Answer Key and SCHEME OF VALUATION
(Scoring Indicators)

Revision:2015
Course Title: Fundamentals of Ac Systems
Course code:3033

Qst. No.	Scoring Indicator	Split-up Score	Total
	Part-A		
I			
1.	form factor = $\frac{\text{rms value}}{\text{average value}}$ = 1.11	2	
2.	Instantaneous value :- The strength of an alternating quantity existing in a circuit at a given instant.	2	
3.	Q-factor = voltage magnification in the series circuit at resonance = X_L/R	2	10
4.	$V_L = V_{ph}$, $I_L = \sqrt{3} I_{ph}$.	1+1	
5.	(1) static capacitors (2) Synchronous condensors (3) Phase advancer. (any two)	1+1	
	Part-B		
II 1.	Advantages of ac systems		
	1. ac power generation at HV is easy 2. ac power transmission at HV is easy 3. voltage canbe stepped up or down 4. ac machines are simple 5. Well suited for lamps 6. wireless technology is possible 7. Any required voltage canbe obtained 8. ac canbe converted to dc easily (Any six)	6×1	6
2.	Simple loop generator :-		

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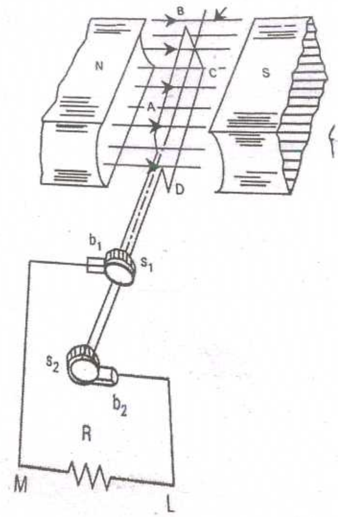
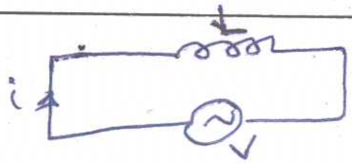
		3	
	* A simple coil or loop of wire is mounted on a shaft between two magnetic poles. Ends are connected to two slip rings. The brushes makeproper contact with rotating slip rings and lead the current to the external load. When the rotor is rotated the flux changes and emf is induced in the stationary conductors as per faraday's laws. The emf is alternating in nature.	3	6
3.	Power consumed in a pure inductor.		



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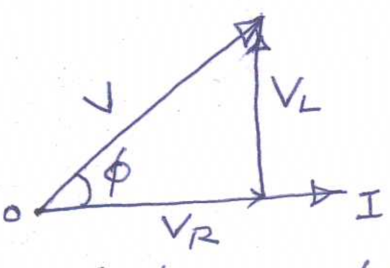
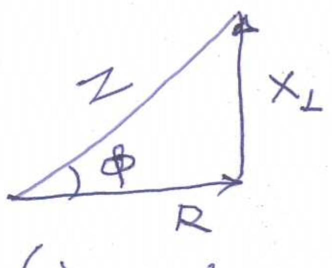
Qst. No.	Scoring Indicator	Split-up Score	Total
3.	$v = L\,di/dt$; $v = V_m \sin\omega t$ $\therefore L\,di/dt = V_m \sin\omega t$; $di = \frac{V_m}{L}\sin\omega t\,dt$ — ① integrating, eqn-① ⇒ $i = \frac{V_m}{L}\left(-\frac{\cos\omega t}{\omega}\right)$ ie $i = \frac{V_m}{\omega L}\sin(\omega t - 90)$ $= I_m \sin(\omega t - 90^\circ)$ | $I_m = \frac{V_m}{\omega L}$ when $\sin(\omega t - 90^\circ) = 1$	3	6
	∴ instantaneous, Power = Vi $p = V_m \sin\omega t \times I_m \sin(\omega t - 90^\circ)$; $\sin(\omega t - 90^\circ) = -\cos\omega t$ $= -\frac{V_m I_m}{2}\sin 2\omega t$ — ② Total power is obtained by integrating eqn-② for limits 0 to 2π the integral of double frequency is zero ∴ $P = 0$ Hence showed.	3	
4.	**R-L series circuit.** (phasor diagram) (impedance diagram)	2×1.5	6
	True power - $VI\cos\phi$	1.5	
	power factor, $\cos\phi = R/Z$ or $\cos\phi$ = True power/App.power	1.5	

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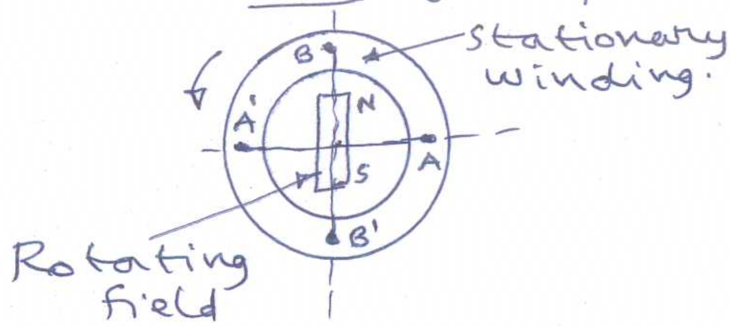
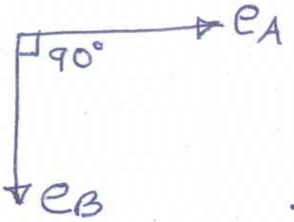
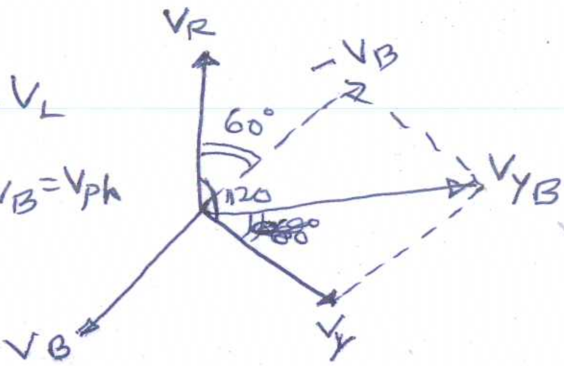
Revision:2015		Course code:3033	
Course Title: Fundamentals of Ac Systems			
Qst. No.	Scoring Indicator	Split-up Score	Total
5.	Generation of 2ϕ voltages  	2x1·5	
	Consider two coils AA' & BB' at right angles to each other. Depending on the angular position of magnetic field, emf's induced in the coils will be maximum or zero. $e_A = E_m \sin \omega t$; $e_B = E_m \sin(\omega t - 90°)$	3	6
6.	Relation between V_L and V_{ph} in star The line values are $V_{RY}, V_{YB}, V_{BR} = V_L$ Phase values, $V_R, V_Y, V_B = V_{ph}$ 	3	
	$V_{BR} = V_B + (-V_R)$ $V_{RY} = V_R - V_Y$ $= V_R + (-V_Y)$ $V_{YB} = V_Y + (-V_B)$ Applying Parallelogram rule, $V_{YB} = V_L = \sqrt{V_Y^2 + V_B^2 + 2 V_Y V_B \cos 60°}$ ie $V_L = \sqrt{V_{ph}^2 + V_{ph}^2 + 2 V_{ph} \cdot V_{ph} \times 1/2}$	3	6

$= \sqrt{3 V_{ph}^2} = \sqrt{3} V_{ph}$.

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Qst. No.	Scoring Indicator	Split-up Score	Total
7.	Effect of Load p.f on Wattmeter readings in 2-wattmeter method R-L Load $W_1 = V_L I_L \cos(30-\phi)$ $W_2 = V_L I_L \cos(30+\phi)$		
	(i) when p.f = 1 ; $\cos\phi = 1$; $\phi = \cos^{-1} 1 = 0$ $W_1 = V_L I_L \cos 30 = \sqrt{3}/2 \, V_L I_L$ $W_2 = V_L I_L \cos 30 = \sqrt{3}/2 \, V_L I_L$ = half of total Load power	2	6
	(ii) when p.f = 0.5 ; $\phi = \cos^{-1} 0.5 = 60°$ $W_1 = \sqrt{3}/2 \, V_L I_L$ $W_2 = V_L I_L \cos 90° = 0$ //	2	
	(iii) when p.f = 0 ; $\phi = \cos^{-1} 0 = 90°$ $W_1 = 1/2 \, V_L I_L$ $\because \cos(-60) = 1/2$ $W_2 = -1/2 \, V_L I_L$ $\because \cos(120) = -1/2$ Equal but of opposite sign	2	
	Part-C UNIT-I		
III	(a) Equation of alternating voltage flux linkages $= N\phi = N\phi_m \cos\theta$ $\theta = \omega t$ By faraday's Laws, $e = -N \frac{d\phi}{dt}$ ie $e = -N \frac{d}{dt}(\phi_m \cos \omega t)$ $= N\omega\phi_m \sin\omega t$ ——— (1)	4	7
	but $e = E_{max}$, when $\omega t = 90°$	3	

or $E_{max} = N\omega\phi_m$.
$\therefore$ Eqn-(1) $\Rightarrow$ $e = E_m \sin\omega t$

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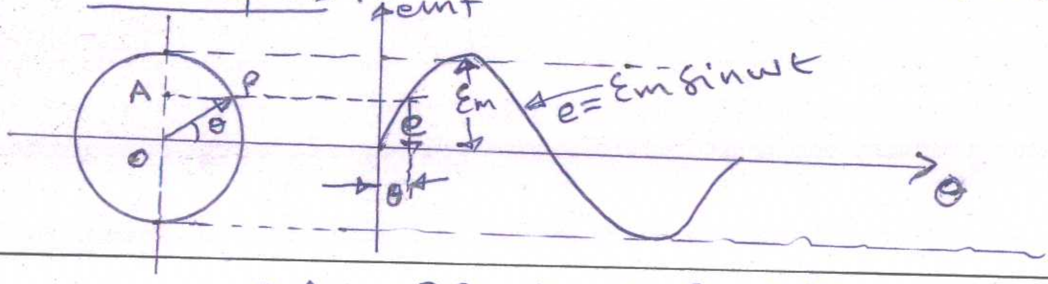
Revision:2015 Course Title: Fundamentals of Ac Systems		Course code:3033	
Qst. No.	Scoring Indicator	Split-up Score	Total
III	(b) (a) Maximum value is the Peak value either positive or negative	2	
	(b) Average value :- That steady (dc) current which transfers across any circuit the same amount of charge as is transferred by that alternating current during the same time	2	
	(c) frequency :- No. of cycles per second	2	
	(d) RMS value :- That steady (dc) current which when flowing through a given circuit for a given time produces the same amount of heat as produced by the alternating current when flowing through the same circuit for the same time.	2	8
	OR		
IV	(a) Representations of alternating quantity. ① By equations : ① Alternating voltage $e = E_m \sin\theta = E_m \sin\omega t$ (2) current, $i = I_m \sin\theta = I_m \sin\omega t$ where $\omega = 2\pi f$	2	
	② By Graphs: 	3	

$OA = OP\sin\theta$ or $e = OP\sin\theta = E_m \sin\theta$

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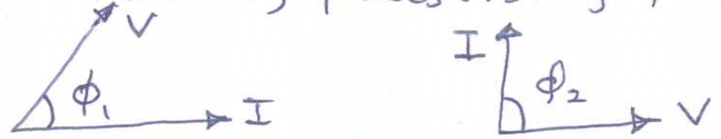
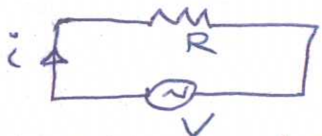
(Scoring Indicators)

Revision:2015

Course Title: Fundamentals of Ac Systems

Course code:3033

Qst. No.	Scoring Indicator	Split-up Score	Total
IV(a)	③ By Phasors :- Vectors are called phasors. Alternating voltage and current canbe represented by phasors. eg. phaser diagrams,  (I lags V) (I leads V)	2	7
IV (b)	$P = 30 + j52$, $Q = -39.5 - j14.36$ $P - Q = 30 + j52 - (39.5 + j14.36)$ $= 69.5 + j66.36$	2	
	(a) Polar form :- slope of $P-Q = \theta = \tan^{-1}\left(\frac{66.36}{69.5}\right) = 43.68°$ Magnitude $= \sqrt{69.5^2 + 66.36^2}$ $= 96.093$	3	8
	∴ Polar form is $96.093 \angle 43.68°$	1	
	(b) Exponential form is $96.093\, e^{j43.68}$	1	
	(c) Trigonometric form is $96.093(\cos 43.68 + j \sin 43.68)$	1	
	UNIT-II		
V (a)	Power through a Pure resistance  $v = V_m \sin \omega t$, $i = I_m \sin \omega t$ $P = vi = V_m \sin \omega t \cdot I_m \sin \omega t = V_m I_m \sin^2 \omega t$ $= V_m I_m \left(\frac{1 - \cos 2\omega t}{2}\right) = \frac{V_m I_m}{2} - \frac{V_m I_m \cos 2\omega t}{2}$	4	

total Power is obtained by integrating eqn-1 with limit 0 to 2π —①

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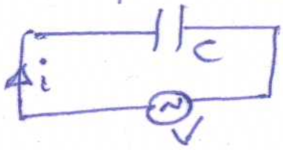
Revision:2015 | Course code:3033

Course Title: Fundamentals of Ac Systems

Qst. No.	Scoring Indicator	Split-up Score	Total
V(a)	But the integral of second term (double freq.) with 0 to 2π limit is zero. $\therefore P = \frac{V_m I_m}{2} = \frac{V_m}{\sqrt{2}} \times \frac{I_m}{\sqrt{2}} = V_{rms} \cdot I_{rms}$	3	7
V	(b) $R = 6\Omega$, $L = 0.03H$, $V = 50V$, $f = 60Hz$ $X_L = 2\pi f L = 2\pi \times 60 \times 0.03 = 11.31\Omega$ $Z = \sqrt{R^2 + X_L^2} = \sqrt{6^2 + 11.31^2} = 12.8\Omega$	2	
	(a) $I = \frac{V}{Z} = \frac{50}{12.8} = 3.906A$ (b) $P.f = \frac{R}{Z} = 0.468$ (lag)	2	
	(c) Volt-ampere $= VI = 50 \times 3.906 = 195.3$ VA	1	
	(d) Reactive power $= VI \sin\phi$ $\phi = \cos^{-1}(0.468) = 62.09°$ $\therefore VI \sin\phi = 50 \times 3.906 \times \sin 62.09 = 172.58$ VAR	2	
	(e) Power consumption $= VI \cos\phi = 91.547W$	1	
	OR		
VI	(a) Power consumed in a pure capacitor  v, q, C ; $v = V_m \sin \omega t$ $q = Cv$; $v = q/C$	2	
	$V_m \sin \omega t = q/C$; $i = \frac{dq}{dt}$ or $i = C \frac{d}{dt}(V_m \sin \omega t) = \omega C V_m \cos \omega t$ $i = I_m \sin(\omega t + 90°)$	2	8
	Power $= vi = V_m \sin \omega t \times I_m \cos \omega t$ $= \frac{1}{2} V_m I_m \sin 2\omega t$ — (1)	2	
	$\therefore$ Total power $= \int_0^{2\pi} \frac{1}{2} V_m I_m \sin 2\omega t$	2	

$= 0$, since integral of double frequency component is zero

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Revision:2015 | Course code:3033
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Qst. No.	Scoring Indicator	Split-up Score	Total
VI (b)	Series Vs Parallel resonant circuits		

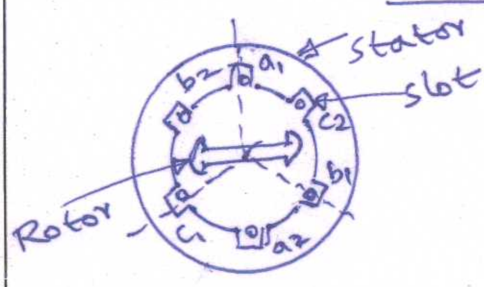
Parameters	Series ckt.	Parallel ckt
① Resonant freq.	$\frac{1}{2\pi\sqrt{LC}}$	$\frac{1}{2\pi}\sqrt{\frac{1}{LC}-\left(\frac{R}{L}\right)^2}$
② impedance at resonance	minimum	Maximum
③ current at resonance	Maximum	Minimum
④ p.f at resonance	unity	unity
⑤ Effective imped.	$Z = R$ (low)	$Z = \frac{L}{CR}$ (high)
⑥ Magnifies	voltage	current
⑦ Reactive components	$X_L = X_C$	$B_L = B_C$
⑧ Q-factor	$\frac{1}{R}\sqrt{L/C}$	$\frac{1}{R}\sqrt{L/C}$

7×1 — 7

Any seven, 7×1 = 7

UNIT – III

VII (a) Generation of 3ϕ voltages



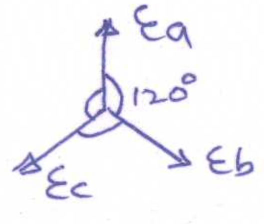


fig. → 3

emfs induced in the respective coils as the rotor rotates. The phase sequence is a-b-c. emf is zero in one coil but positive or negative in the other coils at an instant. } 3 — 7

$e_{a1} = E_m \sin\omega t$; $e_{b1} = E_m \sin(\omega t - 120°)$ } 1
$e_{c1} = E_m \sin(\omega t - 240°)$

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Revision:2015 Course code:3033
Course Title: Fundamentals of Ac Systems

Qst. No.	Scoring Indicator	Split-up Score	Total
VII	(b) 1 star connected		
	$R_{ph} = 8\Omega$ $X_{ph} = 6\Omega$, $V_L = 230V$		
	$V_{ph} = 230/\sqrt{3}$; $Z_{ph} = \sqrt{8^2+6^2} = 10\Omega$	1	
	$I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{230}{\sqrt{3}\times 10} = 13.28A$	1	
	(a) $I_L = I_{ph} = 13.28A$	1	
	(c) power factor, $\cos\phi = \frac{R_{ph}}{Z_{ph}} = \frac{8}{10} = 0.8$ (lag)	2	8
	(b) active power $= \sqrt{3} V_L I_L \cos\phi$ $= \sqrt{3}\times 230\times 13.28\times 0.8$ $= 4232W$	1.5	
	(d) apparent power $= \sqrt{3} V_L I_L$ $= \sqrt{3}\times 230\times 13.28$ $= 5290.4VA$	1.5	
	OR		
VIII	(a) Advantages of Polyphase system		
	① Power delivered is constant		
	② power output is 1.5 times more than 1ϕ output power		
	③ 3ϕ motors are self-starting		
	④ More efficiency		
	⑤ More power factor		
	⑥ Rotating magnetic field can be set-up.		
	⑦ More reliable		
	⑧ parallel operation is simple	4×1	4
	⑨ (Any four) - 4×1		

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Revision:2015

Course Title: Fundamentals of Ac Systems

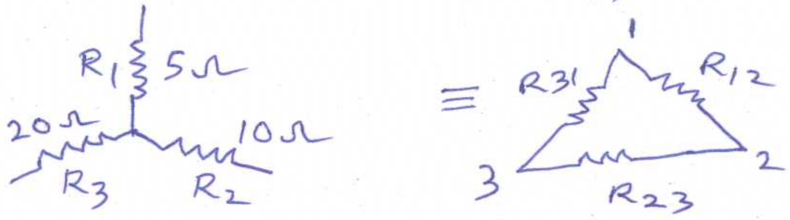
Course code:3033

Qst. No.	Scoring Indicator	Split-up Score	Total
VIII	(b) Comparisons of star and delta (Any five)	5x1	5

Star	Delta
1. Better for 3ϕ, 4 wire distribution	Better for 3ϕ transmission
2. Neutral available	Not available
3. $I_L = I_{ph}$	$I_L = \sqrt{3} I_{ph}$
4. $V_L = \sqrt{3} V_{ph}$	$V_L = V_{ph}$
5. Power $= \sqrt{3} V_L I_L \cos\phi$	$\sqrt{3} V_L I_L \cos\phi$
6. $\angle I_L, V_L$ $30 \pm \phi$	$30 \pm \phi$
7. Line currents (or phase currents) are $120°$ apart	V_L or V_{ph} - $120°$ apart
8. I_L are $30°$ behind I_{ph}	V_L are $30°$ ahead of V_{ph}.

(Any five) 5x1

VIII (c)



Equivalent delta values,

Scoring Indicator	Split-up Score	Total
$R_{12} = R_1 + R_2 + \frac{R_1 R_2}{R_3} = 5 + 10 + \frac{5 \times 10}{20} = 17.5\,\Omega$	2	6
$R_{23} = R_2 + R_3 + \frac{R_2 R_3}{R_1} = 10 + 20 + \frac{10 \times 20}{5} = 70\,\Omega$	2	
$R_{31} = R_1 + R_3 + \frac{R_1 R_3}{R_2} = 5 + 20 + \frac{5 \times 20}{10} = 35\,\Omega$	2	

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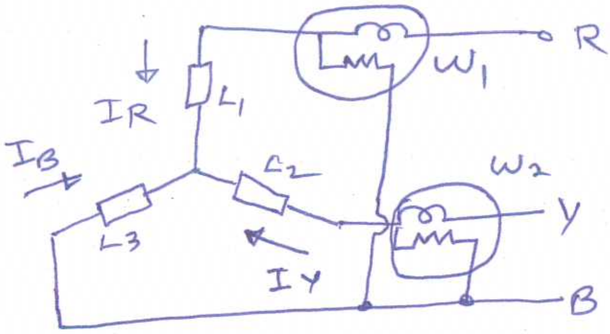
Revision:2015
Course Title: Fundamentals of Ac Systems
Course code:3033

Qst. No.	Scoring Indicator	Split-up Score	Total
	UNIT – IV		
IX	(a) Two wattmeter method	3	
	 Let, $i_R \rightarrow$, $i_Y \rightarrow$, e_{RB}, e_{YB}		
	$w_1 = i_R(e_R - e_B)$, $w_2 = i_Y(e_Y - e_B)$ $w_1 + w_2 = i_R e_R + i_Y e_Y - e_B(i_R + i_Y)$ —(1) but $i_R + i_Y + i_B = 0$ $i_R + i_Y = -i_B$ eqn-1 → $w_1 + w_2 = i_R e_R + i_Y e_Y + i_B e_B$ $= P_R + P_Y + P_B$ = total power.	4	7
	(b) $20 + j20\ \Omega$ delta system $R_{ph} = 20\Omega$, $X_{ph} = 20\Omega$, $V_{ph} = V_L = 440V$ $Z_{ph} = \sqrt{20^2 + 20^2} = 28.284\ \Omega$	1	
	(a) Line current, $I_{ph} = V_{ph}/Z_{ph} = \frac{440}{28.284} = 15.56A$	1	
	$\therefore I_L = \sqrt{3} I_{ph} = 26.94A$	1	
	(b) Power factor $\cos\phi = \frac{R_{ph}}{Z_{ph}} = \frac{20}{28.284} = 0.707$ (lag)	2	8
	(c) $\phi = \cos^{-1}(0.707) = 45°$ (lag)	1	
	$\therefore W_1 = V_L I_L \cos(30 - \phi) = 11450W$	1	
	$W_2 = V_L I_L \cos(30 + \phi) = 3068W$	1	

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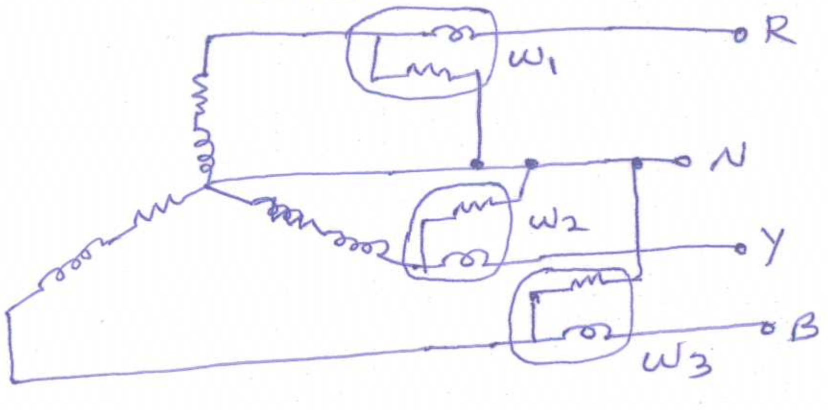
(Scoring Indicators)

Revision:2015 | Course code:3033

Course Title: Fundamentals of Ac Systems

Qst. No.	Scoring Indicator	Split-up Score	Total
X	(a) OR Three wattmeter method		



Total power $= W_1 + W_2 + W_3$

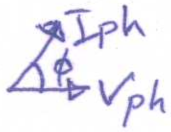
		Split-up Score	Total
	figure	3	6
	Explanation	3	

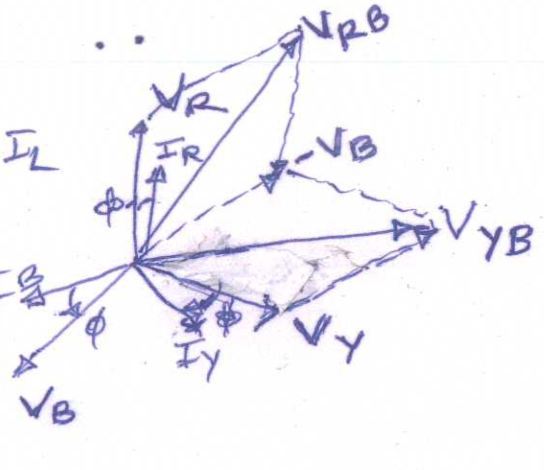
(b) Power factor in 2-wattmeter method

Consider a balanced star system

Let, $V_R, V_Y, V_B = V_{ph}$

$I_R, I_Y, I_B = I_{ph} = I_L$





I_R - current in W_1

I_Y - current in W_2

$V_{RB} = V_R - V_B = V_R + (-V_B)$ across W_1

$V_{YB} = V_Y - V_B = V_Y + (-V_B)$ - W_2