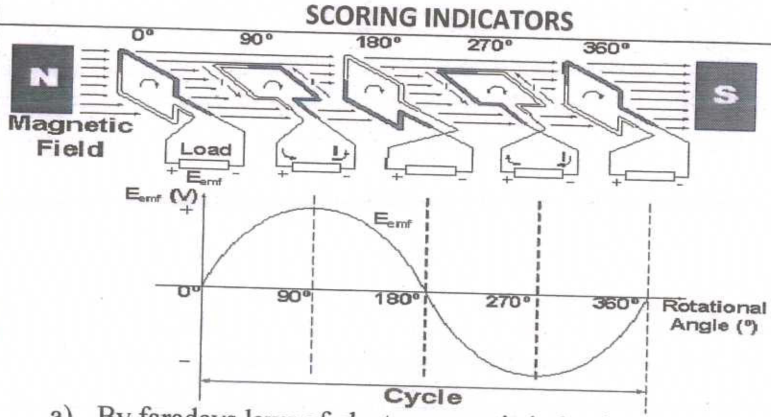
SCHEME OF VALUATION

(Scoring Indicators)

REVISION : 15 | COURSE CODE :TED(15)-3033

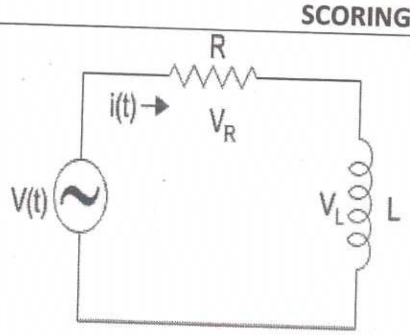
COURSE TITLE: FUNDAMENTALS OF AC SYSTEM

QN NO		SCORING INDICATORS	SPLIT UP SCORE	SUB TOTAL	TOTAL SCORE
I.		**PART A**			
	1.	Time period : Time taken to complete a full cycle of wave is known as time period. Frequency : No of cycles per second is known as frequency of the wave. $T = 1/F$	1x2	2	
	2.	Capacitive reactance is the resistance offered by a capacitor to the AC supply. Its unit is ohm. $X_c = 1/(2\prod FC)$	2x1	2	
	3.	(i) Star connection (ii) Delta connection	1x2	2	
	4.	Three phase power can be expressed as $\mathbf{P = \sqrt{3} \times pf \times I_{line} \times V_{line}}$ **OR** $\mathbf{P = 3 \times pf \times I_{phase} \times V_{phase}}$	2x1	2	
	5.	(i) By adding static capacitor (ii) By using synchronous condenser (iii) By using phase advancer (AnyTwo)	1x2	2	10
		PART B			
II	1.	Form factor : It is the ratio of RMS value of AC to Average value of AC Form factor = RMS value / Average value $= v_m * \prod / V_m * \sqrt{2}$ $= 1.11$ Crest factor : It is the ratio of maximum value of AC to RMS value of AC Crest factor = Maximum value / RMS value $= V_m * \sqrt{2} / V_m$ $= \sqrt{2} = 1.414$	3x2	6	

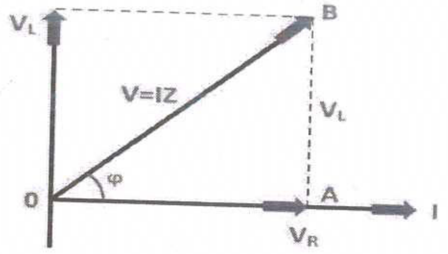
QN NO		SCORING INDICATORS	SPLIT UP SCORE	SUB TOTAL	TOTAL SCORE
II	2.	 	3		
		a) By faradays laws of electromagnetic induction emf induced is directly proportional to the flux change. b) At zero degree flux linkage maximum but emf induced is minimum c) At 90 degree flux linkage minimum but flux change maximum so emf induced attains maximum value d) As move from zero degree to 90 degree flux change increases then emf induced will also increases. e) As move from 180 degree to 360 degree flux change decreases and emf induced also decreases. f) Thus the emf induced has a shape of sine wave.	3	6	
II	3.	For inductor $V = L\,di/dt$ $di = \frac{V}{L} dt \qquad I = \int V/L \, dt$ $I = \int \frac{V_m}{L} \sin \omega t \, dt = \frac{-V_m}{\omega L} \cos \omega t$ $I = \frac{V_m}{\omega L} \sin (\omega t - \pi/2) = I_m \sin (\omega t - \pi/2)$ $I_m = V_m / \omega L = V_m / X_L$ instantaneous Power $= \int_0^{2\pi} V_m \sin \omega t \times I_m \sin (\omega t - \pi/2) \, d\omega t$ Total Power for full cycle $= \int_0^{2\pi} -V_m I_m \sin \omega t \cos \omega t \, d\omega t$ $= \frac{-V_m I_m}{2} \int_0^{2\pi} \sin 2\omega t \, d\omega t$ $= \frac{-V_m I_m}{2} \left[\frac{\cos 2\omega t}{2} \right]_0^{2\pi}$ $= \frac{-V_m I_m}{2} [1-1] = \underline{0}$ So the total power consumed by a pure inductor is zero	6	6	

QN NO		SCORING INDICATORS	SPLIT UP SCORE	SUB TOTAL	TOTAL SCORE
II	4.	(see below)	2, 2, 2	6	
II	5.	(see below)	6	6	

II 4.



Split up score: 2



Split up score: 2

Consider a simple RL circuit in which resistor, R and inductor, L are connected in series with a voltage supply of V volts. Let us think the current flowing in the circuit is I (amp) and current through resistor and inductor is I_R and I_L respectively. Since both resistance and inductor are connected in series, so the current in both the elements and the circuit remains the same. i.e $I_R = I_L = I$. Applying Kirchhoff voltage law (i.e sum of voltage drop must be equal to apply voltage) to this circuit we get,

$V = V_R + V_L$

$IZ = IR + j\,IX_L$ and $X_L = 2\Pi fL$

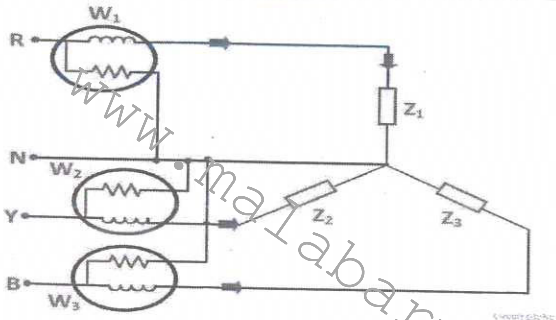
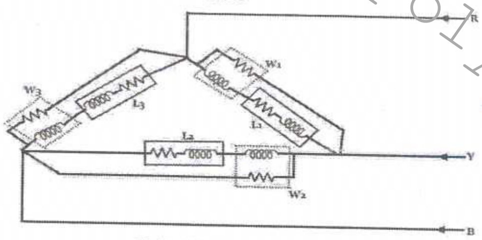
$Z = \sqrt{(R^2+X_L^2)}$ and $\varphi = \tan^{-1}(X_L/R)$

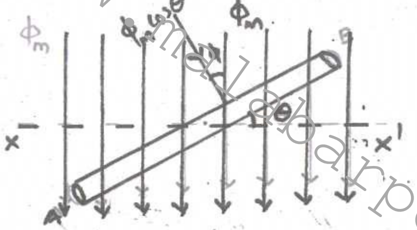
Split up score: 2 | Sub total: 6

II 5.

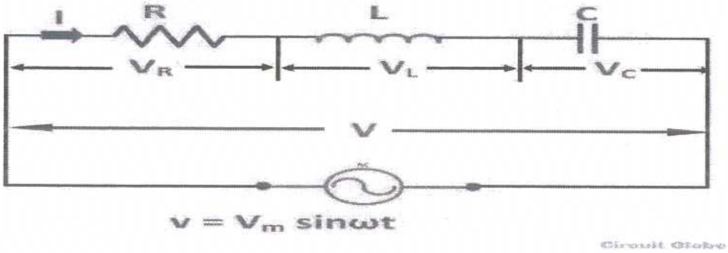
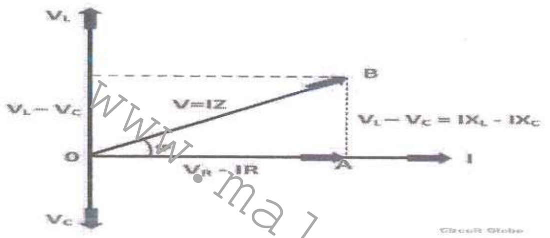
Star connection	Delta connection
Neutral or the star point exists in the star connection.	Neutral point does not exist in the delta connection.
Line current is equal to the Phase current.	Line current is equal to root three times of the Phase Current.
Line voltage is equal to root three times of the Phase Voltage.	Line voltage is equal to the Phase voltage.
The Speed of the star connected motors is slow as they receive $1/\sqrt{3}$ of the voltage.	The Speed of the delta connected motors is high because each phase gets the total of the line voltage.
Insulation required is low.	High insulation is required.
The terminals of the three branches are connected to a common point. The network formed is known as Star Connection.	The end of one phase connected to the start of next phase.
Requires less number of turns.	Requires large number of turns.

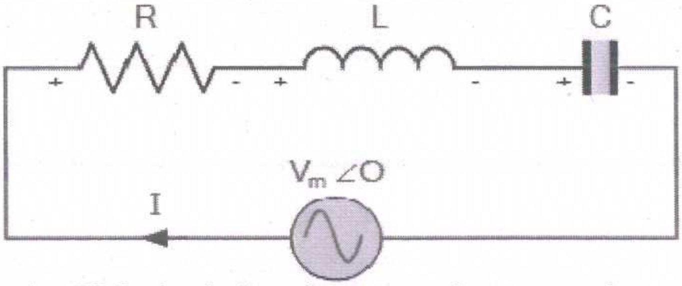
Split up score: 6 | Sub total: 6

QN NO		SCORING INDICATORS	SPLIT UP SCORE	SUB TOTAL	TOTAL SCORE
II	6.	➢ More power can be transmitted by the polyphase transmission system using same amount of conducting material. ➢ Polyphase motors have more uniform torque than the single phase motors(their output torque is pulsating in nature) ➢ In case of Induction motor polyphase induction motors are self starting and more efficient but single phase induction motors are not self starting. ➢ The output of 3 phase machine is always greater than single phase machine of same size. ➢ Power factor of single phase machines is poor compared to three phase machines. ➢ Parallel operation of three-phase generators is simpler than that of single phase generator. ➢ Polyphase system can set up rotating magnetic field in stationary windings. (Any six)	1x6	6	
II.	7.	 OR  Delta connected load	4		
		The total power in a Three wattmeter method of power measurement is given by the algebraic sum of the readings of Three watt meters. The pressure coil of all the Three watt meters namely W_1, W_2 and W_3 are connected to a common terminal known as the neutral point. The product of the phase current and line voltage represents as phase power and is recorded by individual wattmeter.	2	6	5x6=30

QN NO		SCORING INDICATORS	SPLIT UP SCORE	SUB TOTAL	TOTAL SCORE
		PART C			
III	a	$A = 10 + 25j \quad B = 7 - 13j$ $A+B = 10+25j + 7 - 13j$ $= 17 + 12j$ (i) Rectangular form $= 17 + 12j$ (ii) Polar form $= \sqrt{17^2+12^2} \angle \tan^{-1} 12/17$ $= 20.80 \angle 35.2^\circ$ (iii) Trignometric form $= 20.80 \cos 35.2 + j\, 20.80 \sin 35.2$	2 2 2 2	8	
III	b	 → initialy the coil in xx' position then the conductor rotates at an angle $\theta = \omega t$ → The perpendicular component of flux contribute the emf generation. → The $\phi_m \cos\theta = \phi_m \cos\omega t$ causes in Production of Emf → By faradays law of electromagnetic induction $e = -\frac{d}{dt}(N\phi) = -\frac{d}{dt}(N\phi_m \cos\omega t)$ $= N\phi_m \sin\omega t \times \omega = N\phi_m \omega \sin\omega t$ $e = e_m \sin\omega t$ $e_m = N\phi_m \omega$	7	7	15

QN NO		SCORING INDICATORS	SPLIT UP SCORE	SUB TOTAL	TOTAL SCORE
IV	a.	$v = 45 \sin(471t)$ (i) maximum value = 45 V (ii) instantaneous value at t = 2 msec $v = 36.4\,V$ (iii) Average value = $2V_m/\pi$ $= 2 \times 45/3.14$ $= 28.6\,V$ (iv) R.m.s value = $V_m/\sqrt{2}$ $= 31.8\,V$	1 3 2 2	8	
IV	b.	✓ AC can be transmitted using step up transformers but direct current or dc cannot be transmitted by this method. ✓ The ac is easy to generate than dc. ✓ It is cheaper to generate ac than dc. ✓ The ac generators have higher efficiency than dc. ✓ The loss of energy during transmission is negligible for ac. ✓ The ac can be easily converted into dc. ✓ The variation of ac can easily be done using transformers either step up or step down. ✓ 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)**		7	15

QN NO		SCORING INDICATORS	SPLIT UP SCORE	SUB TOTAL	TOTAL SCORE
V	a.		2		
		• $V_R = IR$ that is the voltage across the resistance R and is in phase with the current I. • $V_L = IX_L$ that is the voltage across the inductance L and it leads the current I by an angle of 90 degrees. • $V_C = IX_C$ that is the voltage across the capacitor C and it lags the current I by an angle of 90 degrees.	2		
			2		
		$V = \sqrt{(V_R)^2 + (V_L - V_C)^2} = \sqrt{(IR)^2 + (IX_L - IX_C)^2}$ or $V = I\sqrt{R^2 + (X_L - X_C)^2}$ or $I = \frac{V}{\sqrt{R^2 + (X_L - X_C)^2}} = \frac{V}{Z}$ $Z = \sqrt{(R^2+(X_L-X_c)^2)}$	2	8	
V	b.	$R = 4\Omega$ $L = 5H$ (i) At Resonance $X_L = X_C$ $X_L = 2 \times 3.14 \times 50 \times 5 = 1570\,\Omega$ $X_C = \frac{1}{2\pi f C} = 1570$ $C = 2.02 \times 10^{-6} f = 2.02\,\mu f$	5		
		(ii) At Resonance $Z = R$ $\therefore I = 230/R = 230/4 = 57.5\,A$	2	7	15

<table>
<tr><th colspan="2">QN NO</th><th>SCORING INDICATORS</th><th>SPLIT UP SCORE</th><th>SUB TOTAL</th><th>TOTAL SCORE</th></tr>
<tr><td>VI</td><td>a.</td><td>


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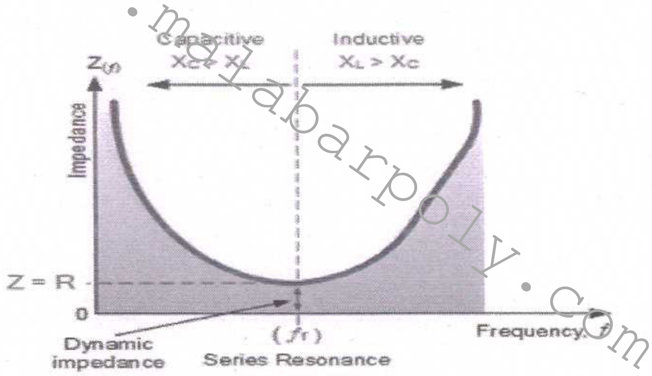
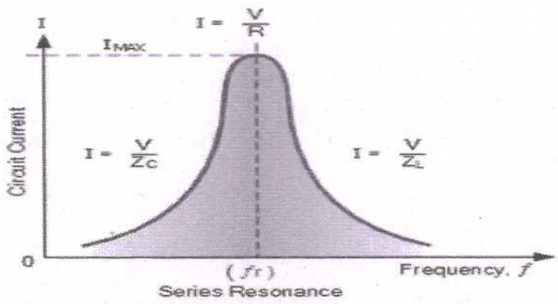
<tr><td></td><td></td><td>
In a series RLC circuit there becomes a frequency point were the inductive reactance of the inductor becomes equal in value to the capacitive reactance of the capacitor. In other words, $X_L = X_C$. The point at which this occurs is called the **Resonant Frequency** point, (f_r) of the circuit, and as we are analysing a series RLC circuit this resonance frequency produces a **Series Resonance**.
$XL=XC$ ie $2\Pi frL = 1/2\Pi frC$
$Fr = 1/2\Pi\sqrt{LC}$
The two reactance cancel each other out thereby making a series LC combination act as a short circuit with the only opposition to current flow in a series resonance circuit being the resistance R.
At resonance the impedance, Z is at its minimum value, (=R). Therefore, the circuit current at this frequency will be at its maximum value.
</td><td>4</td><td></td><td></td></tr>
<tr><td>VI</td><td>a.</td><td>




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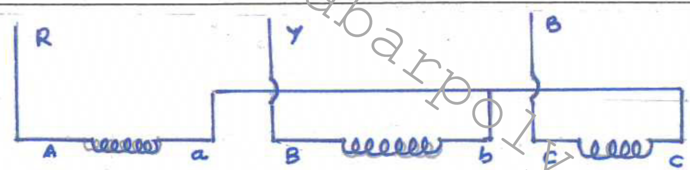
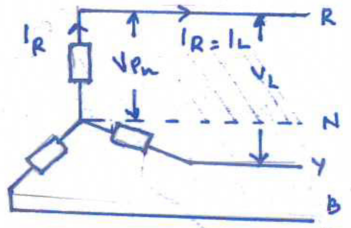
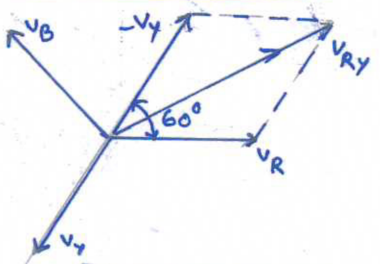
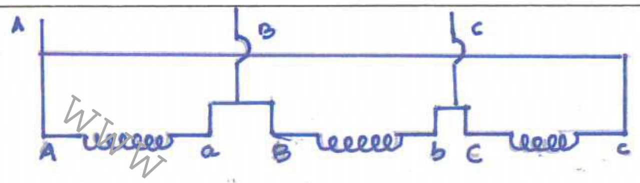
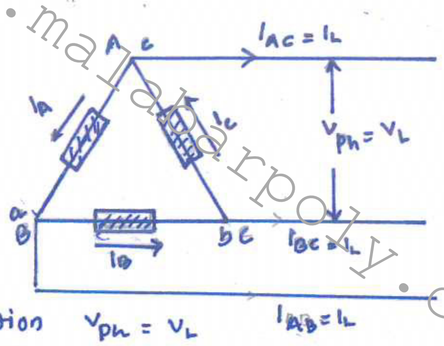
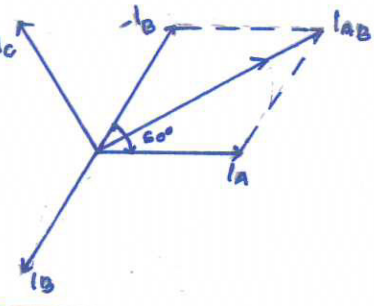
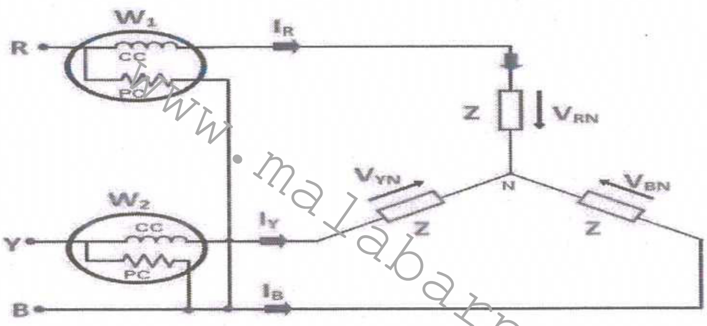
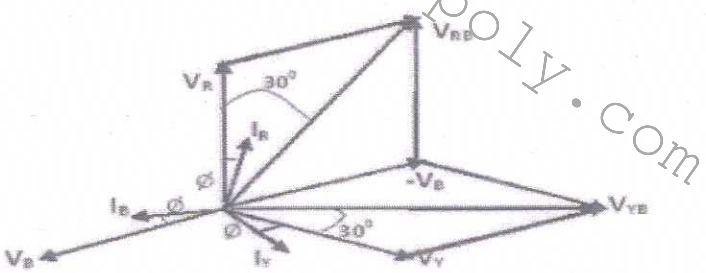
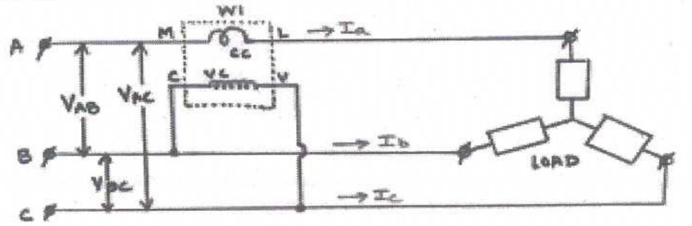
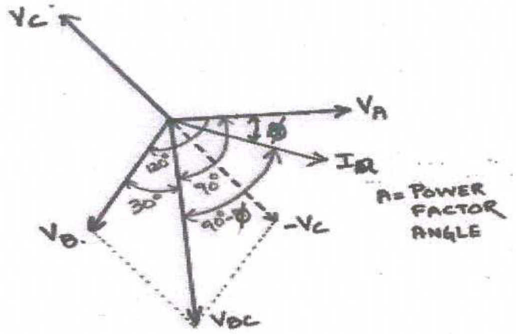
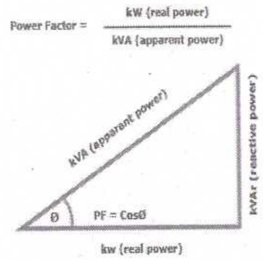
QN NO		SCORING INDICATORS	SPLIT UP SCORE	SUB TOTAL	TOTAL SCORE
VI	b.	$R = 7\Omega$ $L = 31.8\,mH$ $X_L = 2 \times 3.14 \times 50 \times 31.8 \times 10^{-3}$ $= 9.9\Omega$ $Z = R + jX_L = 7 + 9.9j$ $= 12.12 \angle 54.95^\circ$ (i) Current $I = V/Z = \frac{230}{12.12\angle 54.73} = 18.9\angle -54.73$ (ii) Phase angle $= 54.7^\circ$ (iii) Power factor $= \cos\phi$ $= \cos 54.7$ $= 0.57$ (iv) Power consumed $= VI\cos\phi$ $= 230 \times 18.9 \times 0.57$ $= 2510.1\,W$	2 1 2 2	7	15
VII	a.	 1)   $V_{RY} = V_L = \sqrt{V_R^2 + V_Y^2 + 2V_RV_Y} = \sqrt{3}\,V_{ph}$ 2) $I_L = I_{ph}$ 3) Power $P = \sqrt{3}\,V_L I_L \cos\phi$ $= 3\,V_{ph} I_{ph} \cos\phi$	7	7	

QN NO		SCORING INDICATORS	SPLIT UP SCORE	SUB TOTAL	TOTAL SCORE
VII	b.	$P = 8\times10^3 = \sqrt{3}\times V_L\times I_L\times\cos\phi$ $I_L = 8\times10^3/\sqrt{3}\times460\times0.8 = 12.5\,A$ $I_L = I_{phase} = 12.5\,A$ $V_{ph} = V_L/\sqrt{3} = 460/\sqrt{3} = 265.6\,V$ $Z_{ph} = V_{ph}/I_{ph} = 265.6/12.5$ $= 21.24\,\Omega$ $R_{ph} = 21.24\cos 36.86 = 16.9\,\Omega$ $X_{Lph} = 21.24\sin 36.86 = 12.74\,\Omega$	5 3	8	15
VIII	a.	  a) For Delta connection $V_{ph} = V_L$ Phase voltage = line voltage $I_{AB} = I_L$  b) $I_{AB} = \sqrt{I_A^2 + I_B^2 + 2I_A I_B\cos 60} = \sqrt{3I_{ph}^2} = \sqrt{3}\,I_{ph}$ $I_L = \sqrt{3}\,I_{ph}$ c) Power in delta connection $= \sqrt{3}\,V_P\cdot I_L\cos\phi$ $= 3\,V_{ph}\,I_{ph}\cos\phi$	2 5	7	

QN NO		SCORING INDICATORS	SPLIT UP SCORE	SUB TOTAL	TOTAL SCORE
VIII	b.	$Z_{ph} = 8+6j \quad V_L = 400V$ $V_{ph} = 400V \quad I_{ph} = V_{ph}/Z_{ph} = 400/8+6j$ $= 40 \angle -36.8^{\circ}$ (i) $I_L = \sqrt{3} \times I_{ph} = 69.2 \angle -36.8^{\circ}$ (ii) power factor $= \cos\phi = \cos 36.8$ $= 0.8$ (iii) power $= \sqrt{3} \times V_L \times I_L \times \cos\phi$ $= \sqrt{3} \times 400 \times 69.2 \times \cos 36.8$ $= 38389.5W = 38.38 kW$	1 2 2 3	8	15
IX	a.	  From the figure, it is obvious that current through the Current Coil (CC) of Wattmeter W_1 I_R, current though Current Coil of wattmeter W_2 I_B whereas the potential difference seen by the Pressure Coil (PC) of wattmeter $W_1 V_{RB}$ (Line Voltage) and potential difference seen by Pressure Coil of wattmeter W_2 V_{BY}. Active power measured by wattmeter $W_1 = V_{RB} I_R \cos(30° – Ø)$ Active power measured by wattmeter $W_2 = V_{YB} I_Y \cos(30° + Ø)$ Let $V_{RY} = V_{YB} = V_{RB} = V_L$ $W_1 = V_L I_L \cos(30- Ø)$ and $W_2 = V_L I_L \cos(30+ Ø)$ $W_1+W_2 = W = V_L I_L (\cos(30+ Ø) + \cos(30- Ø))$ $= \sqrt{3} V_L I_L \cos Ø$ $W_1 – W_2 = V_L I_L \sin Ø$ $\tan Ø = (\sqrt{3} (W_1-W_2)) / (W_1+W_2)$	2 3 3	8	

QN NO		SCORING INDICATORS	SPLIT UP SCORE	SUB TOTAL	TOTAL SCORE
IX	b.	 W1 = WATTMETER CC = CURRENT COIL VC = VOLTAGE COIL	3		
			3		
		Power measured by wattmeter $W = V_{BC} I_R \cos(90 - Ø)$ $= V_L I_L \sin Ø$ By multiplying the watt meter reading by √3 Reactive power of three phase system is obtained Reactive power $= \sqrt{3} V_L I_L \sin Ø$	1	7	15
X	a.	▪ Power Factor is a measure of how effectively incoming power is used in your electrical system and is defined as the ratio of Real to Apparent (total) power. ▪ Real Power is the power that actually powers the equipment and performs useful, productive work. ▪ Reactive Power is required by some equipment (eg. transformers, motors and relays) to produce a magnetic field for operation; however it does not perform any real work. ▪ Apparent Power is the vector sum of Real and Reactive Power and corresponds to the total power required to produce the equivalent amount of real power for the load.	3		
		 Low power factor cause ❖ More current required to perform the same amount of work. ❖ More current in line increases losses in the system. ❖ The resistance drop causes a voltage drop in lines. That reduces voltage level at the end of transmission line. ❖ The high current requirement increases the size of the systems.(the size of transformer, transmission lines…) ❖ When power factor decrease the cost of energy will increase. So the power factor should be improved by adding power correction equipments to avoid the inverse effects on power systems.	5	8	

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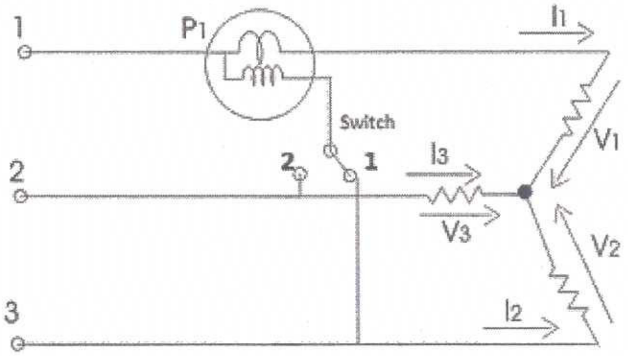
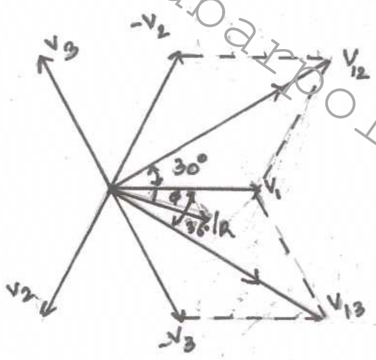
<tr><td>X</td><td>b.</td><td>
</td><td>3</td><td></td></tr>
<tr><td></td><td></td><td>When switch move to the position one wattmeter reads as
$W_1 = V_{13}\ I_1 \cos(30- Ø)$.
When switch move to the position two the wattmeter reads as
$W_2 = V_{12}\ I_1\cos(30+ Ø)$.
$V_{12} = V_{13} = V_{23} = V_L$
$W_1+W_2 = V_L\ I_L(\cos(30- Ø) + \cos(30+ Ø))$.
$= \sqrt{3}\ V_L\ I_L\cos Ø$.
The sum of readings when wattmeter moves from position one to two gives the total active power consumed by the three phase load.
But the three phase system should be in balanced condition.</td><td>2</td><td></td></tr>
<tr><td></td><td></td><td>
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