MANIPAL INSTITUTE OF TECHNOLOGY

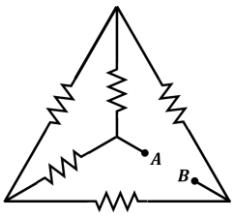
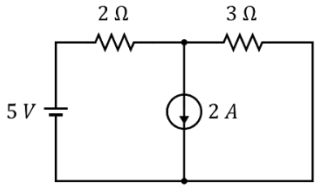
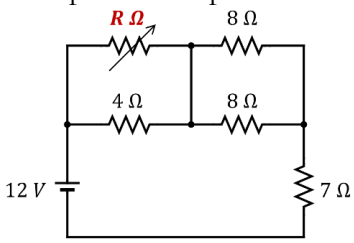
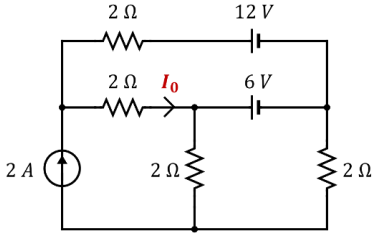
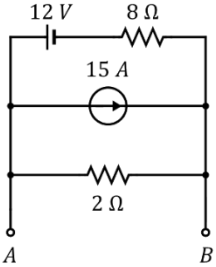
First Semester B. Tech. In-semester 1 October 2022

Subject: ELE 1071 – Basic Electrical Technology

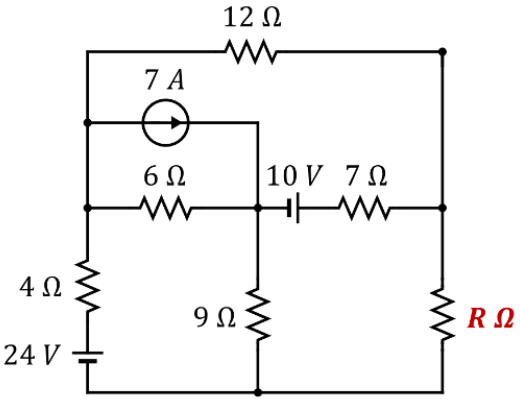
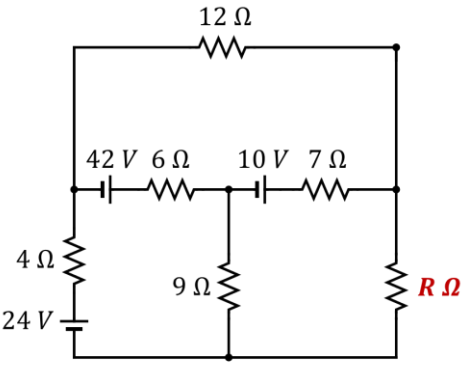
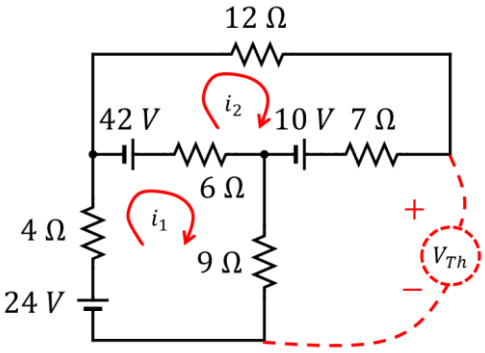
Thursday, October 20, 2022

Time: **2:30 PM – 3:30 PM** **Answer Scheme** Maximum Marks: **15**

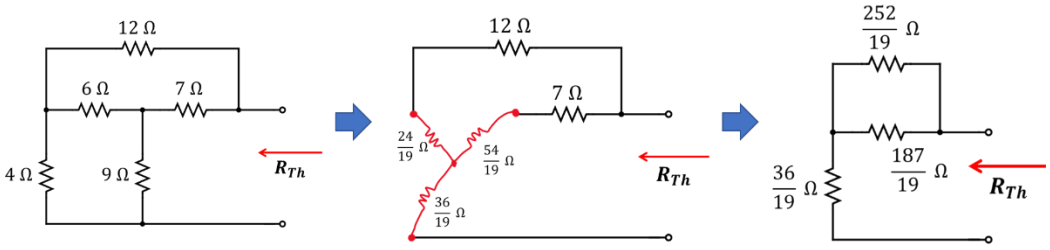
Part A

Q. No.		Marks	CO	BTL
1	With each resistance being 2 Ω, the equivalent resistance between the terminals A and B is:  **a) 2 Ω** b) 4 Ω c) 8 Ω d) 1 Ω	1	1	3
2	The 2 A current source is:  a) Delivering 1.2 W **c) Absorbing 1.2 W** b) Absorbing 0.6 W d) Delivering 0.6 W	1	1	4
3	The value of R so that maximum power dissipation takes place in 7 Ω resistor is:  a) 12 Ω **b) 0 Ω** c) 7 Ω d) 2 Ω	1	1	4
4	The current I_0 in the in the circuit when only 6 V source acting alone is:  **a) – 1.5 A** b) 1.5 A c) 3 A d) 1 A	1	1	4
5	A single voltage source in series with a resistance representation between open terminals A & B will be:  **a) -21.6 V & 1.6 Ω** c) -26.4 V and 1.6 Ω b) -30 V & 1.6 Ω d) 21.6 V & 0 Ω	1	1	3

Part B

Q. No.		Marks	CO	BTL
6	Obtain the value of **R** so that maximum power is dissipated in it. Also, determine the maximum power. What will be the power transfer efficiency if **R** is made **1.25** times the source (Thevenin's) resistance. 	4	1	4
Sol	The circuit can be simplified as,  -------- [0.5M] **To find V_{Th}:**  Finding i_1 and i_2 using inspection method, $$\begin{bmatrix} 19 & -6 \\ -6 & 25 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} 66 \\ -52 \end{bmatrix}$$ $$i_1 = \frac{1338}{439} = 3.0478\ \text{A} \quad \& \quad i_2 = \frac{-592}{439} = -1.3485\ \text{A}$$ -------- [1M] To find V_{Th}, apply KVL: $$(9)\left(\frac{1338}{439}\right) + 10 - (7)\left(\frac{592}{439}\right) - V_{Th} = 0$$ $$\Rightarrow \mathbf{V_{Th} = 27.9908\ V}$$ -------- [0.5M]			

To find R_{Th}: q



$$\Rightarrow \mathbf{R_{Th} = 7.5444\ \Omega}$$

-------- [1M]

Maximum power dissipated in **R** will be,

$$\mathbf{P_{max} = \frac{V_{Th}^2}{4R_{Th}} = 25.9623\ W}$$

-------- [0.5M]

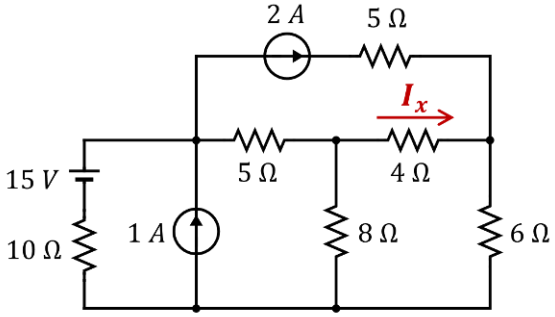
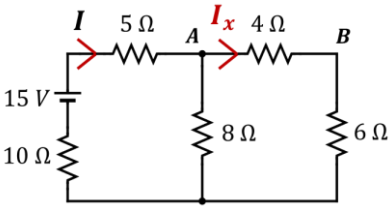
If R is made 1.25 R_{Th} = 9.4305 Ω, the power dissipated in R will be,

$$P_{R=1.25R_{Th}} = \left(\frac{V_{Th}}{R_{Th} + 1.25R_{Th}}\right)^2 (1.25R_{Th}) = \mathbf{25.6419\ W}$$

$$P_{Source,\ R_{Th}} = \left(\frac{V_{Th}}{R_{Th} + 1.25R_{Th}}\right)^2 (R_{Th}) = \mathbf{20.51\ W}$$

$$\textbf{Power transfer efficiency} = \frac{25.6419}{25.6451 + 20.51} \times 100 = 55.559\ \%$$

-------- [0.5M]

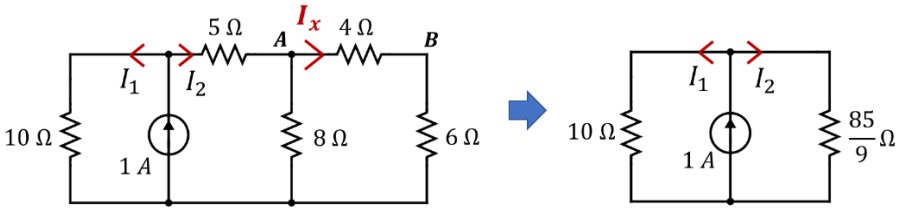
7	Using superposition principle, determine the current I_x as shown. 	3	1	3
Sol	**Current I_x due to 15 V source only:** 			

$$R_{eq} = (10 \,||\, 8) + 5 + 10 = \frac{175}{9}\ \Omega$$

$$I = \frac{15}{\left(175/9\right)} = \frac{27}{35} \qquad \text{Or} \qquad \mathbf{I_x|_{15\ V} = \frac{\left(\frac{27}{35}\right)(8)}{8+10} = 0.3429\ A\ (A\ to\ B)}$$

-------- [1M]

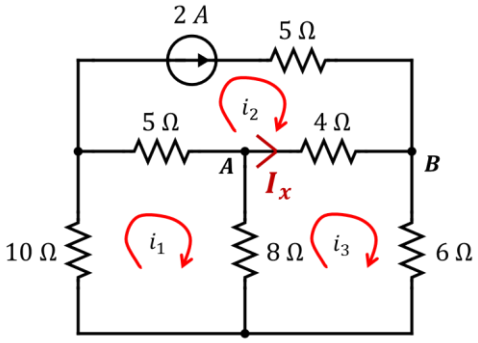
Current $\mathbf{I_x}$ due to 1 A source only:



$$I_2 = \frac{1 \times 10}{10 + \frac{85}{9}} = \frac{18}{35}\text{A} \qquad \text{Or} \qquad \mathbf{I_x|_{1\,A}} = \frac{\mathbf{(I_2)(8)}}{\mathbf{8+10}} = \mathbf{0.2286\ A\ (A\ to\ B)}$$

-------- [1M]

Current $\mathbf{I_x}$ due to 2 A source only:



Using mesh analysis to find the mesh currents,

$\mathbf{i_2 = 2}$ ... **eq. 1**

$-10i_1 - 5(i_1 - i_2) - 8(i_1 - i_3) = 0$

$\mathbf{-23i_1 + 5i_2 + 8i_3 = 0}$ ... **eq. 2**

$-8(i_3 - i_1) - 4(i_3 - i_2) - 6i_3 = 0$

$\mathbf{8i_1 + 4i_2 - 18i_3 = 0}$ ... **eq. 3**

Solving the equations,

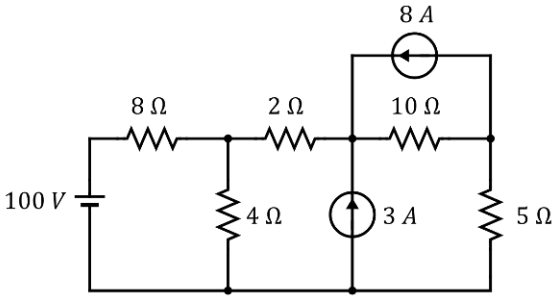
$$i_3 = \frac{132}{175} = 0.7542\ A \quad \text{Or} \quad \mathbf{I_x|_{2\,A} = i_3 - i_2 = -\frac{218}{175} = -1.2457\ A\ (A\ to\ B)}$$

-------- [1M]

As per superposition theorem,

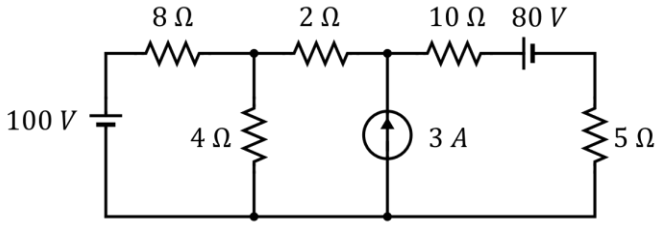
$I_x = \mathbf{I_x|_{15\,V}} + \mathbf{I_x|_{1\,A}} + \mathbf{I_x|_{2\,A}}$

$$\mathbf{I_x = \frac{12}{35} + \frac{8}{35} - \frac{218}{175} = -0.6742\ A}$$

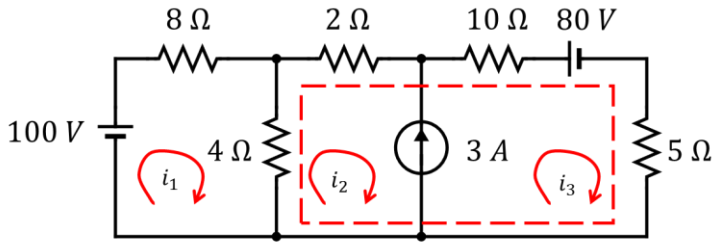
8	Find the current through **2 Ω** resistor and power supplied by **3 A** source in the circuit. 	**3**	**1**	**4**

Sol

Using source transformation, the circuit can be simplified as,



Applying mesh analysis,



-------- [0.5M]

From mesh 1,

$100 - 8i_1 - 4(i_1 - i_2) = 0 \quad \Rightarrow \mathbf{-12i_1 + 4i_2 = -100} \quad \ldots(\mathbf{eq.\ 1})$ -------- [0.5M]

From Supermesh,

$\mathbf{-i_2 + i_3 = 3} \quad \ldots(\mathbf{eq.\ 2})$ -------- [0.5M]

$-4(i_2 - i_1) - 2i_2 - 10i_3 - 80 - 5i_3 = 0 \quad$ Or $\quad \mathbf{4i_1 - 6i_2 - 15i_3 = 80} \quad \ldots(\mathbf{eq.\ 3})$

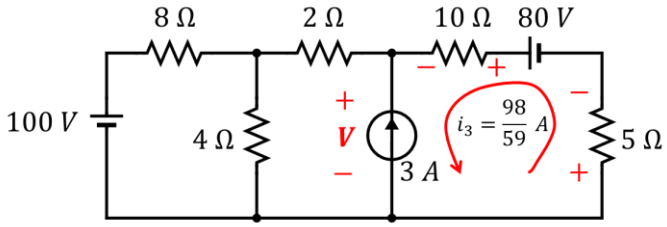
-------- [0.5M]

Solving the three equations,

$$i_1 = \frac{400}{59} = 6.7796\ A \quad \& \quad i_2 = \frac{-275}{59} = -4.6610\ A \quad \& \quad i_3 = -\frac{98}{59} = -1.6610\ A$$

Current through **2 Ω** resistor will be equal to $i_2 \Rightarrow \mathbf{I_{2\Omega} = -4.6610\ A}$ -------- [0.5M]

To find power supplied by **3 A** source in the circuit, assume a voltage of 'V' across the 3 A source:



To find the value of 'V', apply KVL in mesh 3:

$V + (10 + 5)i_3 - 80 = 0 \quad$ Or $\quad V = 80 - (15)\left(\frac{98}{59}\right) = \mathbf{55.0847\ V}$ -------- [0.5M]

Power supplied by 3 A source will be,

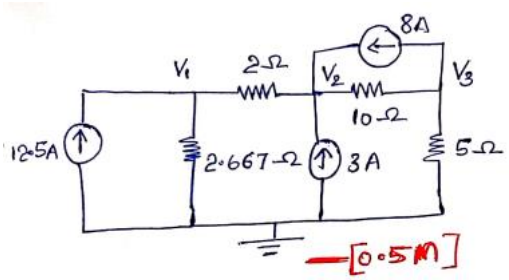
$\mathbf{P_{3A} = 55.0847 \times 3 = 165.2542\ W}$

Note:

Students may solve the problem using nodal analysis.

The scheme for it will be:

- **0.5M** for **100 V in series with 8 Ω** conversion to **12.5 A in parallel with 8 Ω.**
- **1.5M** for **writing nodal equations** taking the bottom node as the datum node.
- **0.5M** for calculation of **current through 2 Ω** based on voltages obtained above
- **0.5M** for calculating **power from 3 A** source using **V ∗ I**



[0.5M]

Node ①

$$-12.5 + \frac{V_1 - V_2}{2} + \frac{V_1}{2.6667} = 0$$

Node ②

$$-3 - 8 + \frac{V_2 - V_1}{2} + \frac{V_2 - V_3}{10} = 0$$

Node ③

$$8 + \frac{V_3 - V_2}{10} + \frac{V_3}{5} = 0$$

[1.5M]

Solving,

$V_1 = 45.763\ V$

$V_2 = 55.0851\ V$

$V_3 = -8.3049\ V$

$I_{2\Omega} = \frac{V_2 - V_1}{2} = 4.66105\ A$ from node ② to node ①

[0.5M]

$P_{3A} = V_2 * 3 = 165.255\ W$

[0.5M]