electric shock can result in ventricular fibrillation.
4) **Severe muscle contractions:** Electric shock can result in fractures, loss of consciousness or dislocation of joints.
5) **Effect on respiratory system:** The respiratory system can be paralyzed and

1 Mark for each of any two = 2 Marks

the heartbeat can either become very fast and irregular or can completely stop beating.

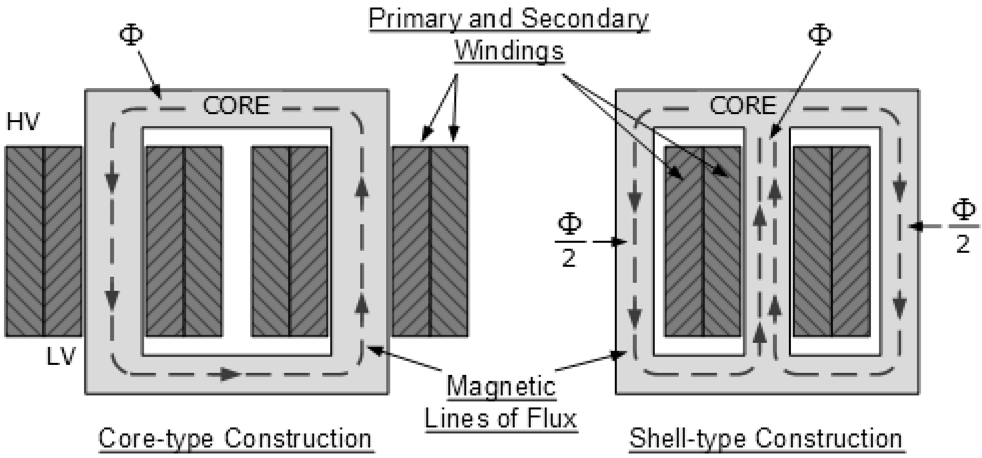
6) **Death of tissues:** Electric shock can cause death of tissues at the entry and the exit points of the current.
7) **Kidney failure:** A drop in blood pressure, disturbance in fluid and electrolyte balance can cause the release of myoglobin and result in kidney failure.
8) **Fatal accident:** Electrical shock can cause fatal accident resulting death of person.

1 (B) **Attempt any TWO of the following:** **8**

1 (B) (a) Draw a neat diagram of constructional details and state the principle of transformer.

Ans:

Constructional details of Transformer:



1 Mark each = 4 Marks

Principle of Transformer:

Transformer works on the principle of electromagnetic induction. When primary winding is connected to AC supply, an alternating current flows through it and alternating magnetic flux is produced in the core. This changing flux then links with the secondary winding and also with primary winding. According to Faraday's laws of electromagnetic induction, when changing flux links with a conductor, an emf is induced in it. Therefore, an emf is induced in both primary winding as well as secondary winding. If load is connected to secondary winding, the secondary winding induced emf can deliver current and hence power to load.

1 (B) (b) List any four types of 1-phase induction motor. State any one application of each.

Ans:

Type of 1-ϕ Induction Motor	Applications
1. Split-phase Induction motor	Air-conditioning fans, Washing machines, Floor polishers, Mixer, Grinders, Blowers, Centrifugal pumps, Drilling and lathe machines
2. Capacitor-start, Induction-run motor	Pumps, Compressors, Refrigerator motor, Air-conditioner compressor, Conveyors and machine tools

½ Mark for type and ½ Mark for application = 1 Mark each (Any four)

3. Capacitor-start, Capacitor-run motor	Pumps, Refrigerators, Air compressors
4. Permanent Split Capacitor motor	Fans and blowers in heaters and air conditioners, Refrigerator compressors, Office machinery
5. Shaded-pole Induction motor	Small table fans, Exhaust fan motors, Small blowers (A/C), Vending & dispensing machines, Hair dryers, photo-copying machines, Air-conditioning & refrigeration equipment

1(B) (c) Mention types of earthing. Draw a neat labelled diagram of any one of it.

Ans:

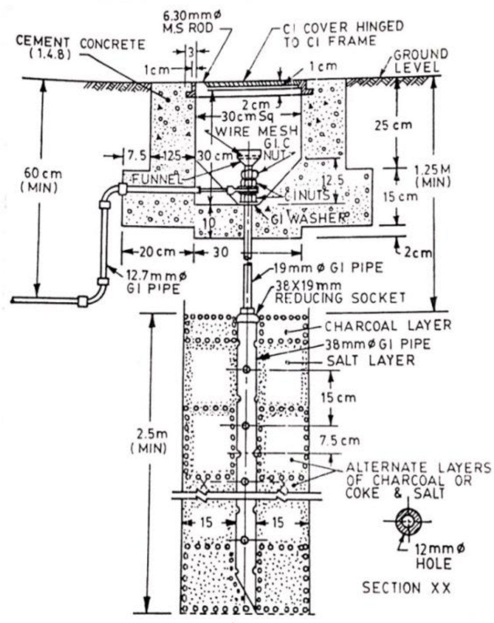
Data Given:

Types of Earthing: 1 Mark for types

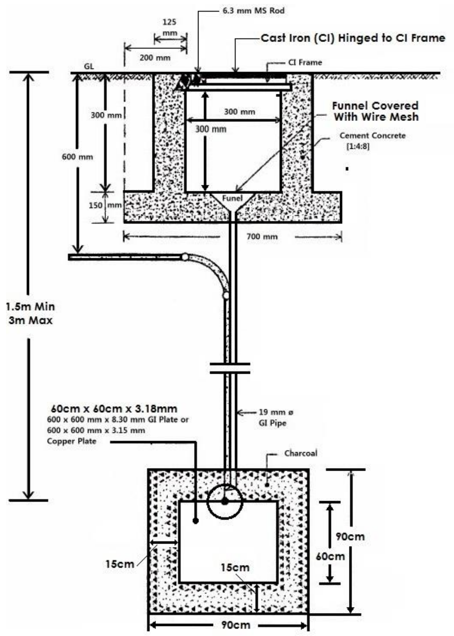
i) Pipe Earthing

ii) Plate Earthing

Pipe Earthing **Plate Earthing**



A typical illustration of pipe earthing.



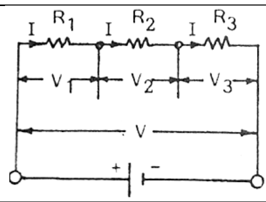
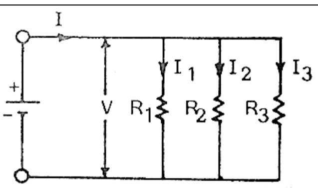
3 Marks for any one figure

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

2(a) Compare series and parallel circuit.

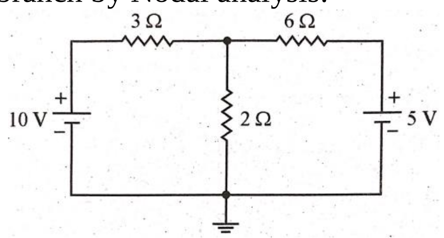
Ans:

Comparison between series and parallel circuit:

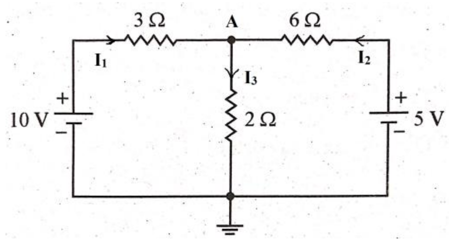
Sr. No.	Series Circuit	Parallel Circuit
1		
2	A series circuit is that circuit in	A parallel circuit is that circuit in

	which the current flowing through each circuit element is same.	which the voltage across each circuit element is same.	
3	The sum of the voltage drops in series resistances is equal to the applied voltage V. $\therefore$ V = $V_1+V_2+V_3$	The sum of the currents in parallel resistances is equal to the total circuit current I. $\therefore$ I = $I_1+I_2+I_3$	1 Mark for each of any four points = 4 Marks
4	The effective resistance R of the series circuit is the sum of the resistances connected in series. $R = R_1 + R_2 + R_3 + \cdots$	The reciprocal of effective resistance R of the parallel circuit is the sum of the reciprocals of the resistances connected in parallel. $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$	
5	Resultant resistance $R = R_1 + R_2 + R_3 + \cdots$	Resultant conductance $G = G_1 + G_2 + G_3 + \cdots$	
6	Different resistors have their individual voltage drops.	Different resistors have their individual currents.	
7	Example: Fuse connection	Example: Connection of various lamps & appliances	

2 (b) Find the current in each branch by Nodal analysis.



Ans:



1 Mark for Current marking on circuit

By applying KCL to Node A

$$I_3 = I_1 + I_2$$

$$\frac{V_A}{2} = \frac{10 - V_A}{3} + \frac{5 - V_A}{6}$$

$$\frac{V_A}{2} + \frac{V_A}{3} + \frac{V_A}{6} = \frac{10}{3} + \frac{5}{6}$$

1 Mark for Voltage equation

$$\frac{6V_A}{6} = \frac{25}{6}$$

$$\mathbf{V_A = 4.17\ volts}$$

1Mark for V_A

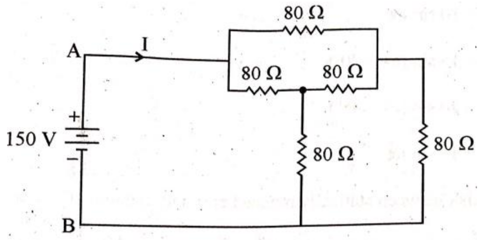
Current flowing through resistance 3 Ω = $I_1 = \frac{10-V_A}{3} = \mathbf{1.94\ Amp}$

Current flowing through resistance 6 Ω = $I_2 = \frac{5-V_A}{6} = \mathbf{0.14\ Amp}$

Current flowing through resistance 2 Ω = $I_3 = \frac{V_A}{2} = \mathbf{2.08\ Amp}$

1 Mark for currents

2 (c) In given Fig. 150V are applied to the terminal AB. Determine
(i) The resistance between the terminal A and B.
(ii) The current I.

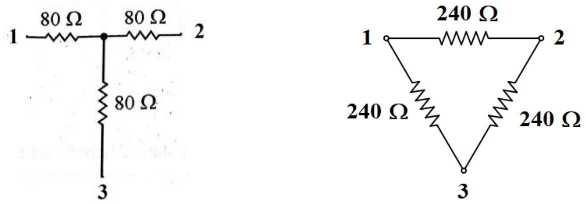


Ans:

(i) The resistance between the terminal A and B:

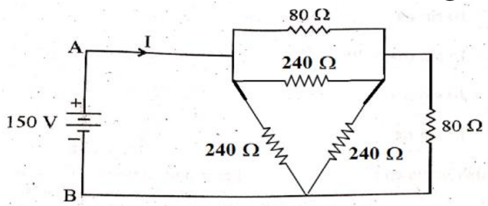
Converting three star connected 80Ω resistors in to equivalent delta,

$R_{12} = R_{23} = R_{31} = R_3 + R_1 + \frac{R_3 R_1}{R_2} = 80 + 80 + \frac{(80)(80)}{80} = 240\Omega$



1 Mark

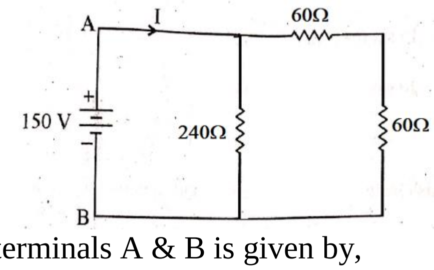
The equivalent circuit is as shown in the figure below.



There are two parallel combinations of 240Ω & 80Ω resistors. The equivalent of these parallel combinations is given by, 1 Mark

R_{eq} = (240)(80)/(240+80) = 60Ω

The equivalent circuit is shown below.



The resistance between terminals A & B is given by,

R_{AB} = 240 || (60 + 60) = 240 || 120 = (240)(120)/(240+120) 1 Mark

R_{AB} = 80Ω

(ii) The current I:

Current I = V/R_{AB} = 150/80

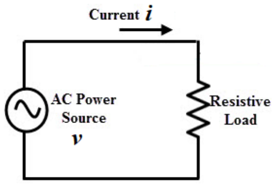
I = 1.875 A 1 Mark

2 (d) When a sinusoidal voltage is applied to the circuit containing resistance only:
(i) Draw circuit diagram.
(ii) Write voltage and current equation.
(iii) Draw waveforms of voltage and current.

(iv) Draw phasor diagram.

Ans:

i) Circuit Diagram:



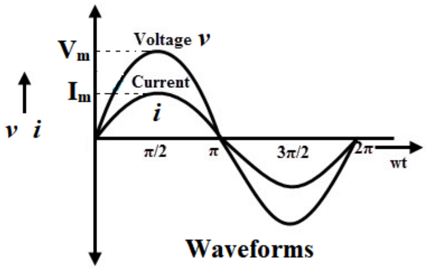
Circuit Diagram

ii) Voltage and Current Equations:

$$v = V_m sin(\omega t)$$
$$i = I_m sin(\omega t)$$

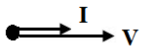
1 Mark for each bit = 4 Marks

iii) Waveform of Voltage & Current:



Waveforms

iv) Phasor Diagram:

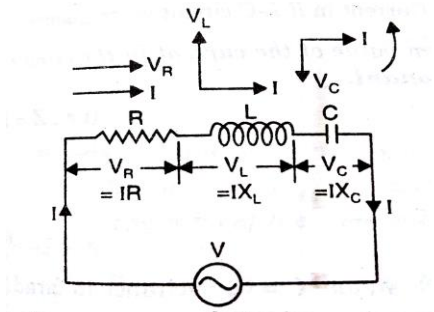


Phasor Diagram

2(e) Explain phenomenon of resonance in R-L-C circuit.

Ans:

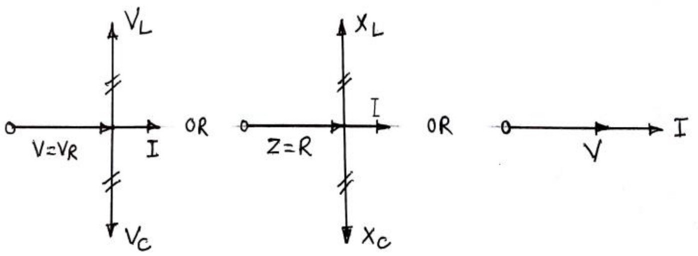
RLC series resonance circuit:



1 Mark for circuit diagram

A series circuit containing resistance, inductance and capacitance, is said to be resonant when the circuit power factor is unity,($X_L = X_C$) i.e. applied voltage and current are in phase.This condition is termed as series resonance.

2 Marks for explanation



1 Mark for phasor diagram

Consider phasor diagram, here in resonance condition voltage across inductance (V_L) is equals to voltage across capacitance (V_C) and cancells each other being 180° out of phase. The applied voltage V becomes equal to voltage across resistor, V_R and is in phase with resultant current I.
Similarly, inductive reactance and capacitive reactance are equal and get cancelled making circuit impedance Z equal to circuit resistance R.

2(f) Draw circuit diagram for measurement of single phase power using dynamometer type wattmeter.

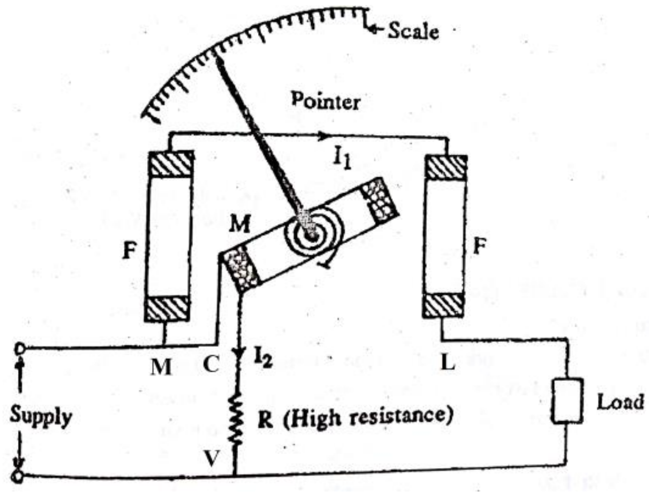
Ans:

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

2 Marks for diagram of dynamometer type wattmeter

1 Mark for terminal markings

1 Mark for proper connections



3 Attempt any FOUR of the following: 16

3(a) Define:

(i) Inductive reactance
(ii) Capacitive reactance
(iii) Impedance
(iv) Power factor

Ans:

i) Inductive Reactance:

The opposition offered by an inductor to the alternating current flowing through it, is called as Inductive reactance.

Inductive reactance $X_L = 2\pi fL$

where, f is the frequency of current or voltage in hertz (Hz),
L is the inductance in henry (H),

1 Mark for each bit

ii) Capacitive Reactance:

The opposition offered by capacitor to the alternating current flowing through it, is called as Capacitive reactance.

Capacitive reactance $Xc = \frac{1}{2\pi fC}$

where, f is the frequency of current or voltage in hertz (Hz),
C is the capacitance in farad (F).

iii) Impedance:

The total opposition offered by circuit or device to the alternating current flowing through it, is called as Impedance.

Impedance $Z = R + j(X_L – X_C)$
Where, R is the resistance,
X_L is the inductive reactance,
X_C is the capacitive reactance.

iv) 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.

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

OR

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

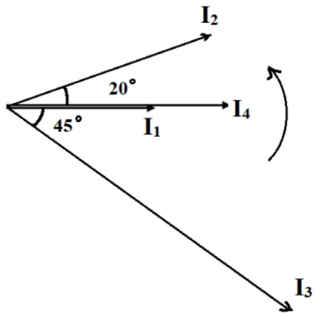
$$\text{Power factor} = \frac{\text{Circuit Resistance}}{\text{Circuit Impedance}} = \frac{R}{Z} = \cos\emptyset$$

3(b) Draw the phasor diagram of following AC:

(i) $I_1 = 10 \sin \omega t$
(ii) $I_2 = 15 \sin (\omega t + 20°)$
(iii) $I_3 = 20 \sin (\omega t - 45°)$
(iv) $I_4 = 15 \sin \omega t$

Ans:

Phasor Diagram:



1 Mark for each phasor

3(c) Distinguish between statically induced emf and dynamically induced emf with example.

Ans:

Distinction 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	Direction of dynamically induced emf

1 Mark for each of any three points + 1 Mark for example

given by Lenz's law.	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

3(d) Define:
(i) Form factor
(ii) Peak factor

Ans:

i) Peak factor:
The peak factor of an alternating quantity is defined as the ratio of its maximum value to the RMS value. 2 Marks

Peak factor $= \frac{Maximum\ value}{RMS\ value}$

ii) Form factor:
The form factor of an alternating quantity is defined as the ratio of the RMS value to the average value. 2 Marks

Form factor $= \frac{RMS\ value}{Average\ value}$

3(e) The voltage and current equations in an AC circuit are given by v = 120 sin ωt and i = 2.5 sin (ωt + π/2). Find the RMS value of current and voltage. Also state type of circuit.

Ans:

i) Voltage:
Standard equation of sinusoidal voltage is $v = V_m \sin(\omega t \pm \emptyset)\ volt.$
On comparing the given voltage with standard equation, we get ½ Mark for V_m
Maximum Value $V_m = \mathbf{120\ V}$
RMS value $V = \frac{V_m}{\sqrt{2}} = \frac{120}{\sqrt{2}} = \mathbf{84.85\ volt}$ 1 Mark for V

ii) Current:
Standard equation of sinusoidal current is $i = I_m \sin(\omega t \pm \emptyset)\ amp.$
On comparing the given current with standard equation, we get ½ Mark for I_m
Maximum Value $I_m = \mathbf{2.5\ A}$
RMS value $I = \frac{I_m}{\sqrt{2}} = \frac{2.5}{\sqrt{2}} = \mathbf{1.77\ A}$ 1 Mark for I

iii) Type of Circuit:
Argument of sin function in voltage equation: (ωt)
Argument of sin function in current equation: (ωt + π/2) 1 Mark
Therefore, the current is leading the voltage by (π/2) radians or 90° degrees. The current leads the voltage by 90° only in purely capacitive circuit. Hence the type of circuit is "Purely Capacitive".

3 (f) State types of power. Give their expressions and show them on power triangle.

Ans:

(i) Apparent Power :

Apparent power (S) is simply the product of RMS voltage and RMS current. 1 Mark
$S = VI = I^2Z$ volt-amp.

(ii) Active power:

Active power (P) is the product of voltage, current and the cosine of the phase angle between voltage and current. **OR**

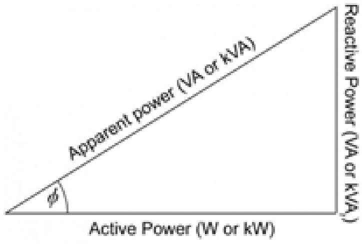
It is the power actually utilized in the circuit, hence called real or true power. 1 Mark

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

(iii) Reactive Power:

Reactive power (Q) is the product of voltage, current and the sine of the phase angle between voltage and current. 1 Mark

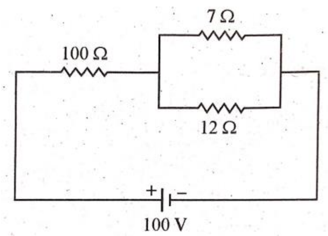
$Q = VI\sin\emptyset = I^2X$ volt-amp-reactive.



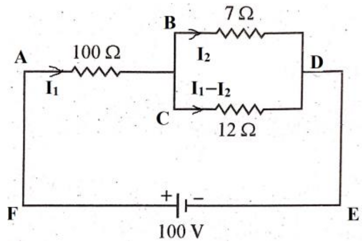
1 Mark

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

4 (a) In the circuit given in Fig. calculate the current in 7Ω resistance using Kirchhoff's law.



Ans:



By applying KVL to loop ABDEFA,

$$100 - 100I_1 - 7I_2 = 0$$

$$100I_1 + 7I_2 = 100 \text{ ------------------- (1)}$$ 1 Mark

By applying KVL to loop BDCB

$$-7I_2 + 12(I_1 - I_2) = 0$$

$$12I_1 - 19I_2 = 0 \text{ ------------------- (2)}$$ 1 Mark

Multiply eq (1) by 12 and eq (2) by 100, we get

$1200I_1 + 84\ I_2 = 1200$ -------------------------(3)

$1200I_1 - 1900\ I_2 = 0$ -------------------------(4) 1 Mark

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

$1984\ I_2 = 1200$

$\therefore\ I_2 = \frac{1200}{1984} = \mathbf{0.605\ A}$

The current through 7 Ω is I_2 = **0.605A** 1 Mark

4 (b) Define the following terms with waveforms:

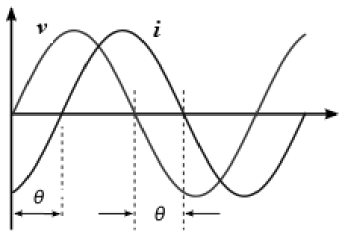
(i) Phase difference
(ii) Lagging phase difference
(iii) Leading phase difference
(iv) Out of phase

Ans:

i) Phase difference:-

Phase difference between two alternating quantities is the angular distance between their respective zero or maximum values. 1 Mark

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



ii) Out of Phase: When two quantities do not attain their respective zero or peak values simultaneously, then the quantities are said to be out-of-phase quantities. 1 Mark

OR

If phase difference between two alternating quantities is non-zero, then they are called as "Out-of- phase" quantities.

In the above diagram, it is seen that the voltage *v* and current *i* do not attain their respective zero values simultaneously, hence they are out of phase quantities with phase difference of θ. 1 Mark

iii) Leading Phase difference:

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

In the above diagram, the voltage attains its zero or positive peak first and after an angle of θ, the current attains its respective zero or positive peak value, hence voltage is said to be leading the current by an angle of θ. 1 Mark

iv) Lagging Phase difference:

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

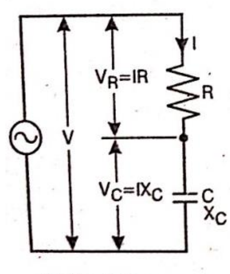
In the above diagram, the current attains its zero or positive peak later than the voltage after an angle of θ, hence current is said to be lagging the voltage by an angle of θ.

4 (c) For R-C circuit

(i) Draw the circuit diagram
(ii) Write the voltage and current equation
(iii) Draw the vector diagram
(iv) Draw the impedance triangle

Ans:

i) Circuit Diagram:



(a) Circuit Diagram

ii) Voltage & Current Equations:

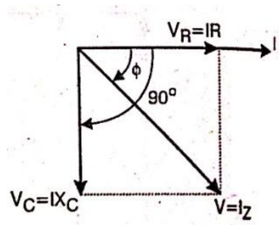
$v = V_m sin(\omega t)$

$i = I_m sin(\omega t + \emptyset)$

where, phase angle $\emptyset = tan^{-1}\left(\frac{X_C}{R}\right)$

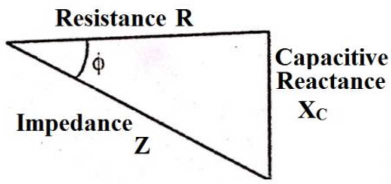
1 Mark for each bit

iii) Vector Diagram:



(c) Phasor Diagram

iv) Impedance Triangle:



Impedance triangle for R-C series circuit

4 (d) A coil having 10Ω resistance and 0.1 H inductance is connected across 230V, 50Hz ac supply. Calculate impedance, current, power factor, power absorbed by the coil.

Ans:

Data Given: Resistance R = 10Ω, Inductance L = 0.1H
Supply Voltage V = 230∠0° V, Supply frequency f = 50Hz,

(i) Inductive reactance $X_L = 2\pi f L = 2\pi(50)(0.1)$ =**31.4Ω**

(ii) Impedance of series circuit

$Z = R + jX_L = 10 + j31.4$

$= \mathbf{32.95\angle 72.33°\Omega}$

(iii) Current $I = \frac{V}{Z} = \frac{230\angle 0°}{32.95\angle 72.33°} = \mathbf{6.98\angle -72.33°}$ **A**

(iv) Power factor cos∅ = cos(72.33°) = **0.3035 lagging**

(v) Power absorbed by coil i.e Active power

$P = VIcos\emptyset = (230)(6.98)(0.3035) = \mathbf{487.24\ watt}$

1 Mark for Each of Z, I, pf, P

OR

Any other method of computation may please be considered and marks be alloted

4 (e) State the working principle of capacitor start single phase induction motor.

Ans:

Working principle of Capacitor-start Single phase Induction Motor:

When single-phase ac supply is given to single-phase stator winding of motor, a magnetic field is produced in the air gap between stator and rotor. However, this magnetic field is not rotating in nature, rather it is pulsating or oscillating in nature. So torque is not developed and motor cannot start itself. Thus single-phase induction motor is not self-starting.

To make the motor self-starting, it is essential that rotating magnetic field must be produced in the air gap between stator and rotor. For that, the single phase winding is split into two parts (windings) and such two windings are placed in stator core with 90° displacement. To obtain large phase difference (close to 90° in time phase) between their currents, a capacitor is inserted in series with one winding. This winding is referred as Starting or Auxiliary winding. Other winding is the Main or Running winding. These two windings when connected in parallel across single-phase supply, two currents of large phase difference flow through these windings and rotating magnetic field is produced. The rotating magnetic field is cut by short circuited rotor conductors, which then carry current. Due to interaction between rotor current and stator magnetic field, force is exerted on rotor and rotor rotates. Once motor picks up the speed nearly 75% of rated speed, the centrifugal switch get opened and starting winding is disconnected from supply. The motor then continues to run with only main winding in the circuit and its pulsating magnetic field. Since a capacitor is used in series with the auxiliary winding to produce starting torque and to start the motor, it is referred as Capacitor-start motor.

4 Marks For correct answer

4 (f) Explain voltage ratio, current ratio and transformer ratio of a transformer with a neat sketch of it, showing all voltages and currents.

Ans:

i) Voltage Ratio:

The ratio of secondary load voltage V_2 to the primary supply voltage V_1 is known as the voltage ratio.

Voltage Ratio $= \frac{V_2}{V_1}$

ii) Current Ratio:

The ratio of secondary current I_2 to the primary current I_1 is known as the current ratio.

Current Ratio $= \frac{I_2}{I_1}$

iii) Transformation Ratio:

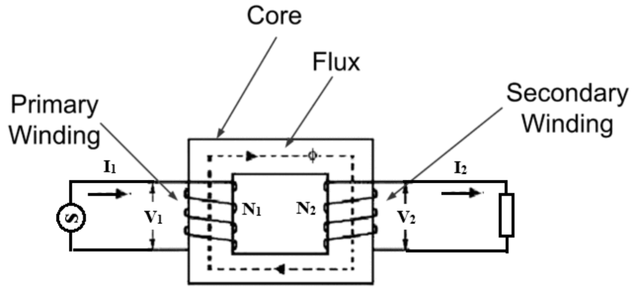
In general, the turns ratio or emf ratio is called as transformation ratio.

The ratio of secondary emf E_2 to the primary emf E_1 is known as the transformation ratio.

Also the ratio of secondary turns N_2 to the primary turns N_1 is known as the transformation ratio.

Transformation Ratio $= \frac{E_2}{E_1} = \frac{N_2}{N_1}$

1 Mark for each ratio = 3 Marks + 1 Mark for diagram



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

5(a) The equation of an alternating voltage v = 282.8 sin 314t. determine

(i) Peak voltage
(ii) RMS value
(iii) Frequency
(iv) Time period

Ans:

Standard equation of sinusoidal voltage is $v = V_m \sin(\omega t)\ volt.$

On comparing the given voltage with standard equation, we get — 1 Mark for each bit

(i) Peak or Maximum Value $V_m = \mathbf{282.8\ volt}$

(ii) RMS value $V = \frac{V_m}{\sqrt{2}} = \frac{282.8}{\sqrt{2}} = \mathbf{199.97} \cong \mathbf{200\ volt}$

(iii) Angular frequency ω = 314 rad/sec = 2πf

∴ frequency $f = \frac{314}{2\pi} = 49.97 \cong$ **50Hz**

(iv) Time period T = 1/f = 1/50 = 0.02 sec = **20 millisecond**

5b) For a delta connected balanced system, state

(i) Relation between line and phase voltage.
(ii) Relation between line and phase current.
(iii) Power in terms of phase and line voltage
(iv) Draw phasor diagram.

Ans:

i) Relation Between Line and Phase Voltage in Delta Connected Balanced System: — 1 Mark

Line voltage = Phase voltage

$$\mathbf{V_L = V_{ph}}$$

ii) Relation Between Line and Phase Current in Delta Connected Balanced System:

Line current = $\sqrt{3}$ (Phase Current) — 1 Mark

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

iii) Power Equations:

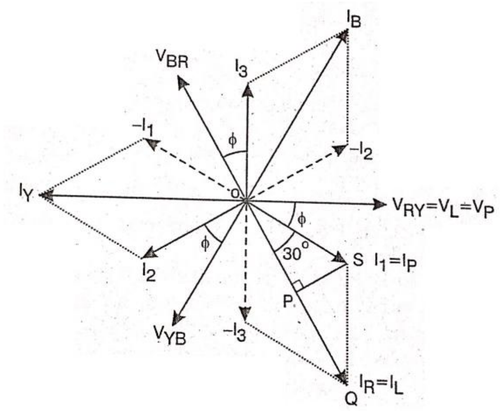
Three-phase Apparent power $S = 3V_{ph}I_{ph} = \sqrt{3}V_L I_L$ volt-amp

Three-phase Active power $P = 3V_{ph}I_{ph}cos\emptyset = \sqrt{3}V_L I_L cos\emptyset$ watt — 1 Mark

Three-phase Reactive power $Q = 3V_{ph}I_{ph}sin\emptyset = \sqrt{3}V_L I_L sin\emptyset$ VAr

Where, ∅ is the phase angle between phase voltage and phase current.

iv) Phasor Diagram:



1 Mark

5c) Explain the need of star or delta connection for three phase generator.

Ans:

Need of Star connection for Three-phase Generator:

i) With star connection, neutral wire is available. So the single-phase loads can be connected to the generator along with three-phase loads.

ii) Due to availability of earthed neutral in star connection, earth–fault protection system can be easily implemented as compared to delta connection.

iii) For star connection, the line voltage is $\sqrt{3}$ times the phase voltage. Therefore, the phase winding need to be designed for lower phase voltage as compared to delta connection for same line voltage. Thus there is saving in cost of insulation.

iv) For star connection, the phase current is equal to line current. Therefore, the phase winding need to be designed for higher phase current as compared to delta connection for same line current. So star connection is preferred for high-voltage, low-current generator.

2 Marks for each of any two points = 4 Marks

OR

Need of Delta connection for Three-phase Generator:

i) With delta connection, neutral wire is not available. So only three-phase loads can be connected to the generator.

ii) For delta connection, the line voltage is equal to the phase voltage. Therefore, the phase winding need to be designed for higher phase voltage as compared to star connection for same line voltage.

iii) For delta connection, the line current is equal to $\sqrt{3}$ times phase current. Therefore, the phase winding need to be designed for lower phase current as compared to star connection for same line current. So delta connection is preferred for low-voltage, high-current generator.

5d) Three inductive coils, each with a resistance of 15Ω and inductance of 0.3H are connected in star to a three-phase, 400V supply. Calculate the phase current, line current and total power absorbed.

Ans:

Data Given: Line Voltage V_L = 400V, **Assuming Frequency f = 50 Hz**

Resistance R = 15 Ω, Inductance L = 0.3 H

∴ Inductive reactance per phase $X_L = 2\pi fL = 2\pi(50)(0.3) = 94.26\,\Omega$

∴ Impedance per phase $Z = R + jX_L = 15 + j94.26 = 12.89\angle 21.43°\,\Omega$

$$Z = \sqrt{\left(R^2 + {X_L}^2\right)} = \sqrt{15^2 + (94.26)^2} = 95.44\,\Omega$$

1 Mark

In star-connected system, phase voltage $V_{ph} = \frac{1}{\sqrt{3}}$ Line voltage = $\frac{400}{\sqrt{3}} = 230.94\,V$

$\therefore$ Phase current $I_{ph} = \frac{V_{ph}}{Z} = \frac{230.94}{95.44} = \mathbf{2.419\ A}$ 1 Mark

In star-connected system, **Line current = Phase current = 2.419 A** 1 Mark

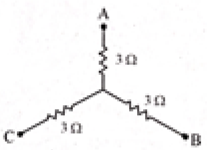
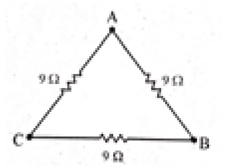
Power absorbed by the circuit,

$$P_{3\emptyset} = 3{I_{ph}}^2 R$$
$$= 3(2.419)^2(15)$$
$$= \mathbf{263.32\ watt}$$ 1 Mark

5 e) Compare 3-phase star connection with 3-phase delta connection.

Ans:

Comparison between 3-phase star and 3-phase delta connection:

Star-connection	Delta-connection
This is obtained by connecting one end of three resistors / windings together.	This is obtained by connecting three resistors / windings in series to form a closed loop.
It is also known as Y-connection.	It is aso known as Δ-connection.
Phase voltage is equal to $\frac{1}{\sqrt{3}}$ times line voltage.	Phase voltage is equal to line voltage.
Phase current is equal to line current.	Phase current is equal to $\frac{1}{\sqrt{3}}$ times line current.
Neutral is available.	Neutral is not available.
Star-connected resistors 	Delta-connected resistors 

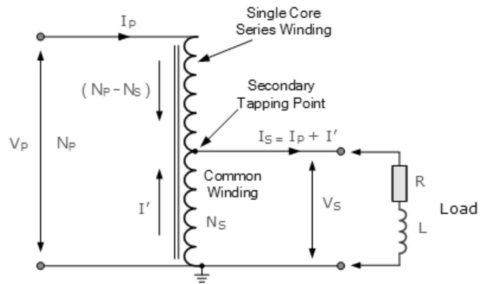
2 Marks each =4 Marks

5 f) Explain construction and working of auto-transformer.

Ans:

Construction of Autotransformer:

Autotransformer has only one winding, part of the winding is common for primary and secondary, as shown in the figure. This single winding is placed on Spiral core. The facility is provided to change the no. of secondary turns. It is done by movable contact whose position can be changed by rotating the knob. Their exists electrical connection between primary and secondary. 2 Mark

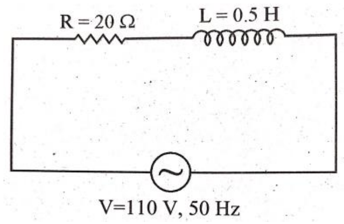


Working of Autotransformer:

When supply is given to the winding, the primary current I_P flows and the core get magnetized with changing flux. The changing flux links with full winding turns and according to Faraday's laws of electromagnetic induction, emf is induced in it. The emf induced in common winding delivers the load current as shown in the figure above. Since the primary and secondary windings are electrically connected, the power from primary to load is transferred partly conductively and inductively. 2 Marks

6 Attempt any FOUR of the following 16

6a) For a circuit given in Fig. find Inductive reactance, Impedance, Current, Phase difference between V and I.



Ans:

Data Given:

Resistance R = 20Ω, Inductance L = 0.5H, Supply Voltage V = 110V and f = 50Hz.

(i) Inductive reactance $X_L = 2\pi f L = 2\pi(50)(0.5) = \mathbf{157.08\,\Omega}$

(ii) Impedance of series circuit Z = R + j X_L = 20+j157.08 — 1 Mark for each = 4 Marks

$$Z = \sqrt{R^2 + (X_L)^2} = \sqrt{20^2 + (157.08)^2}$$
$$= \mathbf{158.35\,\Omega}$$

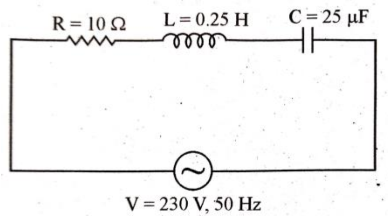
(iii) Current $I = \frac{V}{Z} = \frac{110}{158.35} = 0.695$ A.

(iv) Phase difference: $\phi = \tan^{-1}(X_L/R) = \tan^{-1}(157.08/20) = 82.74°$

6b) For the circuit given below in Fig., calculate

(i) Total impedance in the circuit

(ii) Current in the circuit.



Ans:

Data Given:

Resistance R = 10Ω, Inductance L = 0.25H, Capacitance C = 25μF =25 ×10^{-6} F

Supply Voltage V = 230V and f = 50Hz.

Inductive reactance $X_L = 2\pi f L = 2\pi(50)(0.25) = \mathbf{78.54\,\Omega}$ 1 Mark

Capacitive reactance $X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi(50)(25\times10^{-6})} = \mathbf{127.32\,\Omega}$ 1 Mark

(i) **Impedance of series circuit**

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{10^2 + (78.54 - 127.32)^2}$$
$$= \mathbf{49.79\,\Omega}$$ 1 Mark

(ii) **Current** $I = \frac{V}{Z} = \frac{230}{49.79}$
$= \mathbf{4.62\ A.}$ 1 Mark

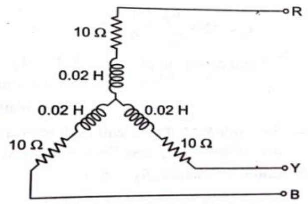
6c) Define the following for polyphase circuit:
(i) Balanced load
(ii) Unbalanced load
(iii) Balanced supply
(iv) Unbalanced supply

Ans:

i) Balanced Load:

Balanced three phase load is defined as star or delta connection of three equal impedances having equal real parts and equal imaginary parts.

Example circuit:

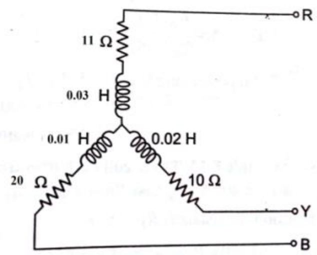


1 Mark

ii) Unbalanced Load:

When the magnitudes and phase angles of three impedances are differ from each other, then it is called as unbalanced load. OR If a load does not satisfy the condition of balance, then it is called as unbalanced load.

Example circuit:



1 Mark

iii) Balanced Supply:

Balanced supply is defined as three phase supply voltages having equal magnitude but displaced from each other by an angle of 120° in time phase.

e.g $V_a = 230\angle 0°$ volt, $V_b = 230\angle -120°$ volt, $V_c = 230\angle 120°$ volt represents balanced supply. 1 Mark

iv) Unbalanced supply:

If a supply does not satisfy the condition of balance it is called as unbalanced supply. **OR**

Unbalanced supply is defined as three phase supply voltages having unequal magnitude and/or unequal displacement from each other. 1 Mark

6d) A single phase transformer of 50 Hz has maximum flux in the core as 0.21 Wb, the number of turns of primary being 460 and that on secondary is 52. Calculate emf induced in primary and secondary windings of a transformer.

Ans:

Data Given:

Primary turns $N_1 = 460$ Secondary turns $N_2 = 52$

Frequency f = 50 Hz ϕ_m= 0.21Wb

$$E_1 = 4.44\,\emptyset_m f N_1$$
$$= 4.44 \times 0.21 \times 50 \times 460$$
$$= 21445.2\text{ V}$$

2 Marks

$$\frac{N_2}{N_1} = \frac{E_2}{E_1} = \frac{52}{460}$$

$$E_2 = \frac{21445.2}{460} \times 52 = 2424.24\text{ V}$$

2 Marks

6e) Write down three different formulae for transformation ratio k of transformer. What do you understand if value of k
(i) k < 1
(ii) k > 1

Ans:

Transformation Ratio:

$$k = \frac{Secondary\ emf}{Primary\ emf} = \frac{E_2}{E_1}$$

$$k = \frac{\text{Secondary No. of turns}}{\text{Primary No. of turns}} = \frac{N_2}{N_1}$$

$$k = \frac{Secondary\ voltage}{Primary\ voltage.} = \frac{V_2}{V_1}$$

$$k = \frac{Primary\ current.}{Secondary\ current} = \frac{I_1}{I_2}$$

1 Mark for each formula = 3 Marks

i) $k < 1$ Step down Transformer ½ Mark
ii) $k > 1$ Step up Transformer ½ Mark

6f) State any four precautions to be taken against electric shock.

Ans:

Precautions to be taken against electric shock:

1) While using any electrical device, put on rubber sole footwear and keep your hands dry.
2) Always switch off main switch before replacing a blown fuse.
3) Ensure that the electrical equipment is properly earthed.
4) Keep earth connection in good condition.
5) Replace broken or damaged switches, plugs etc.
6) A plug point should never be disconnected by pulling the flexible cable.
7) Make plug point connection by plug tops and not by bare wires.
8) Check for proper working of safety devices.
9) Keep electrical hand tools in proper condition.
10) Don’t wear loose clothes while working on installation.

1 Mark for any four = 4 Marks