A

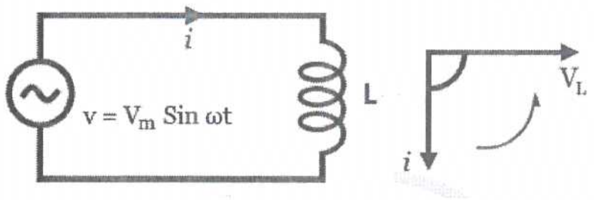
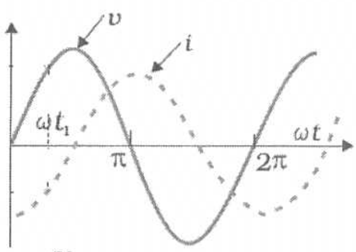
27

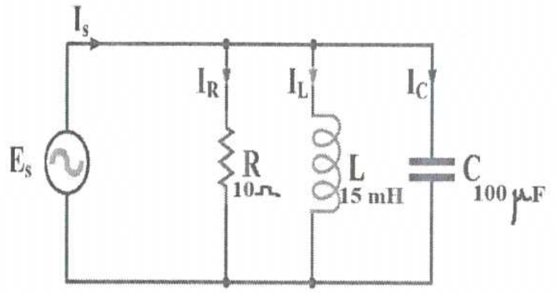
SL NO. 1/Sem3/033

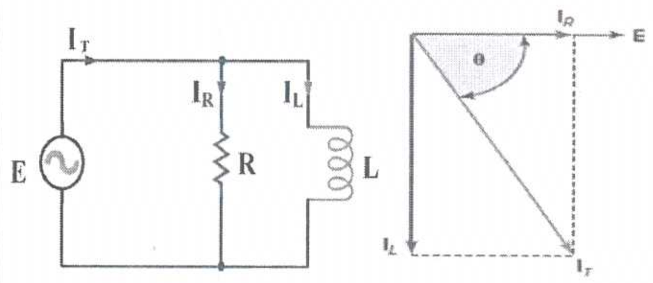
Scoring Indicators

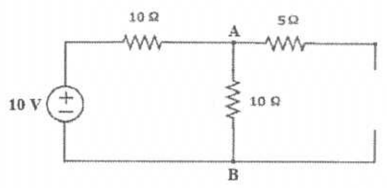
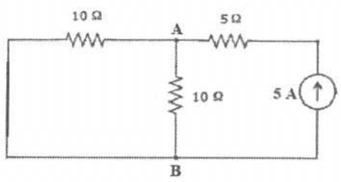
FUNDAMENTALS OF ELECTRIC CIRCUITS

Q No	Scoring Indicators	Split score	Sub Total	Total Score
	PART A			**9**
I.1.	Voltage source, current source			
I. 2.	c. Current source in parallel with a resistor			
I. 3.	*3.6 ∟56.3°*			
I. 4.	$X_L = X_C$			
I. 5.	$P = VI \sin \phi$			
I. 6.	Vector method, admittance method, phasor algebra, equivalent impedance method **Any one method – 1 mark**			
I. 7.	Admittance			
I. 8.	Star connection or Delta connection			
I. 9.	$I_L=\sqrt{3}\, I_{ph}$			
	PART B			**24**
II. 1.	***Steps --- 3 marks***			
	✓ Remove the load resistance ✓ Determine the open circuit voltage (V_{OC})across the open circuit terminals ✓ Deactivate the energy sources (voltage source by short circuit & for current source by an open circuit) and find the internal resistance (R_{Th}) of the source side looking through the open circuited load terminals ✓ Obtain the Thevenin's equivalent circuit by connecting V_{OC} in series with R_T			

	✓ Reconnect the load resistance across the load terminals.			
II. 2.	***Statement – 3 marks***		**3**	
	In a linear bilateral network, if a voltage source V in a branch 'a' produces a current I in branch 'b' then if the same voltage source is removed and inserted in branch 'b' it will produce a current I in the branch 'b'. In other words, V and I are interchangeable			
II. 3.	***Polar form- 1.5 marks*** ***Rectangular form – 1.5 marks***	**1.5 +1.5**	**3**	
	A/B = (4+j3)/(5+j6) = $\frac{5\angle 36.87^\circ}{7.8\angle 50.19^\circ}$ **=** **<u>0.64∠-13.32°</u>** **In Rectangular form** **<u>0.623 – j 0.147</u>**			
II.4	***Explanation – 2 marks*** ***Waveform / Vector diagram – 1 mark***	**2+1**	**3**	
	  $v = L\frac{di}{dt} = V_m \sin\omega t$ $i = \frac{V_m}{L}\int \sin\omega t$ $i = -\frac{V_m}{\omega L}\cos\omega t$ $i = I_m \sin\left(\omega t - \frac{\pi}{2}\right)$ (current lags by 90°)			
II.5.	***Condition – 1 mark*** ***Steps – 1 mark***	**1+1+1**	**3**	

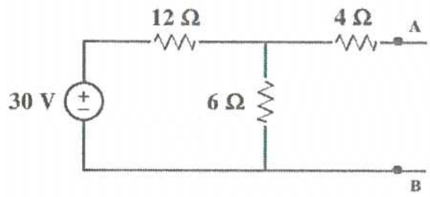
	Final equation – 1 mark			
	At resonance $X_L = X_C$ $L\omega_r = \frac{1}{\omega_r C}$ $\omega_r^2 = \frac{1}{LC}$ $\omega_r = \frac{1}{\sqrt{LC}}$ $2\pi f_r = \frac{1}{\sqrt{LC}}$ $f_r = \frac{1}{2\pi\sqrt{LC}}$			
II.6.	*Current in each branches – 3 * 1 mark each*	1+1+1	3	
	 R = 10 Ω XL = 2πfL = 4.71 Ω = j4.71 XC = $\frac{1}{2\pi f C}$ = 31.84 Ω = -j31.84 I_R= 200/10 = **20 A** I_L = 200/j4.71 = 200/(4.71∟90°) = **42.46 ∟-90° A** I_C = 200/-j31.84 = 200/(31.84∟-90°)= **6.28∟90° A**			
II.7.	*Equation – 1 mark* *Steps – 1mark* *Final Answer – 1 mark*	1+1+1		
	$f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$ = **197 Hz** ***Neglecting the resistance, f_r may be found also as*** $f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$ =**197.4 Hz** ***Any one method may be followed***			
II.8.	*Circuit – 1mark* *Vector diagram – 2 marks*	1+2	3	

				
II.9.	***Any 3 advantages – 3 x 1 mark each***	**1 +1+1**	**3**	
	1. To transmit a specific power over a specific distance at a given rated voltage, a three-phase system needs less conductor material as compared to the single-phase system. 2. The size of a three-phase system operated machine is less than the machine operated at single phase voltage having the same output rating. 3. In a three-phase power supply system, the less voltage drop occurs from source to the load points, 4. A three-phase supply produces uniform rotating magnetic field therefore, three phase motors are simpler in construction, small in size and can be started automatically with smooth operation. 5. A polyphase system produces power at a constant rate in the load. 6. A three-phase system can transmit more power as compared to a single-phase system. 7. The efficiency of three phase operated devices and appliances is higher than the single-phase operated machines. 8. Three phase machines are less costly and more efficient.			

	9. A three-phase system provides constant power while a single-phase system provides pulsating power which leads to a smooth and vibration free operation of a 3-Φ machine as compared to the 1-Φ machines with noise and vibration. 10. A three-phase supply can be easily converted to a single-phase supply 11. Three phase motors are self-starting while single phase motors are not			
10	***Active Power – 1mark*** ***Reactive Power – 1mark*** ***Apparent Power – 1mark***	**1.5 + 1.5**	**3**	
	$P_{active} = 3\ V_{ph}I_{ph}\cos\phi$ or $\sqrt{3}\ V_LI_L\cos\phi$ $P_{reactive} = 3\ V_{ph}I_{ph}\sin\phi$ or $\sqrt{3}\ V_LI_L\sin\phi$ Apparent Power $= 3\ V_{ph}I_{ph}$ or $\sqrt{3}\ V_LI_L$			
	PART C			**42**
III	***Steps – 3 march each(3*2= 6 marks)*** ***Total Current – 1mark***	**6+1**	**7**	
	10 V acting alone (case 1)  **5A source acting alone (case 2)**  In case 1, current through AB = 10/(10+10) =10/20 = 0.5 A In case 2 current through AB = 5 * $(\frac{10}{10+10})$ = 2.5 A Total current due to the effect of two sources **= 0.5 A+ 2.5 A = 3 A**			
IV	***Calculation of V_{th} – 3 marks***	**3+2+2**	**7**	

Calculation of R_{th} – 2 marks
Final Answer – 2 mark

Step 1: Remove the load resistor 2 ohm and name the terminals as AB



Step 2: Calculate the open circuit voltage V_{AB}

V_{AB} is the voltage across 6 Ω.

The total resistance = 12 Ω + 6 Ω = 18 Ω.

Using Ohms law, I = V/R = 30/18 = 5/3 Ω

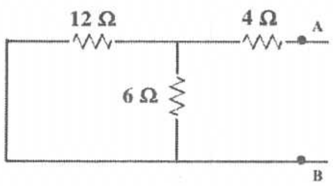
Voltage across 6 Ω = I*R = $\frac{5}{3}$* 6 = 10 V

Thus $\underline{\mathbf{V_{AB} = V_{Th} = 10\ V}}$

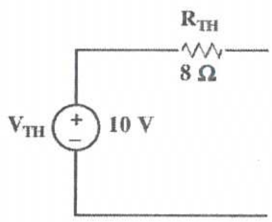
Step 3: Calculate Rth looking from the terminals AB. To find Rth replace voltage source by a short circuit and current source by an open circuit.

R_{Th} =(12 Ω parallel to 6 Ω) in series with 4 Ω

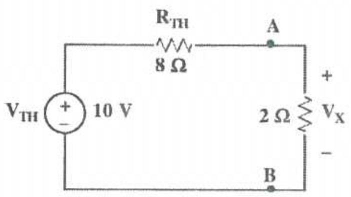
$$\mathbf{R_{Th}} = \frac{12*6}{12+6} + 4 = \underline{8\ \Omega}$$



Step 4: Draw the Thevenins equivalent circuit

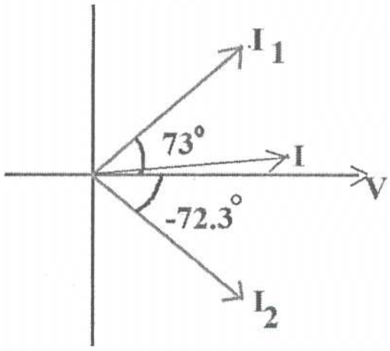


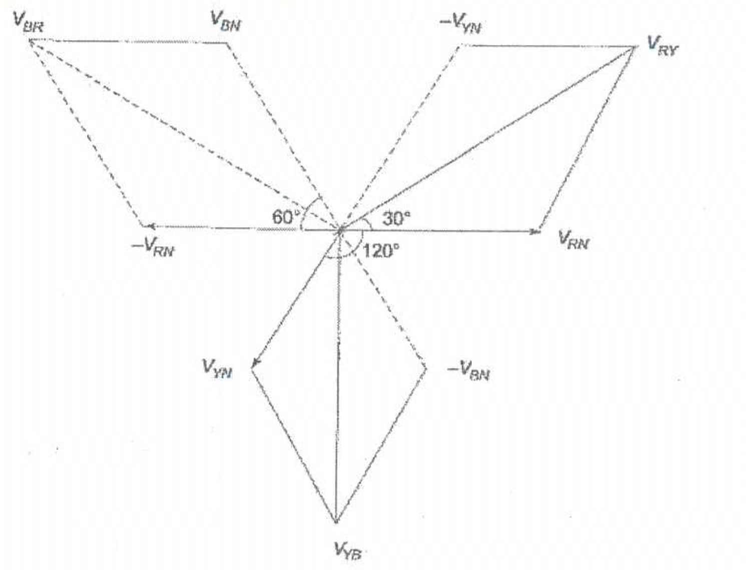
Step 5: Reconnect the load resistor ie, 2Ω back to the circuit and redraw the circuit

	 Now current in the circuit is, I = V/ R The total resistance is 8 Ω + 2 Ω = 10 Ω I = 10/10 = 1 Amp Thus, voltage drop in 2 ohm resistor is **V= I*R = 1*2 =<u>2 Volts</u>**			
V	***Theorem – 3 marks*** ***Steps – 4 marks***	3+4	7	
	<u>Theorem:</u> Any two terminal linear active network (containing independent voltage and current sources), may be replaced by a constant current source IN in parallel with a resistance RN, where IN is the current flowing through a short circuit placed across the terminals and RN is the equivalent resistance of the network as seen from the two terminals with all sources replaced by their internal resistance. **<u>Steps:</u>** i. Open the two terminals between which we need to find Norton's equivalent circuit ii. Short the load resistor. iii. Calculate the Short Circuit Current. This is the Norton Current (I_N). iv. Open Current Sources, Short Voltage Sources and Open Load Resistor. v. Calculate /measure the Open Circuit Resistance. This is the Norton Resistance (R_N). vi. Now, Redraw the circuit with measured short circuit Current (I_N) in Step (2) as Current			

	Source and measured open circuit resistance (R_N) in step (4) as a parallel resistance vii. Reconnect the load resistor which we had removed in Step (3). This is the Equivalent Norton Circuit viii. Now find the Load current and Load Voltage by using the Current divider rule.			
VI	***Maximum Power transfer theorem- 3.5 marks*** ***Superposition theorem – 3.5 marks***	**3.5+** **3.5**	7	
	Maximum Power transfer theorem For any power source, the maximum power transferred from the power source to the load is when the resistance of the load RL is equal to the equivalent or input resistance of the power source (Rin = RTh or RN). ***Superposition theorem*** **Superposition theorem** states that in any linear, active, bilateral network having more than one energy source, the response in any element is the sum of the responses obtained from individual source considered separately and all other sources are replaced by their internal resistance			
VII	***Current – 3 marks*** ***Voltage across R and L – 2 marks*** ***Power dissipated – 2 marks***	**2+1 +** **2+2**	7	
	R = 10 Ω L= 0.2 H V = 230 V, f = 50 Hz XL = 2πfL = 62.82 Ω Z = $\sqrt{R^2 + {X_L}^2}$ = 63.61 Ω I = V/Z = 230/63.61 = **3.61 A** Power factor, cos ϕ = R/Z = 10/63.61 = 0.157			

	P.d across R = IR = 3.61 * 10 = **36.1 V** P.d across L = IX_L = 3.61* 62.82 = **226.78 V** Power dissipated = VIcosϕ = 230*3.61*0.157 = **130.36 W**			
VIII	***Current – 4 marks*** ***Power factor – 3 marks***	3+4	7	
	Impedance = 8 -j6 = 10∟-36.8° **Voltage = 150 + j120 =192.1∟38.7°** **I = V/Z** $= \frac{192.1∟38.7°}{10∟-36.8°}$ = **19.21∟75.5°** **Power factor = cos ϕ = cos (75.5°) = 0.25**			
IX	***Current - 4 marks*** ***Power factor - 3 marks***	4+3	7	
	Z1 = 10 + j5 and Z2 = 25 – j10 Y1 = 1/(10 + j5) = 1/(11.18∟26.56°) = 0.089 ∟-26.56° Y 2 = 1/(25 – j10) =1/(26.93∟-21.8°) = 0.037 ∟21.8° Y = Y1 + Y2 **Y = 0.089 ∟-26.56° + 0.037 ∟21.8°** **= 0.08 – j 0.04 + 0.034 + j 0.014** = 0.114 - j0.026 = **0.117∟-12.9°** I = VY = 100∟0 * 0.117∟-12.9° = **11.7 ∟-12.9°** Power factor = cos(-12.9)= **0.9747**			
X	***Current in each branch – 2 marks each – 4 marks*** ***Vector diagram – 3 marks***	4+1+2	7	
	Branch 1 R = 10 Ω Xc = $\frac{1}{2*\pi*50*100*10^{-6}}$ = 31.83 Ω Z_1 = 10 -j31.83 **I_1 = V/Z_1** **= (230+j0)/(10 -j31.83)** $= \frac{230\angle 0°}{33.364\angle -73°} = 6.89\angle 73°$			

	Branch 2 $R = 10\ \Omega$ $X_L = 2*\pi * 50 * 0.1 = 31.42\ \Omega$ $Z_2 = 10 + j31.42$ $\mathbf{I_2 = V/Z_2}$ $\mathbf{= (230 + j0)/(10 + j31.42)}$ $= \frac{230\angle 0°}{32.97\angle 72.3°} = \mathbf{6.89\angle -72.3°}$ 			
XI	***Phasor diagram – 2 mark*** ***Steps -3 marks*** ***Final relation – 2 marks***			
	Let $V_{RN} = V_{YN} = V_{BN} = V_{ph}$ are the phase values of voltage Let $V_{RY} = V_L$ be the line value of voltage By parallelogram law method, $V_{RY} = \sqrt{V_{ph}^2 + V_{ph}^2 + 2V_{ph}\cos 60°}$ $V_L = \sqrt{3V_{ph}^2}$ **$\underline{V_L = \sqrt{3} * V_{ph}}$**			



XII

Any 5 features – 7 marks

Star Connection	Delta Connection
It is a 4 – wire connection (4th wire is optional in some cases)	A Delta Connection is a 3 – wire connection.
In a Star Connection, one end of all the three wires are connected to a common point in the shape of Y, such that all the three open ends of the three wires form the three phases and the common point forms the neutral.	In a Delta Connection, every wire is connected to two adjacent wires in the form of a triangle (Δ) and all the three common points of the connection form the three phases.
The Common point of the Star Connection is called Neutral or Star Point.	There is no neutral in Delta Connection
Line Voltage and Phase Voltage is different.	Line Voltage and Phase Voltage are same.
Line Voltage is root three times phase voltage i.e. $VL = \sqrt{3}\ V_{ph}$.	Line Voltage is equal to Phase Voltage i.e. $V_L = V_{ph}$.
$I_L = I_{ph}$. Here, IL is line current and IP is phase current.	In Delta connection, $I_L = \sqrt{3}\ I_{ph}$
Since Line Voltage and Phase Voltage are different ($VL = \sqrt{3}\ V_{ph}$),	In a Delta Connection, the Line and Phase Voltages are same and hence, more

<table>
<tr><td></td><td><table><tr><td>the insulation required for each phase is less in a Star Connection.</td><td>insulation is required for individual phases.</td></tr></table></td><td></td><td></td><td></td></tr>
<tr><td>XIII</td><td>Impedance calculation –2 mark
Current – 2 marks
Power factor- 1 mark
Power consumed = 2 marks</td><td>2+2 +1+ 2</td><td></td><td></td></tr>
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$E_L = E_{ph} = 415$ V

$R = 45\ \Omega$

$X_L = = 2\pi fL = 62.8\ \Omega$

$\mathbf{Z_{ph}} = \sqrt{R_{ph}^{\ 2} + X_{ph}^{\ 2}} = \underline{77.23\ \Omega}$

$\mathbf{I_{ph} = E_{ph}/\ Z_{ph} = 415/77.23 = \underline{5.37\ A}}$

$\mathbf{I_L = \sqrt{3}\ \ I_{ph} = \sqrt{3} * 5.37 = 9.3\ A}$

$\mathbf{Pf = \cos\phi\ = R/Z = 45/77.23 = 0.\underline{582}}$

Power consumed = $\sqrt{3}\ E_L\ I_L \cos\emptyset$

$\underline{\mathbf{= 3895\ Watts}}$

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<tr><td>XIV</td><td>Figure – 1 mark
Calculation of resistor values- 2 marks each – 6 marks</td><td>1+6</td><td>7</td><td></td></tr>
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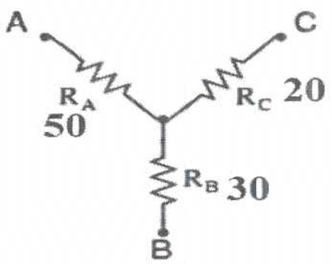

$R_{AB} = \frac{R_AR_B + R_AR_C + R_BR_C}{R_C}$

$R_{BC} = \frac{R_AR_B + R_AR_C + R_BR_C}{R_A}$

$R_{AC} = \frac{R_AR_B + R_AR_C + R_BR_C}{R_B}$

$R_{AB} = \frac{50*30+30*20+20*50}{20} = \underline{155\ \Omega}$

$R_{BC} = \frac{50*30+30*20+20*50}{50} = \underline{62\ \Omega}$

$R_{CA} = \frac{50*30+30*20+20*50}{30} = \underline{103.3\ \Omega}$

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