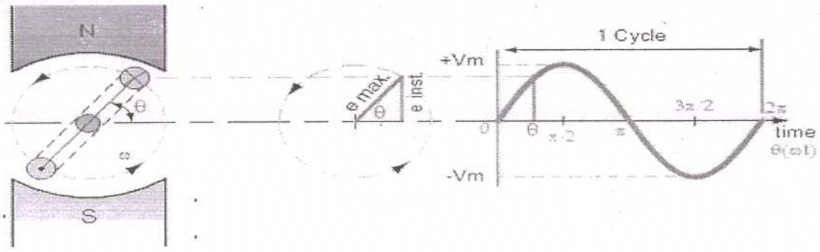
Scoring Indicators

Code : 3033 Fundamentals of AC system Version:

Qn. No.	Scoring Indicators	Split score	Total score
	PART - A		
I.1.	Average value of AC or alternating current is expressed by that DC current which transfers across any point of circuit the same charge as is transferred by the AC current for the same time. $I_{avg} = (2I_m / \pi) = 0.637I_m$	2	2
I. 2.	In a RLC series circuit, the condition at which the capacitive reactance is equal to inductive reactance is known as resonant condition. Then the total impedance in the RLC circuit is resistance (R) only. At resonance $f = f_r$ and on solving above equation we get, $f_r = 1/ 2\pi\sqrt{LC}$.	2	2
I. 3.	It is essential because of the following reasons: The parallel operation of the three-phase transformer or alternator is only possible when its phase sequence is known. The rotational direction of the three-phase induction motor depends upon its sequence of phase on three-phase supply.	2	2
I.4.	(i)Static Capacitor (ii) Synchronous Condenser (iii) Phase Advancer (any two)	2	2
I. 5.	Susceptance is the reciprocal of a pure reactance, X and is given the symbol B. In AC circuits Susceptance is defined as the ease at which a reactance (or a set of reactance) allows an alternating current to flow when a voltage of a given frequency is applied.	2	2
	PART – B		
II.1.	As the coil rotates anticlockwise around the central axis which is perpendicular to the magnetic field, the wire loop cuts the lines of magnetic force set up between the north and south poles at different angles as the loop rotates. The amount of induced EMF in the loop at any instant of time is proportional to the angle of rotation of the wire loop. So we can see that when the loop or coil physically rotates one complete revolution, or 360o, one full sinusoidal waveform is produced with one cycle of the waveform being produced for each revolution of the coil. As the coil rotates within the magnetic field, the electrical connections are made to the coil by means of carbon brushes and slip-rings which are used to transfer the electrical current induced in the coil.	3	
		3	6

II.2.

Power $= VI\cos\theta = 1390W$

Power factor $= \cos\theta = 1390/VI = 1390/250 \times 10 = 0.55A$

Impedance (Z) $= V/I = 250/10 = \mathbf{25\Omega}$

We know that Resistance (R) $= Z\cos\theta$

Reactance (X) $= Z\sin\theta$ **2**

Where $\cos\theta = 0.55$

$\theta = \cos^{-1} 0.55 = 56^0\ 18`$

hence **Reactance (X)** $= 25\text{x}\ \sin\ 56^0\ 18` = 25 \times 0.832 = \mathbf{20.85\ \Omega}$ **2**

Therefore **Inductance (L)** $= X/\omega = 20.85/2\pi f = 20.85/2\pi \times 50 = \mathbf{0.0663\ H}$

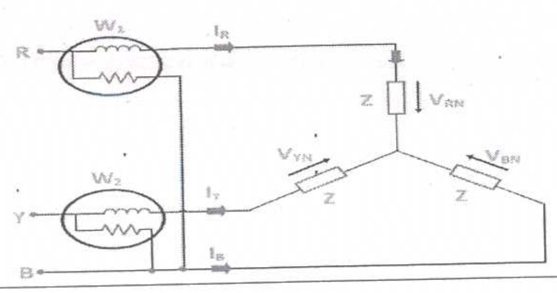
2 **6**

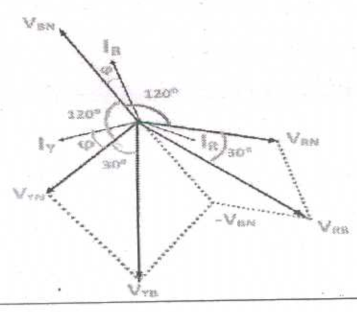
II.3. The following are the main advantages of 3 Phase system over Single Phase system.

1. Higher Rating: The rating, i.e. the output of a three-phase machine is nearly 1.5 times the rating (output) of a single phase machine of the same size.
2. Constant Power: In single phase circuits, the power delivered is pulsating. Even when the voltage and current are in phase, the power is zero twice in each cycle. Whereas, in the polyphone system, the power delivered is almost constant when the loads are in balanced condition.
3. Power Transmission Economics: The three phase system requires only 75% of the weight of conducting material of that required by single phase system to transmit the same amount of power over a fixed distance at a given voltage.
4. Superiority of 3 Phase Induction Motors: Three phase induction motors are self-starting whereas the single phase induction motor is not self-starting.
5. The three Phase Induction motors have higher power factor and efficiency than that of a single phase induction motor.
6. Size and Weight of alternator: The 3 Phase Alternator is small in size and light in weight as compared to a single phase alternator.
7. Requirement of Copper and Aluminium: 3 Phase system requires less copper and aluminium for the transmission system in comparison to a single phase transmission system.
8. Frequency of Vibration: In 3 phase motor, the frequency of vibrations is less as compared to single phase motor because in single phase the power transferred is a function of current and varies constantly.
9. Dependency: A single phase load can be efficiently fed by a 3 phase load or system, but 3 phase system cannot depend or feed by a single phase system.
10. Torque: A uniform or constant torque is produced in a 3 phase system, whereas in a single phase system pulsating torque is produced.

(any six) **1x6** **6**

II. 4. In this, to prove the power measured by the Two Wattmeter i.e. the sum of the two wattmeter readings is equal to root 3 times of the phase voltage and line voltage ($\sqrt{3}V_L I_L \cos\phi$) which is the actual power consumed in a 3 phase load.
The connection diagram of a 3 phase balanced load connected as Star Connection is shown below.





3

The load is considered as an inductive load, and thus, the phasor diagram of the inductive load is drawn below. The three voltages VRN, VYN and VBN, are displaced by an angle of 120 degrees electrical as shown in the phasor diagram. The phase current lag behind their respective phase voltages by an angle ϕ. Now, the current flowing through the current coil of the Wattmeter, W1 will be given as

$$W_1 = I_R$$

Potential difference across the pressure or potential coil of the Wattmeter, W1 will be

$$W_1 = \overline{V_{RB}} = \overline{V_{RN}} - \overline{V_{BN}}$$

To obtain the value of VYB, reverse the phasor VBN and add it to the phasor VYN as shown in the phasor diagram above. The phase difference between VRB and IR is $(30^o - \phi)$

Therefore, the power measured by the Wattmeter, W1 is

$$W_1 = V_{RB} I_R \cos(30^\circ - \varphi)$$

Current through the current coil of the Wattmeter, W2 is given as

$$W_2 = I_Y$$

The phase difference V_{YB} and I_Y is $(30^o + \phi)$.Therefore, the power measured by the Wattmeter, W_2 is given by the equation shown below.

$$W_2 = V_{YB} I_Y \cos(30^\circ + \varphi)$$

Since, the load is in balanced condition, hence,

$$I_R = I_Y = I_B = I_L \quad \text{and}$$

$$V_{RY} = V_{YB} = V_{BR} = V_L$$

Therefore, the wattmeter readings will be

$$W_1 = V_L I_L \cos(30^\circ - \varphi) \quad \text{and}$$ 3

$$W_2 = V_L I_L \cos(30^\circ + \varphi)$$

Now, the sum of two Wattmeter readings will be given as

$$W_1 + W_2 = V_L I_L \cos(30^\circ - \varphi) + V_L I_L \cos(30^\circ + \varphi)$$

$$W_1 + W_2 = V_L I_L [\cos(30^\circ - \varphi) + \cos(30^\circ + \varphi)] \quad \text{or}$$

$$W_1 + W_2 = V_L I_L [\cos 30^\circ \cos\varphi + \sin 30^\circ \sin\varphi + \cos 30^\circ \cos\varphi - \sin 30^\circ \sin\varphi] \text{ or}$$

$$W_1 + W_2 = V_L I_L (2 \cos 30^\circ \cos\varphi) \quad \text{or}$$

$$W_1 + W_2 = V_L I_L \left(2 \frac{\sqrt{3}}{2} \cos\varphi\right)$$

$$W_1 + W_2 = \sqrt{3}\, V_L I_L \cos\varphi$$

$$W_1 + W_2 = P$$

Thus two watt meters are enough for measuring power in three phase power measurement. 6

II.5. RMS value of an AC is defined as the "**amount of AC power that produces the same heating effect as an equivalent DC power**".

A periodic sinusoidal voltage is constant and can be defined as V(t) = Vmax*cos(ωt) with a period of T. Then we can calculate the root-mean-square (rms) value of a sinusoidal voltage (V(t)) as:

$$V_{RMS} = \sqrt{\frac{1}{T}\int_0^T V_m^2 \cos^2(\omega t)\, dt}$$

Integrating through with limits taken from 0 to 360° or "T", the period gives:

$$V_{RMS} = \sqrt{\frac{V_m^2}{2T}\left[t + \frac{1}{2\omega}\sin(2\omega t)\right]_0^T}$$

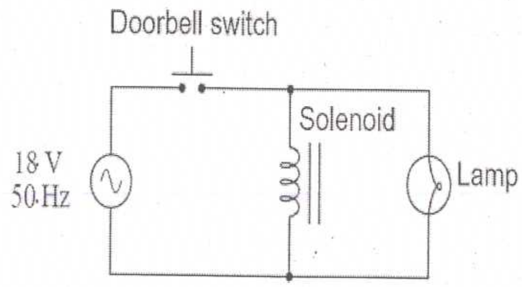
Where: Vm is the peak or maximum value of the waveform. Dividing through further as $\omega = 2\pi/T$, the çomplex equation above eventually reduces down too:

RMS Voltage Equation

$$V_{RMS} = V_{pk}\frac{1}{\sqrt{2}} = V_{pk} \times 0.7071$$

(definition + proof) 6

II.6. 2 + 4

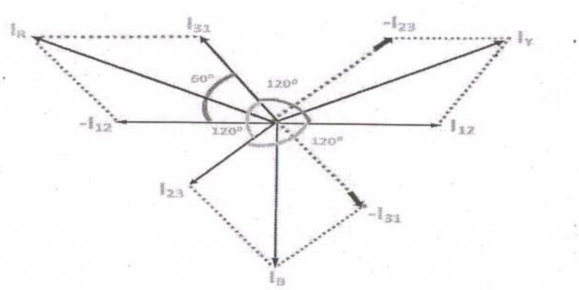


In this circuit Inductance (L) = 63mH; Resistance (R) = 150Ω
Inductive reactance $X_L = 2\pi fL$ = 2x3.14x50x 63x 10-3 = **19.782Ω**
Current through inductor I_L = V / XL = 18 / 19.782 = **0.9099A**
Current through lamp I_R = V / R = 18 / 150 = **0.12A**
Phase shift of voltage and current
when switch is on = $\theta = \tan^{-1} I_L / I_R = \tan^{-1} 7.58 = \mathbf{82.48^0}$

1.5x4

II.7. As in the balanced system the three phase current I_{12}, I_{23} and I_{31} are equal in magnitude but are displaced from one another by 120 degrees electrical. 6

The **phasor diagram** is shown below.



(vector diagram) 3

Hence,

$$I_{12} = I_{23} = I_{31} = I_{ph}$$

If we look at figure A, it is seen that the current is divided at every junction 1, 2

and 3. Applying Kirchhoff's Law at junction 1 The Incoming currents are equal to outgoing currents. $$\overline{I_{31}} = \overline{I_R} + \overline{I_{12}}$$ And their vector difference will be given as $$\overline{I_R} = \overline{I_{31}} - \overline{I_{12}}$$ The vector I_{12} is reversed and is added in the vector I_{31} to get the vector sum of I_{31} and $-I_{12}$ as shown above in the phasor diagram. Therefore, $$I_R = \sqrt{I_{31}^2 + I_{12}^2 + 2I_{31}I_{12}\cos 60^\circ} \quad \text{or}$$ $$I_L = \sqrt{I_{ph}^2 + I_{ph}^2 + 2I_{ph}I_{ph} \times 0.5}$$ As we know, $I_R = I_L$, therefore, $$I_L = \sqrt{3I_{ph}^2} = \sqrt{3}I_{ph}$$ Similarly, $$\overline{I_Y} = \overline{I_{12}} - \overline{I_{23}} \quad \text{or} \quad I_L = \sqrt{3}I_{ph} \quad \text{and}$$ $$\overline{I_B} = \overline{I_{23}} - \overline{I_{31}} \quad \text{or} \quad I_L = \sqrt{3}I_{ph}$$ Hence, in Delta connection line current is root three times of phase current. $$\text{Line Current} = \sqrt{3} \times \text{Phase Current}$$ (derivation)	3	6

PART – C

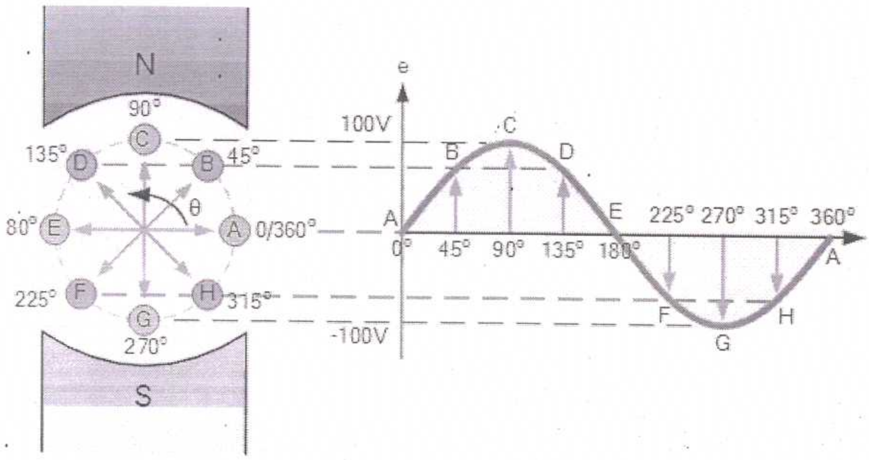
III. (a) If a single wire conductor is moved or rotated within a stationary magnetic field, an "EMF", (Electro-Motive Force) is induced within the conductor due to the movement of the conductor through the magnetic flux. The EMF induced in the coil at any instant of time depends upon the rate or speed at which the coil cuts the lines of magnetic flux between the poles and this is dependent upon the angle of rotation, θ of the generating device. Because an AC waveform is constantly changing its value or amplitude, the waveform at any instant in time will have a different value from its next instant in time.

The instantaneous values of a sinusoidal waveform is given as the "Instantaneous value = Maximum value x sin θ " and this is generalized by the formula.

$$V_i = V_{max} \sin \theta$$

Where, Vmax is the maximum voltage induced in the coil and $\theta = \omega t$, is the rotational angle of the coil with respect to time.

If we know the maximum or peak value of the waveform, by using the formula above the instantaneous values at various points along the waveform can be calculated. By plotting these values out onto graph paper, a sinusoidal waveform shape can be constructed.



Similarly instantaneous value of current can be written as

$$I_i = I_{max} \sin \theta$$

(sketch + explanation)

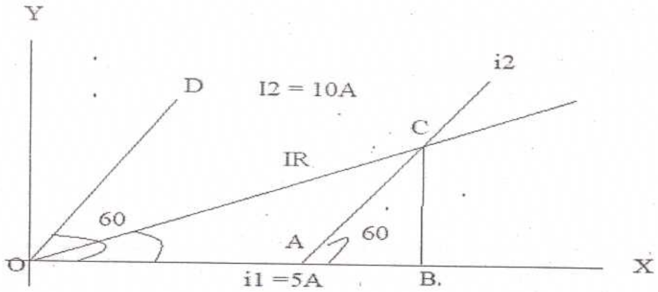
5+4 | 9

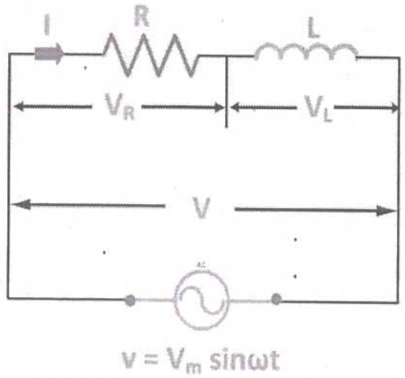
(b) Advantages of ac over dc:

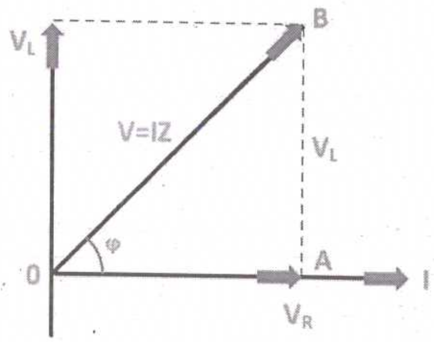
1. AC can be transmitted using step up transformers but direct current or dc cannot be transmitted by this method.
2. The ac is easy to generate than dc.
3. It is cheaper to generate ac than dc.
4. The ac generators have higher efficiency than dc.
5. The loss of energy during transmission is negligible for ac.
6. The ac can be easily converted into dc.
7. The variation of ac can easily be done using transformers either step up or step down.
8. The value or magnitude of ac can be decreased easily without loss of excess of energy. This can be done by using choke coil.

(any six points)

1x6 | 6

IV. (a)	The given circuit $V(t) = V_p \sin \omega t = \mathbf{20 \sin \omega t}$ The current passing through the circuit $I_p(t) = V_p(t) / R = 20 \sin \omega t / 2x10^3$ $= \mathbf{10 \times 10^{-3} \sin \omega t}$ Therefore Ip = **10 x 10-3A** The peak current = **10mA** Peak – to - peak current **Ipp = 20mA** RMS value Irms = 0.707 x 10mA = **7.07 mA** Average value Iav = 0.637 x 10mA = **6.37.mA**	**1.5 X 6**	**9**
(b)	Let i_1 = 5sinωt, i_2 = 10sinωt + 60^0  Draw OA = 5A along X axis; OD = 10 A at 600 to X – axis. Draw AC = 10A parallel to OD at A, join O, and C ; OC gives the resultant i_R of i_1 and i_2. Therefore iR is vector sum of i_1 and i_2. $OC = (OB^2 + BC^2)^{½}$ $\infty = \tan^{-1} (BC / OB)$ From triangle ABC $\sin 60^0 = BC / AC$ $BC = AC \sin 60^0$ $BC = 10 \sin 60^0 = 8.66A$ $\cos 60^0 = AB / AC$ $AB = AC \cos 60^0 = 5$ A OB = OA + AB = 5 + 5 = 10 OC = (102 + 8.662) ½ =13.228 $\infty = \tan^{-1} (8.66 / 10) = 40.89^0$ iR = **13.228.sin (ωt + 40.89⁰)**	**6**	**6**
V. (a)	Reactance of the inductance XL = 2πfL = 2xπx50x60x10-3 = **18.84Ω** Reactance of capacitor Xc = 1/ 2πfC = 1/ 2π x 50 x 130 x 10-6 = **24.5 Ω** i. Impedance (Z) = **20.8Ω** ii. Power factor = R/Z = **0.96** iii. The current in the ckt. = V/Z = **11.05A** iv. Voltage across the coil = I XL = **208.5V** v. Voltage across the capacitor = IXC = **271V**	**1.5x6**	**9**
(b)	A circuit that contains pure resistance R ohms connected in series with a coil having pure inductance of L (Henry) is known as R L Series Circuit. When an AC supply voltage V is applied the current, I flow in the circuit. IR and IL will be the current flowing in the resistor and inductor respectively, but the amount of current flowing through both the elements will be same as they are connected in series with each other. The circuit diagram of RL Series Circuit is shown below		





The following steps are given below which are followed to draw the phasor diagram step by step.
Current I is taken as a reference.
The Voltage drop across the resistance VR = IR is drawn in phase with the current I.
The voltage drop across the inductive reactance VL =IXL is drawn ahead of the current I.
As the current lags voltage by an angle of 90 degrees in the pure Inductive circuit.
The vector sum of the two voltages drops VR and VL is equal to the applied voltage V.
Now,

In right angle triangle OAB
VR = IR and VL = IXL where XL = 2πfL

$$V = \sqrt{(V_R)^2 + (V_L)^2} = \sqrt{(IR)^2 + (IX_L)^2}$$

$$V = I\sqrt{R^2 + X_L^2} \quad \text{or}$$

$$I = L = \frac{V}{Z}$$

Where Z is the impedance

$$Z = \sqrt{R^2 + X_L^2}$$

Putting the value of v and i , we will get

$$P = (V_m \operatorname{Sin}\omega t) x\, I_m \sin(\omega t - \varphi)$$

$$p = \frac{V_m I_m}{2} 2\sin(\omega t - \varphi)\sin\omega t$$

$$P = \frac{V_m}{\sqrt{2}}\frac{I_m}{\sqrt{2}}[\cos\varphi - \cos(2\omega t - \varphi)]$$

$$P = \frac{V_m}{\sqrt{2}}\frac{I_m}{\sqrt{2}}\cos\varphi - \frac{V_m}{\sqrt{2}}\frac{I_m}{\sqrt{2}}\cos(2\omega t - \varphi)$$

The average power consumed in the circuit over one complete cycle is given by the equation shown below

$$P = \text{average of } \frac{V_m}{\sqrt{2}}\frac{V_m}{\sqrt{2}}\cos\varphi - \text{average of } \frac{V_m}{\sqrt{2}}\frac{V_m}{\sqrt{2}}\cos(2\omega t - \varphi) \quad \text{or}$$

$$P = \frac{V_m}{\sqrt{2}}\frac{I_m}{\sqrt{2}}\cos\varphi - \text{Zero} \quad \text{or}$$

$$P = V_{r.m.s} I_{r.m.s}\cos\varphi = V\,I\cos\varphi$$

Where cosϕ is called the power factor of the circuit.

$$\cos\varphi = \frac{V_R}{V} = \frac{IR}{IZ} = \frac{R}{Z}$$

3+3 | 6

VI (a)

Potential difference across the coil = 20V, DC current = 2A,
Then Resistance of the coil = V/I = 20 /2 = **10Ω**
When AC connected across the coil at 2A = 140V
Then I x XL = 140V, therefore XL = 140/2 = 70Ω
XL = 2πfL ; then L = 70 / (2π x 40) = **0.279H**
When 230V, 50Hz AC connected to the coil
the inductive reactance XL = 2πfL
= 2π x 50 x 0.279 = **87.61Ω**
Then, Impedance $Z = (10^2 + 87.61^2)^{1/2}$ = 88.18Ω

(i) The current = V/Z = 230/ 88.18 = **2.61A**
(ii) Pf = R/Z = 10/88.18 = **0.113**
(iii) Active power = VI cosɵ = 230x2.61x 0.113
= **67.83W**

1.5 x6 — **9**

(b)

In a series RLC circuit there becomes a frequency point were the inductive reactance of the inductor becomes equal in value to the capacitive reactance of the capacitor. In other words, XL = XC. The point at which this occurs is called the Resonant Frequency point, (*fr*) of the circuit, and as we are analysing a series RLC circuit this resonance frequency produces a Series Resonance.
Electrical resonance occurs in an AC circuit when the two reactance which are opposite and equal cancel each other out as XL = XC. In a series resonant circuit, the resonant frequency, *fr* point can be calculated as follows.

$$X_L = X_C \Rightarrow 2\pi f L = \frac{1}{2\pi f C}$$

$$f^2 = \frac{1}{2\pi L \times 2\pi C} = \frac{1}{4\pi^2 LC}$$

$$f = \sqrt{\frac{1}{4\pi^2 LC}}$$

$$\therefore f_r = \frac{1}{2\pi\sqrt{LC}} \text{ (Hz)} \quad \text{or} \quad \omega_r = \frac{1}{\sqrt{LC}} \text{ (rads)}$$

The Q or quality factor is a dimensionless number and it describes the damping in the circuit. It also provides an indication of the resonator's bandwidth relative to its centre frequency. It can also be defined for an inductor as the ratio of its inductive reactance to its resistance at a particular frequency, and it is a measure of its efficiency.

4+2 — **6**

VII. (a)

Given R = 10Ω ; L = 0.05H ; XL = 2π x 50 x 0.05 = **15.7Ω**
Impedance $Z = (10^2 + 15.7^2)^{1/2}$ = **18.6Ω**
Pf R/Z = 10 / 18.6 = 0.54
In star connection line voltage = 400V
Then phase voltage = 400/√3 = 230.94V
Therefore phase current = 230.9/18.6 = 12.42A

(i) The phase current = **12.42A**
(ii) Line current = **12.42A**
(iii) Total phase power = (230.94 x 12.42 x 0.54)3
= **4646.6W**
(iv) Total line power = √3 x 400 x 12.42 x 0.54
= **4646.5W**

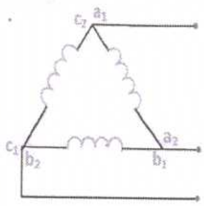
1.5 x 6 — **9**

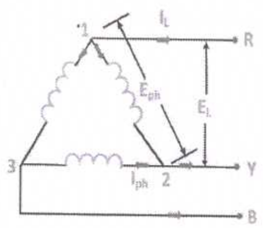
(b)

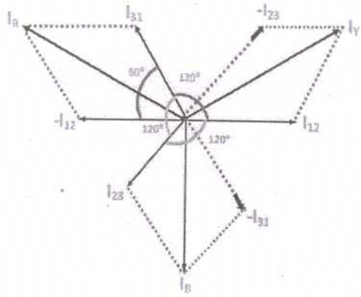
The difference between the Star and Delta Connection are given below in the **tabulated form.**

BASIS	STAR CONNECTION	DELTA CONNECTION		
Basic Definition	The terminals of the three branches are connected to a common point. The network formed is known as Star Connection	The three branches of the network are connected in such a way that it forms a closed loop known as Delta Connection		
Connection of terminals	The starting and the finishing point that is the similar ends of the three coils are connected together	The end of each coil is connected to the starting point of the other coil that means the opposite terminals of the coils are connected together.		
Neutral point	Neutral or the star point exists in the star connection.	Neutral point does not exist in the delta connection.		
Relation between line and phase current	Line current is equal to the Phase current.	Line current is equal to root three times of the Phase Current.		
Relation between line and phase voltage	Line voltage is equal to root three times of the Phase Voltage	Line voltage is equal to the Phase voltage.		
Phase voltage	Phase voltage is low as 1/√3 times of the line voltage.	Phase voltage is equal to the line voltage.		
Network Type	Mainly used in the Power Transmission networks..	Used in the Power Distribution networks.		
Type of system	Both Three phase four wire and three phase three wire system can be derived in star connection.	Three phase four wire system can be derived from the Delta connection.	1x6	6

VIII. (a) In Delta (Δ) or Mesh connection, the finished terminal of one winding is connected to start terminal of the other phase and so on which gives a closed circuit. The three line conductors are run from the three junctions of the mesh called Line Conductors. The connection in Delta form is shown in the figure below.







The current flowing through each phase is called Phase Current (Iph), and the current flowing through each line conductor is called Line Current (IL).

The voltage across each phase is called Phase Voltage (Eph), and the voltage across two line conductors is called Line Voltage (EL). The phase voltages are

$$E_{12} = E_{23} = E_{31} = E_{ph}$$

The line voltages are

$$E_{RY} = E_{YB} = E_{BR} = E_L$$

As in the balanced system the three phase current I12, I23 and I31 are equal in magnitude but are displaced from one another by 120 degrees electrical. From this

$$I_L = \sqrt{3I_{ph}^2} = \sqrt{3}I_{ph}$$

$$\text{Line Current} = \sqrt{3} \text{ x Phase Current}$$

Power developed = 3 x E_{ph} x I_{ph} x cosө
= √3 E_L I_L cosө

9

3+3+3

(circuit + Vector diagram + explanation)

(b)

STAR CONNECTION
Line voltage = **10.6KV**, phase voltage = 10.6 x 1000 / √3 = **6120.09 V**
Coil current = 100 x 10^6 / 6120.09 x 3 = **5446.62A**, Line current = **5446.62A**

3

DELTA CONECTION
Line voltage = **10.6 KV**, phase voltage = **10.6KV**
Coil current = 100 x 10^6 / 10.6 x 1000 x3 = **3144.65A**,
Line current = √3 x 3144.65 = **5446. 54A**

3

6

IX.
(a)

(i) When the power factor is zero, cos $\theta = 0$. Therefore,

$$\theta = \cos^{-1}(0) = 90°$$

$$\tan 90 = \sqrt{3}\,\frac{W_1 - W_2}{W_1 + W_2}$$

$$\frac{(W_1 + W_2)}{(W_1 - W_2)} = \frac{\sqrt{3}}{\infty} = 0$$

Hence

$$W_1 + W_2 = 0$$
$$W_1 = -W_2$$
$$\frac{W_1}{W_2} = -1$$

Both readings are equal but one of them gives a negative reading.

	(iv) When power factor = 0.5 lag, $\theta = \cos^{-1}(0.5) = 60°$. Then $$\tan 60° = \sqrt{3}\ \frac{W_1 - W_2}{W_1 + W_2}$$ $$\sqrt{3} = \sqrt{3}\ \frac{W_1 - W_2}{W_1 + W_2}$$ Hence $$W_1 + W_2 = W_1 - W_2$$ $$\Rightarrow 2W_2 = 0$$ that is one of the meters gives zero reading. (v) When power factor = 0.707 lag; $\theta = \cos^{-1}(0.707) = 45$. Then $$\tan 45° = \sqrt{3}\ \frac{W_1 - W_2}{W_1 + W_2}$$ $$\frac{1}{\sqrt{3}} = \frac{W_1 - W_2}{W_1 + W_2}$$ Hence $$W_1 + W_2 = \sqrt{3}\ W_1 - \sqrt{3}\ W_2$$ $$(\sqrt{3} - 1)\ W_1 = (\sqrt{3} + 1)W_2$$ $$\frac{W_1}{W_2} = \frac{\sqrt{3}+1}{\sqrt{3}-1}$$ that is, both meters give unequal reading. (vi) When power factor = unity; $\theta = \cos^{-1}(1.0) = 8$. Then $$\tan 0° = \sqrt{3}\ \frac{W_1 - W_2}{W_1 + W_2}$$ $$\left(\frac{W_1 + W_2}{\sqrt{3}}\right) \times 0 = W_1 - W_2$$ $$W_1 = W_2 \text{ or } \frac{W_1}{W_2} = 1$$ that is both meters read equal and positive.	2x4 +1	9
(b)	Given R = 25Ω, L = 0.5H, C = 30μF, V = 500V, f = 50Hz Then XL = 2πf L = **57Ω**, XC = **106.1Ω** Hence impedance = **56.65Ω** Power factor = R/Z = 0.44, power factor angle = **63.84⁰** Phase voltage = 500/ √3 ; current / phase = 500 / √3 x 56.65 $\llcorner$ 63.84⁰ = 5.09 $\llcorner$ 63.84⁰ Total power = √3 VL IL cosθ = **1943.42W** W1 + W2 = 1943.42W tanθ = √3 (W1 – W2) / W1 + W2 tan 63.84 = 2.035 = √3 (W1 – W2) / 1943.42 then W1 – W2 = 2283.41W solving W1 = **2113.4W** and W2 = **-170 W**	1x6	6

X. **(a)**	$W1 = 5.2$ KW, $W2 = -1.7$KW (due to –ve reading) Total power $= 5.2 - 1.7 =$ **3.5 KW** Power factor $\cos\theta = \cos(\tan^{-1}(\sqrt{3}(W1 - W2) / W1 + W2) =$ **0.147** That is $R / Z = 0.147$ Then $R = Z \cos\theta$ and $XL = Z \sin\theta = 0.98Z$ $\sqrt{3} X400 \times IL \times 0.147 = 3.5KW$ $IL = 3500/ 101.84 =$ **34.37A** $Z = 400 / 34.37 =$ **11.63Ω** Then inductive reactance $= 11.63 \times 0.98 =$ **11.4 Ω** $2\pi f L = 11.4$, $L = 11.4 / 2\pi f =$ **0.036 H**	**1.5x6**	**9**
(b)	The following devices and equipment are used for Power Factor Improvement. Static Capacitor Synchronous Condenser Phase Advancer 1. Static Capacitor For Power factor improvement purpose, Static capacitors are connected in parallel with those devices which work on low power factor. These static capacitors provides leading current which neutralize (totally or approximately) the lagging inductive component of load current (i.e. leading component neutralize or eliminate the lagging component of load current) thus power factor of the load circuit is improved. 2.Synchronous Condenser When a Synchronous motor operates at No-Load and over-exited then it's called a synchronous Condenser. Whenever a Synchronous motor is over-exited then it provides leading current and works like a capacitor. When a synchronous condenser is connected across supply voltage (in parallel) then it draws leading current and partially eliminates the re-active component and this way, power factor is improved. Generally, synchronous condenser is used to improve the power factor in large industries. 3.Phase Advancer Phase advancer is a simple AC exciter which is connected on the main shaft of the motor and operates with the motor's rotor circuit for power factor improvement. Phase advancer is used to improve the power factor of induction motor in industries. *******************	**2x3**	**6**