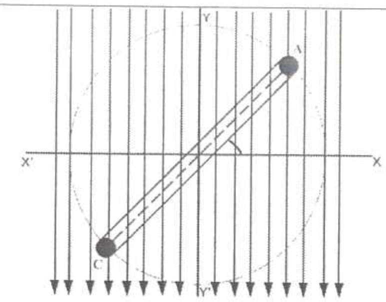
SCHEME OF VALUATION

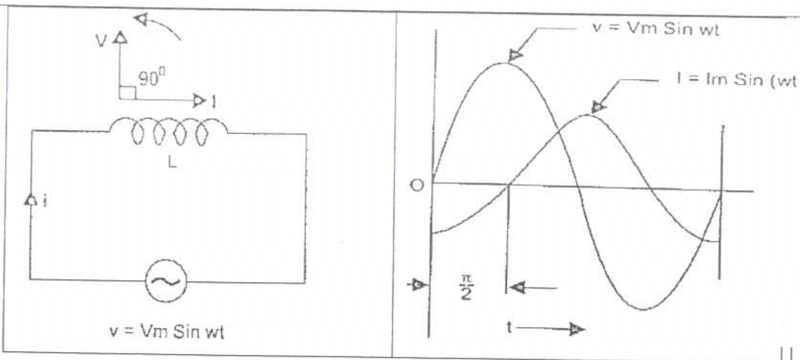
(Scoring Indicators)

Revision:15				Course Code: 3033
	Course Title: Fundamentals of AC System			
Qn. No	**Scoring Indicator**	**Split up Score**	**Sub Total**	**Total**
	Part - A			
1	**Cycle:** - one complete set of positive and negative values of an alternating quantity **Frequency:** - it is the number of cycles per second	**1** **1**	**2**	**10**
2	$X_c = \frac{1}{2\pi fC}$	**2**	**2**	
3	1. Star or Wye (Y) connection 2. Delta or mesh connection	**1** **1**	**2**	
4	1. Three wattmeter method 2. Two wattmeter method 3. One wattmeter method	**1 mark Any two**	**2**	
5	It is the three phase load, in which all the phases the connected loads are distributed equally. In a balanced condition the neutral current will be zero. Unbalanced load in which loads are not distributed equally. Therefore, the neutral current will not be zero	**1** **1**	**2**	

1	The average value of an alternating current or voltage is given by that DC current which transfers across any circuit the same amount of charge as is transferred by the that AC during the same time. For symmetrical AC waves (2 half cycles are exactly equal), the average value over a complete cycle is zero. But for unsymmetrical AC waves (2 half cycles are not equal), an average value can be obtained. We know that instantaneous value of current, $i = I_m \mathrm{Sin}\theta$. Integrate the value (instantaneous value) over the limit (0-π) w.r.t θ. $I_{avg} = \frac{1}{\pi}\int_0^{\pi} I_m \,\mathrm{Sin}\,\theta d\theta$ $= \frac{I_m}{\pi}\int_0^{\pi} \mathrm{Sin}\,\theta d\theta$ $= \frac{I_m}{\pi}[-\cos\theta]_0^{\pi}$ $= \frac{I_m}{\pi}[-\cos\pi + \cos 0]$ $= \frac{I_m}{\pi}[1+1]$ $= \frac{2I_m}{\pi} = 0.637 I_m$ Therefore, $I_{avg} = 0.637 I_m$ We can find out the average value of an AC by multiplying the maximum current/voltage with the value of 0.637.	2 4	6	

2	 A rectangular coil AC (single turn) rotating in a magnetic field of flux density B webber/m^2. Let the length of each of its sides A and C be 'l' meters and their peripheral velocity 'v' m/s. let the angle be measured from the horizontal position i.e., from the x-axis. When in horizontal position. The two sides A&C moves parallel to the lines of magnetic flux. Hence no flux is cut and so no emf is generated through the coil. When the coil has turned through angle θ. Its velocity can be resolved into two mutually components. ie, 1. Vcos θ Component 2. Vsin θ Component Vcos θ component is parallel to the direction of magnetic flux, so no emf is generated due to this component. Vsin θ component is perpendicular to the direction of magnetic flux. Therefore the emf induced/generated entirely due to Vsin θ. This can be expressed, The emf generated **e=Blvsin θ**. If there is N number of conductors equation will be, e = NBlvSin θ. The total emf generated both sides of the coil. Therefore, e = 2BlvSin θ.vdt. We can write 2BNlv = E_m. So the equation above can be written as **e = E_mSin θ** , where $\theta = \omega t$ There fore we can write, e = **E_mSin*wt***	2 4	6	

3



2

Consider a circuit containing a coil of pure inductance. This is denoted by L. if an alternating current is applied across the inductor in the circuit, a magnetic flux will be set up when the current flows through it. Due to the inference of the magnetic flux an alternating emf is induced in the coil. It is called back emf, and is due to self-induction. The back emf will oppose the rise or fall of current through it, and is equal and opposite to the applied emf.

6

The instantaneous voltage equation, $v = L.\frac{di}{dt}$ (1)

where, $v = V_m \sin \omega t$, L= self-inductance.

Equate both voltage equations, we get, $L.\frac{di}{dt} = V_m \sin \omega t$

$$= v \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$di = \frac{V_m}{L} \sin \omega t.dt \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Integrating both sides,

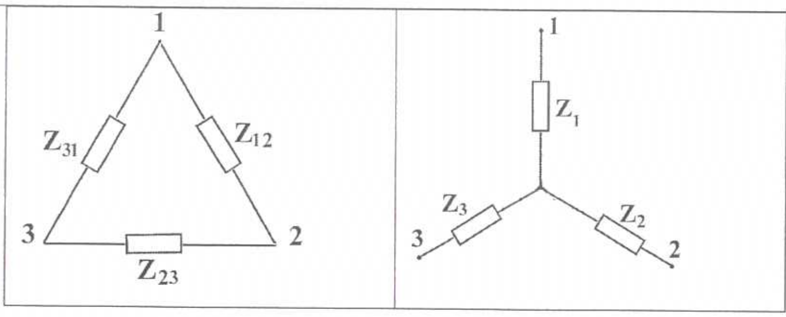
$$\int di = \int \frac{V_m}{L} \sin \omega t.dt \ldots \quad (4)$$

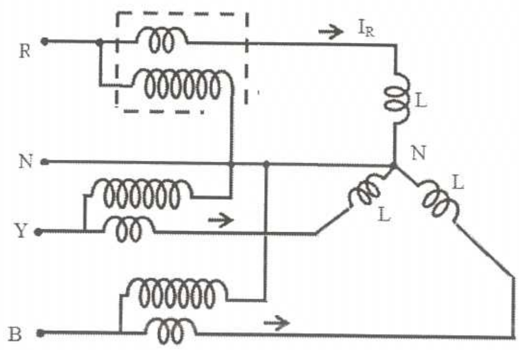
4

$$\int di = \frac{V_m}{L} \int \sin \omega t.dt \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

$$i = \frac{V_m}{L}\left(\frac{-\cos \omega t}{\omega}\right) \ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

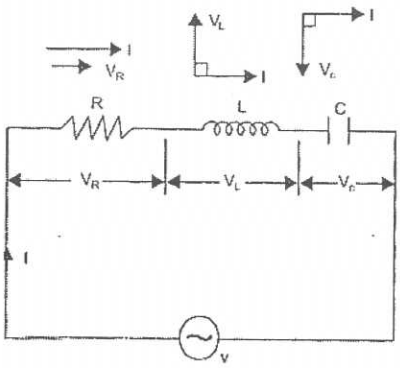
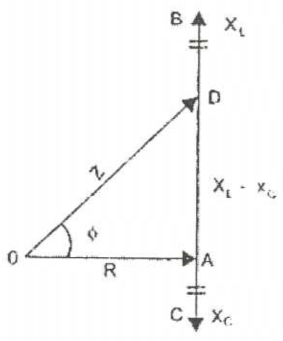
	$$i = \frac{V_m}{\omega L}(-\cos \omega t) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$ $$i = \frac{V_m}{\omega L}(\sin \omega t - 90^0) \ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$ Current 'i' is max I_m, when $(\sin \omega t - 90^0)$ is unity. $$I_m = \frac{V_m}{\omega L} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$ Substitute eqn 9 in 8 we get, $i = I_m(\sin \omega t - 90^0)$ By analyzing the above equation, we can see that the current lags behind the applied voltage by 90^0 or the phase difference between the two is $\pi/2$ radians as shown in figure below. The quantity ωL is known as inductive reactance and denoted by X_L and is measured in Ω.			
4	**1.** In a single phase circuit the power delivered is pulsating. While in a polyphase system the total power delivered is constant if loads are balanced **2.** The output of the three phase motor is 1.5 times the output of single phase motor for a given size **3.** Single phase induction motor are not self-starting, where 3 phase induction motors are self-starting **4.** The efficiency of polyphase motors is greater than single phase motor **5.** Power factor of polyphase motor is more than the single phase motor for same rating **6.** Rotating magnetic field can be set up by polyphase supply **7.** Three phase system requires $\frac{3}{4}th$ weight of copper to transmit same power at a given voltage **8.** Polyphase system is more reliable	**1 Mark Each** **Any 6**	6	**30**

	9. Parallel operation of polyphase alternators is simple			
5	 For Y- load, total impedance between terminals 1 and 2 is Z_1+Z_2 (it should be noted that double subscript notation of Z_{01} and Z_{02} has been avoided. Considering terminals 1 and 2 of delta load, we find that there are two parallel paths having impedances of Z_{12} and (Z_{31} +Z_{23}). Hence, the equivalent impedance between terminals 1 and 2 is given by $\frac{1}{Z}=\frac{1}{Z_{12}}+\frac{1}{Z_{13}+Z_{23}} \, or \, Z=\frac{Z_{12}(Z_{13}+Z_{23})}{Z_{12}+Z_{13}+Z_{23}}.$ Therefore, for equivalence between the two systems $Z_1+Z_2=\frac{Z_{12}(Z_{13}+Z_{23})}{Z_{12}+Z_{13}+Z_{23}}$ ....1 Similarly, $Z_2+Z_3=\frac{Z_{23}(Z_{13}+Z_{12})}{Z_{12}+Z_{13}+Z_{23}},$ ......2 $Z_3+Z_1=\frac{Z_{31}(Z_{23}+Z_{12})}{Z_{12}+Z_{13}+Z_{23}}$ ....3 Adding equation 3 to 1 and subtracting equation 2, we get $2Z_1=\frac{Z_{12}(Z_{13}+Z_{23})+Z_{31}(Z_{12}+Z_{23})-Z_{23}(Z_{12}+Z_{13})}{Z_{12}+Z_{13}+Z_{23}}$	1 5	6	

	$$= \frac{2Z_{12}Z_{13}}{Z_{12}+Z_{13}+Z_{23}}$$ $$\therefore Z_1 = \frac{Z_{12}Z_{13}}{Z_{12}+Z_{13}+Z_{23}}$$ $$\therefore Z_2 = \frac{Z_{12}Z_{23}}{Z_{12}+Z_{13}+Z_{23}}$$ $$\therefore Z_3 = \frac{Z_{13}Z_{23}}{Z_{12}+Z_{13}+Z_{23}}$$			
6	 In this method, three watt meters are inserted one in each phase and the algebraic sum of their readings gives the total power consumed by the three phase load whether delta connected or star connected. A wattmeter consist of a current coil and a pressure coil. The current coil of each wattmeter carries the current of one phase only and the pressure coil measures the phase-voltage of this phase. Hence, each wattmeter measures the power in a single phase. The algebraic sum of the readings of three wattmeters must give the total power in the load.	3 3	6	
7	1. Large kVA rating of equipment 2. Greater conductor size 3. Large copper losses 4. Poor voltage regulation	6	6	

	5. Reduced handling capacity of system			
III (a)	**Alternating current** :-It is the current whose amplitude is changing continuously and changes its direction in a regular interval	2		
	Instantaneous value: it is the value of voltage or current at any instant	2		
	Form factor: The ratio of the rms value to the average value of an ac is known as form factor and is denoted by the letter K_f Form factor $K_f = \frac{r.m.s\ value}{average\ value}$	2	8	
	Angular velocity: The angle through which any radius of a body turns in a second. Usually it is represented by omega (ω) and measured in radian/second.	2		

III b	$5\angle 30^0 = 5(\cos 30^0 + \sin 30^0) = 4.33 + j2.5$ $8\angle -30^0 = 8[\cos(-30^0) + \sin(-30^0)] = 6.93 - j4$ $A + B = (4.33 + j2.5) + (6.93 - j4)$ $= 11.26 - j1.5$ Polar form $a\angle\theta$ $a = \sqrt{(11.26)^2 + 1.5)^2} = 11.35$ $\theta = \tan^{-1}(-1.5/11.26) = 7.6^0$ $A + B = 11.35\angle 7.6^0$ Multiplication AXB $A \times B = (8 \times 5)\angle(30 + -30)$ $= 40\angle 0^0 \; or\, 40$	1 2 2 2	7	60
IV (a)	**Phase:** The angle turned /moved/rotated through by an alternating current or voltage from a given instant is called phase. **Phase difference:** The angle between the phases of two alternating quantity of the same frequency as measured in degrees is known as phase difference. **RMS value:** The rms value of an AC is given by that DC current which when flowing through a given circuit for a given time produces same amount of heat as produced by the AC when flowing through same circuit for the same time. **Maximum value:** it is the maximum amplitude achieved by an	2 2 2	8	

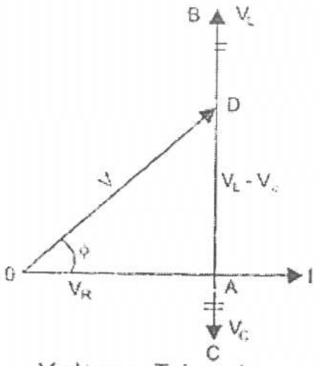
	alternating quantity during a cycle	2		
IV (b)	$I_{avg} = 0.637\, I_m$ $= 0.637 \times 25 = 15.925\, A$ $I_{rms} = 0.707\, I_m$ $= 0.707 \times 25 = 17.675\, A$ $Ins\tan eous\, current, i = I_m \sin \omega t$ $= 25 \times \sin(2 \times 180 \times 50 \times \frac{1}{600})$ $= 25 \times \sin(30) = 25 \times 0.5$ $= 12.5\, A$	2 2 3	7	
V (a)	**AC THROUGH R-L-C SERIES CIRCUIT** Consider a circuit consisting of Resistor (R), Inductor (L) and Capacitor(C) connected in series and the applied voltage is v.  Let, $V_R = IR$ $V_L = IX_L$ $V_C = IX_C$ $v = V_m \sin \omega t$. **i)Impedance**  Impedance Triangle from impedance triangle $OD^2 = OA^2 + AD^2$ $Z^2 = R^2 + (X_L - X_C)^2$ $Z = \sqrt{R^2 + (X_L - X_C)^2}$ **ii) Current** 180^0 out of phase with each	 2 2		

In voltage triangle V_L, V_C are that $V_L > V_C$

other. It has been assumed

The net reactive drop = AB - BD= $V_L - V_C$

from voltage triangle



Voltage Triangle

$$OD^2 = OA^2 + AD^2$$

$$V^2 = V_R^2 + (V_L - V_C)^2$$

$$= (IR)^2 + (IX_L - IX_C)^2$$

$$V = I\sqrt{R^2 + (X_L - X_C)^2}$$

$$I = \frac{V}{\sqrt{R^2 + (X_L - X_C)^2}}$$

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

Where Z is the impedance of the circuit

8

iii) Power factor

$$\cos\phi = \frac{R}{Z} = \frac{R}{\sqrt{R^2 + (X_L - X_C)^2}} = \frac{R}{\sqrt{R^2 + (X)^2}}$$

2

iv)Phase angle

$$\phi = \cos^{-1}\left(\frac{R}{Z}\right)$$

The voltage and current equations in RLC circuit are,

$$v = V_m \sin \omega t$$

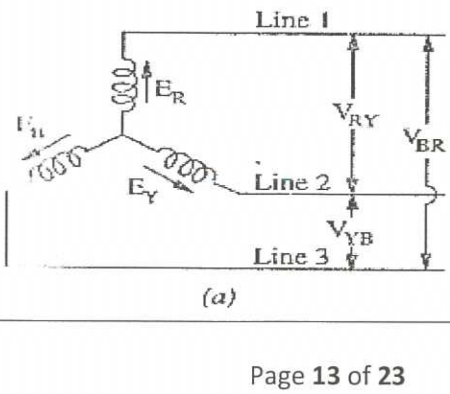
2

$$i = I_m \sin(\omega t \pm \phi)$$

+ve sign is to be used when $X_C > X_L$ (or current leads)

-ve sign is to be used when $X_L > X_C$ (or current lags)

	v) Power Power consumed $= VI\cos\phi$	2		
V (b)	$X_L = 0.2\times 2\pi f = 0.2\times 2\times 3.14\times 50 = 63\Omega, C = 10\mu F = 10^{-4}F$ $X_C = \frac{1}{2\pi fC} = \frac{1}{314\times 10^{-4}} = 32\Omega$ Net reactance value $= X = X_L - X_C = 63 - 32 = 31\Omega$ $i) Z = \sqrt{(20^2 + 31^2)} = 37\Omega$ $ii) I = \frac{220}{37} = 5.9459\ ;\ 6A$ $iii) V_R = I\times R = 6\times 20 = 120V$ $V_L = I\times X_L = 6\times 63 = 278V$ $V_C = I\times X_C = 6\times 32 = 192V$ $iv) pf = \cos\theta = \frac{R}{Z} = \frac{20}{37} = 0.54$ $v) Power\ in\ watts = VI\cos\theta = 220\times 6\times 0.54 = 713W$	1 1 3 1 1	7	
VI (a)	A series circuit is said to be in electrical resonance when its net reactance is zero.ie, $X_L - X_C = 0$ where $X_L = X_C$. The impedance of the circuit can be found out from the equation, $Z = \sqrt{R^2 + (X)^2}$. Here $(X)^2$ be the net reactance. The supply voltage is kept constant, the frequency of the supply varying from zero to infinity, at a certain frequency of applied voltage the inductive reactance (X_L) becomes equal to the capacitive reactance (X_C) in magnitude. This situation is known as resonance. The frequency at which $X_L = X_C$ is known as **resonance frequency** and is represented by f_r. $$f_r = \frac{1}{2\pi\sqrt{LC}}$$ At resonance condition the net reactance X=0. $\therefore$ The	6		

	impedance will be equal to resistance of the circuit 'R'. Therefore the circuit will act as a purely resistive circuit and current is in phase with the applied voltage v. We know that, $V_L = IX_L$ and $V_C = IX_C$. From the figure, we can see that $V_L = V_C$ and in opposite. Therefore they are opposite in direction (phase). Hence both the voltages are cancel each other. The two reactances (X_L, X_C) taken together act as a short circuit since no voltage develops across them. The whole of the applied voltage drops across the resistance. ie, $V = IR$.		**8**	
	Q-FACTOR OF A SERIES CIRCUIT It is the voltage magnification in the series circuit at resonance. The formula for finding Q-factor as follows $Q-factor = \frac{1}{R}\sqrt{\frac{L}{C}}$	**2**		
VI (b)	$f_o = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{50\times10^{-3}\times25\times10^{-6}}} = 142.3Hz$ $I_o = \frac{V}{R} = \frac{200}{10} = 20A$ $Q_o = \frac{1}{\omega_o CR} = \frac{1}{2\pi\times142.3\times50\times10^{-6}\times10} = 4.47$	**3** **1** **3**	7	
VII (a)	 *(a)*	**1**		

Line Voltages and Phase Voltages

The p.d. between lines 1 and 2 is $V_{RY} = V_R - V_Y$ (vector difference)

Hence, V_{RY} is found by compounding V_R and V_Y reversed and its value is given by the diagonal of the parallelogram of figure. Obviously, the angle between V_R and V_Y reversed is 60^0. Hence if $E_{RY} = E_R - E_Y = E_{ph}$ - the phase emf., then

$$V_{RY} = 2 \times E_{ph} \times \cos(60/2)$$

3

$$V_{RY} = 2 \times E_{ph} \times \cos 30$$

$$V_{RY} = 2 \times E_{ph} \times \frac{\sqrt{3}}{2} = \sqrt{3}E_{ph}$$

Similarly, $V_{YB} = E_Y - E_B = \sqrt{3}E_{ph}$

$$V_{BR} = E_B - E_R = \sqrt{3}E_{ph}$$

Now, V_{RY}=V_{YB}=V_{BR}=

Line voltage, say, V_L. Hence, in star connection

$V_L = \sqrt{3}E_{ph}$.

8

It will be noted from the figure that

1. Line voltages are 120^0 apart.
2. Line voltages are 30^0 ahead of their respective phase voltages
3. The angle between the lined currents and the corresponding line voltages is $(30+\phi)$ with current lagging.

Line Currents and Phase Currents

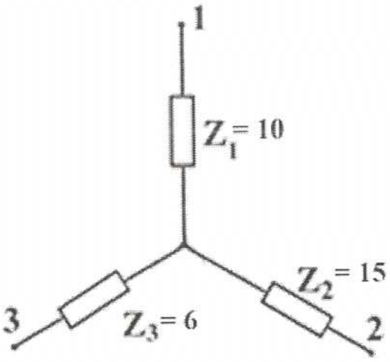
It is seen from figure that each line is in series with its individual phase winding, hence the line current in each

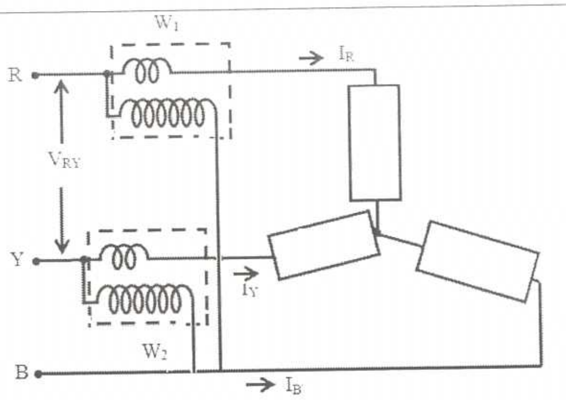
	line is the same as the current in the phase winding to which the line is connected. Current in line 1 = I_R, Current in line 2= I_Y, Current in line 3=I_B Since I_R= I_Y=I_B=say, I_{ph}-phase current, therefore line current I_L=I_{ph} **Power** The total active or true power in the circuit is the sum of the three phase powers. Hence, total active power = 3× phase power or P=$3\times V_{ph}I_{ph}\cos\phi$ Now $V_{ph}=\frac{V_L}{\sqrt{3}}$ and I_{ph}= I_L, hence, in term of line values, the above expression becomes $$P=3\times\frac{V_L}{\sqrt{3}}I_L\cos\phi \text{ or } P=\sqrt{3}\times V_L I_L\cos\phi$$ It should be particularly noted that ϕ is the angle between phase voltage and phase current and **not** between the line voltage and line current. Similarly, total reactive power is given by $Q=\sqrt{3}\times V_L I_L\sin\phi$ By convention, reactive power of a coil is taken as positive and that of a capacitor as negative. The total apparent power of the three phase is $S=\sqrt{3}\times V_L I_L$ obviously, $S=\sqrt{P^2+Q^2}$	1 3		

<table>
<tr><td>VII
b</td><td>Star Connection
$X_L = 2\pi \times 50 \times 0.05 \cong 15\Omega$
$Z_{ph} = \sqrt{15^2 + 20^2} = 25\Omega$
$V_{ph} = \frac{400}{\sqrt{3}} = 231V, I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{231}{25} = 9.24A$
$I_L = I_{ph} = 9.24A$
$Power = \sqrt{3}\, V_L\, I_L \cos\phi \quad , \cos\phi = \frac{R}{Z} = \frac{20}{25} = 0.8$
$P = \sqrt{3} \times 400 \times 9.24 \times 0.8 = 5120W$

Delta Connection
$V_L = V_{ph} = 400V, I_{ph} = \frac{400}{25} = 16\ A$
$I_L = \sqrt{3} \times I_{ph} = \sqrt{3} \times 16 = 27.7\ A$
$Power = \sqrt{3}\, V_L\, I_L \cos\phi \quad , \cos\phi = \frac{R}{Z} = \frac{20}{25} = 0.8$
$P = \sqrt{3} \times 400 \times 27.7 \times 0.8 = 15360W$</td><td>4

3</td><td>7</td><td></td></tr>
<tr><td>VIII
(a)</td><td>Star | Delta
Favorable for 3-phase distribution system | Favorable for 3-phase transmission system
Neutral point is available | No Neutral point
$V_L = \sqrt{3}E_{ph}$ | $V_L=V_{ph}$
$I_L=I_{ph}$ | $I_L = \sqrt{3}\, I_{ph}$
I_L are 30^0 behind the | V_L are 30^0 ahead of respective V_{ph}</td><td>8</td><td></td><td></td></tr>
</table>

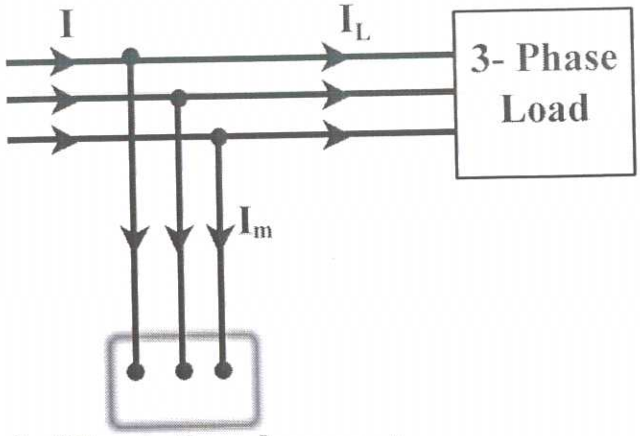
	respective I_{ph}				
	Line currents (phase current also) 120^0 apart	Line Voltages 120^0 apart		8	
	The angle between IL and VL is $30 \pm \phi$	The angle between IL and VL is $30 \pm \phi$			
	$P = \sqrt{3} \times V_L I_L \cos\phi$	$P = \sqrt{3} \times V_L I_L \cos\phi$			
	$Z_1 = \frac{Z_{12} \times Z_{13}}{Z_{12} + Z_{23} + Z_{13}} = \frac{50 \times 20}{50 + 20 + 30} = 10\Omega$		2	7	
	$Z_2 = \frac{Z_{12} \times Z_{23}}{Z_{12} + Z_{23} + Z_{13}} = \frac{50 \times 30}{50 + 20 + 30} = 15\Omega$		2		
	$Z_3 = \frac{Z_{13} \times Z_{23}}{Z_{12} + Z_{23} + Z_{13}} = \frac{20 \times 30}{50 + 20 + 30} = 6\Omega$		2		
			1		
IX (a)	It can be proved that the sum of the instantaneous power indicated by W_1 and W_2 give the instantaneous power absorbed by the three loads L_1, L_2 and L_3. A star-connected loads because a Delta connected load can always be replaced by an equivalent Star-connected load.				

	 Let, Instantaneous current through W_1 $= i_R$ PD across $W_1 = e_{RB}$ $= e_R - e_B$ power read by W_1 $= i_R\left(e_R - e_B\right)$ Instantaneous current through W_2 $= i_Y$ Instantaneous PD across $W_2 = e_{YB}$ $= e_Y - e_B$ Instantaneous power read by W_2 $= i_Y\left(e_Y - e_B\right)$ Total power = W_1+W_2 $= i_R\left(e_R - e_B\right) + i_Y\left(e_Y - e_B\right)$ $= i_R e_R + i_Y e_Y - e_B\left(i_R + i_Y\right)$ According to Kirchhoff's current law, $\left(i_R + i_Y + i_B\right) = 0$ $\therefore \left(i_R + i_Y\right) = -i_B$ Substitute the value of $i_R + i_Y$ in the above equation $W_1+W_2 = i_R e_R + i_Y e_Y - e_B\left(-i_B\right)$ $= i_R e_R + i_Y e_Y + e_B i_B$ $= p_1 + p_2 + p_3$ Where, p_1, p_2 and p_3 are the power absorbed by the loads L_1, L_2	**Fig 2** **6**	**8**	

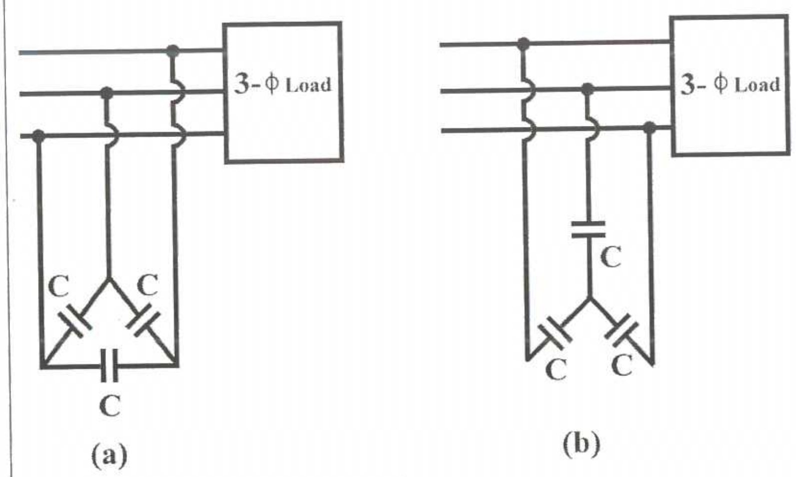
	and L_3 respectively. $\therefore$ **$W_1+W_2=$** $p_1+p_2+p_3$ **(Total power absorbed)**			
IX (b)	$Motor\ input\ (W_1+W_2)=\frac{motor\ output}{\eta}=\frac{73550}{0.82}=89695W \quad ...1$	1		
	$Phase\ angle,\ \phi=\cos^{-1}(0.8)=36.87^0$ $\tan\phi=\frac{\sqrt{3}(W_1-W_2)}{(W_1+W_2)}$ $\tan 36.87=\frac{\sqrt{3}(W_1-W_2)}{89695}$ $\frac{0.75}{\sqrt{3}}=\frac{(W_1-W_2)}{89695}$ $\therefore W_1-W_2=\frac{0.75\times 89695}{\sqrt{3}}=38839W......2$	2		
	Add the expressions 1 and 2, $W_1+W_2=89695$ $W_1-W_2=38839$ $2W_1=128534$ $\therefore W_1=\frac{128534}{2}=64267W$ Substituting the value of W1 in equation 1, we get $64267+W_2=89695$ $\therefore W_2=89695-64267=25428W$ $W_1=64267W\ ,\ W_2=25428W$	2	7	
	Line current, $I_L=\frac{P}{\sqrt{3}\times V_L\times\cos\phi}=\frac{89695}{\sqrt{3}\times 400\times 0.8}=161.83A$	1		
	Phase current , $I_{ph}=\frac{I_L}{\sqrt{3}}=\frac{161.83}{\sqrt{3}}=93.43A$	1		

<table>
<tr><td>X</td><td></td><td></td><td></td><td></td></tr>
<tr><td>a</td><td>The following equipment can be installed in the factory for improving or correcting the power factor:

1. **Synchronous Motors(or capacitors)**



3- Phase Synchronous Motor</td><td>2</td><td></td><td></td></tr>
<tr><td></td><td>A synchronous motor takes a leading current when over-excited and therefore, behaves as a capacitor. An over-excited synchronous motor running on no load is known as synchronous condenser.
When such a machine is connected in parallel with the supply, it takes a leading current which partly neutralizes the lagging reactive component of the load. Thus the power factor is improved. They are employed for correcting power factor in bulk and have the special advantage that the amount of correction can be varied by changing their excitation.
The figure shows the power factor improvement by synchronous condenser method. The 3ϕ load takes current I_L at low power factor $\cos\phi_L$. The synchronous condenser takes a current I_m which leads the voltage by an angle ϕ_m. The resultant current I is the phasor sum of I_m and IL and lags behind the</td><td>2</td><td></td><td></td></tr>
</table>

	voltage by an angle ϕ. It is clear that ϕ is less than Φ_L . thus the powe4r factor is increased from $\cos\Phi_L$ to $\cos\phi$. Synchronous condenser are generally used at major bulk supply substation for power factor improvement. **2.Static Capacitors** The power factor can be improved by connecting capacitors in parallel with the equipment operating at lagging power factor. The capacitor draws a leading current and partly or completely neutralizes the lagging reactive component of load current. This raises the power factor of the load. For three-phase loads, the capacitors can be connected in delta or star as shown in figure. Static capacitors are invariably used for power factor improvement in factories.		8	
		Fig 2		
	3 Phase Advancers They are used to improve the power factor of induction motors. They are fitted with individual machines. The low power factor of an induction motor is due to the fact that its stator winding draws exciting current which lags behind the supply by 90^0. If the exciting ampere turns can be provided from some other AC source, then the stator winding will be relieved of exciting current and the power factor of the motor can be	4		

	improved. This job is accomplished by the phase advancer which is simply an AC exciter. The phase advancer is mounted on the same shaft as the main motor and is connected in the rotor circuit of the motor. It provides on the same shaft as the main motor and is connected in the rotor circuit of the motor. It provides exciting ampere turns to the rotor circuit at slip frequency. By providing more ampere turns than required, the induction motor can be made to operate on leading power factor like an over-excited synchronous motor. Phase advancers have two principal advantage. Firstly, as the exciting ampere turns are supplied at slip frequency, therefore, lagging kVAR drawn by the motor are considerably reduced. Secondly, phase advancer can be conveniently used where the use of synchronous motor is inadmissible. However, the major disadvantage of phase advancers is that they are not economical for motors below 200 H.P.	**Any 2**		
X b	$Motor\ input\ (W+W_2) = 30000W$ ....1 $Power\ factor,\ \cos\phi = 0.397$ $Phase\ angle, \phi = \cos^{-1}(0.397) = 66.61^0$ $\tan\phi = \frac{\sqrt{3}(W_1 - W_2)}{(W_1 + W_2)}$ $\tan 66.61 = \frac{\sqrt{3}(W_1 - W_2)}{30000}$ $\frac{2.31}{\sqrt{3}} = \frac{(W_1 - W_2)}{30000}$ $(W_1 - W_2) = \frac{2.31 \times 30000}{\sqrt{3}} = 40043W$ $(W_1 - W_2) = 40043W$.........2 Add the expression 1 and 2,	**1** **2**		

	$(W_1+W_2)=30000$ $(W_1-W_2)=40043$ $2W_1=70043$ $W_1=\frac{70043}{2}=35021.5$ Substitute the value of W1 in equation 1, $(35021+W_2)=30000$ $\therefore W_2=30000-35021$ $=-5021$ $W_1=35021W\approx 35kW$ $W_2=-5021W\approx -5kW$	2 2	7		