POSTAL Book Package 2023

ESE

Electronics Engineering

Conventional Practice Sets

Network Theory

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1 CHAPTER

Basics, Circuit Elements, Nodal & Mesh Analysis

Q.1 A 10 V battery with an internal resistance of 1 Ω is connected across a non-linear load whose *V-I* characteristics is given by $7I = V^2 + 2$ V. Find the current delivered by the battery.

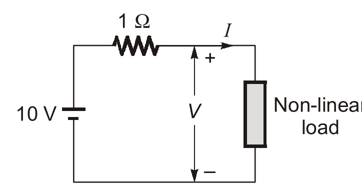
Solution:

Using KVL,

$$V + I = 10 \quad \text{...(i)}$$

Given,

$$7I = V^2 + 2\text{ V} \quad \text{...(ii)}$$



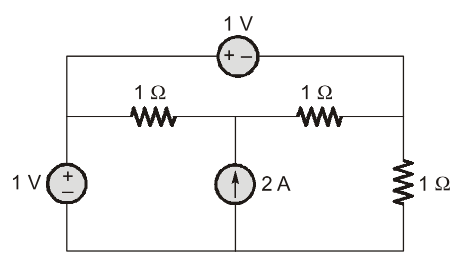
On solving equation (i) and equation (ii)

we get,

$$V = 5 \text{ Volts}$$

$$I = 5 \text{ A}$$

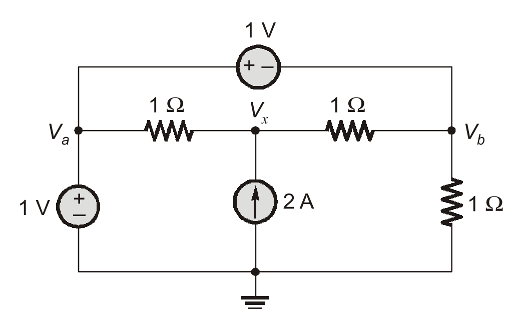
Q.2 Find the power delivered by the current source in the figure shown below.



Solution:

Consider node voltages V_a, V_b, V_x as shown below.

Applying nodal analysis,



$$\frac{V_x - V_a}{1} + \frac{V_x - V_b}{1} = 2$$

$$\Rightarrow \quad 2V_x - (V_a + V_b) = 2$$

$$\Rightarrow \quad V_x = \frac{2 + (V_a + V_b)}{2} \quad \text{...(i)}$$

Also,

$$V_a - V_b = 1 \text{ V}$$

$$V_a = 1 \text{ V}$$

Thus,

$$V_b = 0 \text{ V}$$

Solving further,

$$V_x = \frac{2 + (1 + 0)}{2} = 1.5 \text{ V}$$

$\therefore$ Power delivered by current source $= V_x \cdot I$ $\quad$ [$I = 2$ A (given)]

$= (1.5) \times 2 = 3$ Watts

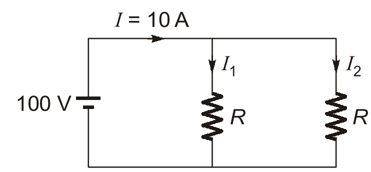
Q.3 Two identical coils connected in parallel across 100 V dc supply, take 10 A current from the supply. Power dissipated in one coil is 600 W. What is the resistance of each coil?

Solution:

Given, $\quad$ Power dissipated in one coil = 600 W

$$I = I_1 + I_2$$

$$I_1 = I_2$$

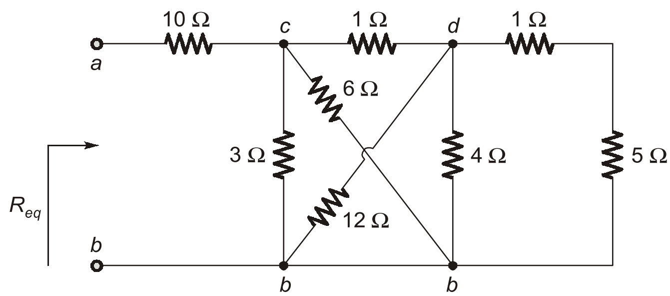


$$I_1 = I_2 = \frac{10\text{ A}}{2} = 5\text{ A}$$

Power dissipated, $P = I_1^2 R$

Hence, resistance of coil, $R = \frac{P}{I_1^2} = \frac{600}{(5)^2} = 24\ \Omega$

Q.4 Calculate equivalent resistance R_{eq} in the circuit shown.



Solution:

3 Ω and 6 Ω resistors in parallel because they are connected to same two nodes c and b. Their combined resistance is

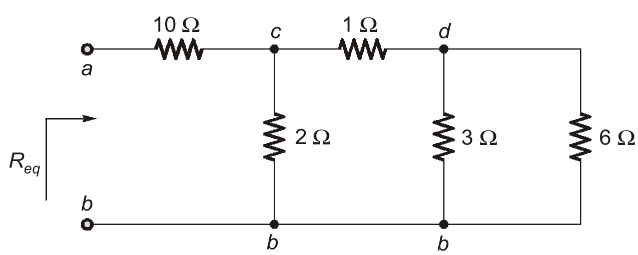
$$= \frac{3\times 6}{3+6} = 2\ \Omega$$

Similarly, 12 Ω and 4 Ω resistors are in parallel since they are connected to same two nodes *d* and *b*.

Hence, $12\ \Omega || 4\ \Omega = \frac{12\times 4}{12+4} = 3\ \Omega$

Also, 1 Ω and 5 Ω resistors are in series, hence combined resistance,

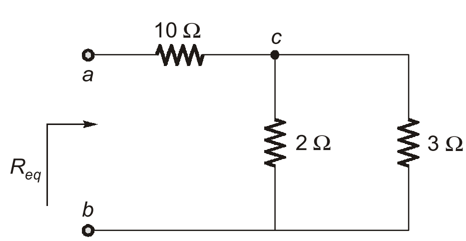
$$1\ \Omega + 5\ \Omega = 6\ \Omega$$



Further 3 Ω and 6 Ω in parallel gives equivalent resistance $= \frac{3\ \Omega\times 6\ \Omega}{(3+6)\ \Omega} = 2\ \Omega$

This 2 Ω in series with 1 Ω.

Given equivalent as (2 + 1) Ω = 3 Ω as shown below.

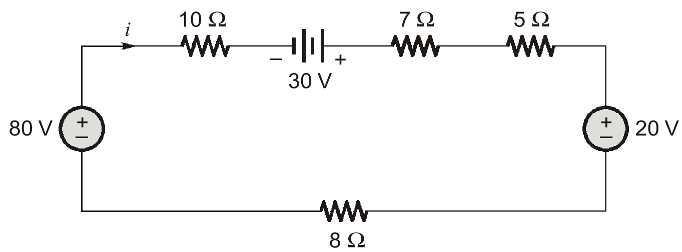


Now 2 Ω and 3 Ω parallel's combination in series with 10 Ω resistance.

Hence, $R_{ab} = R_{eq} = 10\,\Omega + (2\,\Omega || 3\,\Omega)$

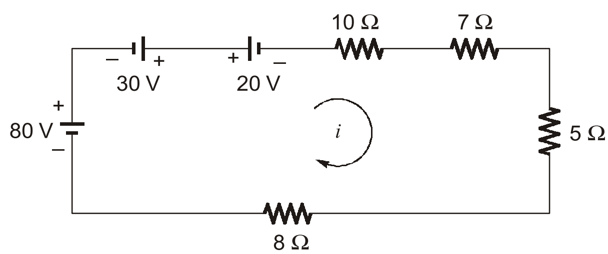
$$= 10 + \frac{2\times3}{2+3} = 11.2\,\Omega$$

Q.5 Use resistance and source combinations to determine the current *i* in figure shown and power delivered by 80 V source.



Solution:

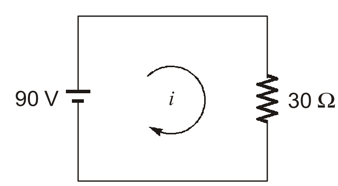
The circuit can be redrawn as,



Further combining the three voltage sources into an equivalent source of 90 V as shown below.

All the resistance, combined in series as,

$$R_{eq} = (10 + 7 + 5 + 8)\,\Omega = 30\,\Omega$$

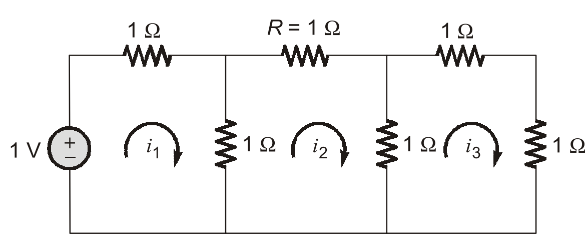


Simply applying kVL, $-90 + 30i = 0$

Hence, $i = 3$ A

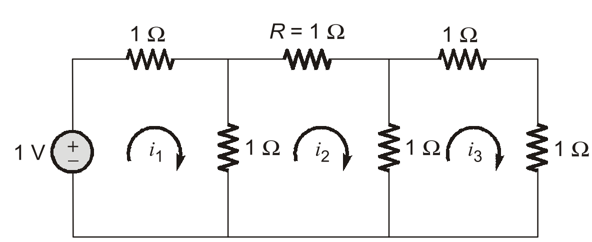
Power delivered by 80 V source $= 80\text{ V} \times 3\text{ A} = 240$ W

Q.6 Find the power dissipated in the resistor *R* in the ladder network shown in the figure below.



Solution:

Using KVL in loop,



$$1 = 2i_1 - i_2 \quad ...(1)$$

$$0 = 3i_2 - i_1 - i_3 \quad ...(2)$$

$$0 = 3i_3 - i_2 \quad ...(3)$$

$$\therefore \quad i_3 = \frac{i_2}{3}$$

By solving the equations, we get,

$$i_2 = \frac{3}{13}\text{ A}$$

$\therefore$ Power dissipated in the resistor $R = i^2 R = \dfrac{9}{169}$ W

Q.7 The following mesh equations pertain to a network:

$$8I_1 - 5I_2 - I_3 = 110$$
$$-5I_1 + 10I_2 + 0 = 0$$
$$-I_1 + 0 + 7I_3 = 115$$

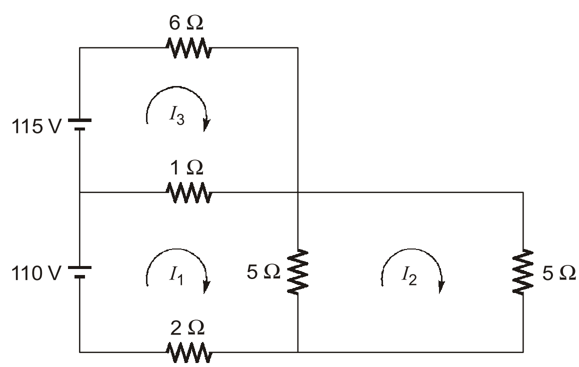
Draw network showing each element.

Solution:

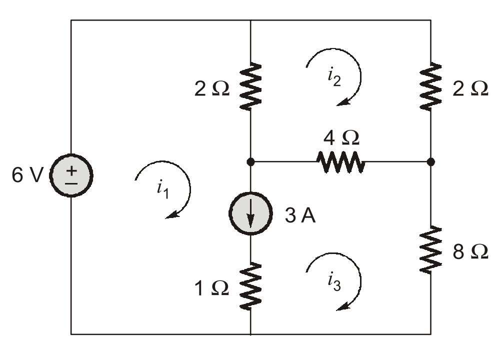
All the mesh equations can be rearrangement as,

$$8I_1 - 5I_2 - I_3 = 110$$
$$\Rightarrow \quad 5(I_1 - I_2) + (I_1 - I_3) + 2I_1 = 110 \quad ...(1)$$
$$-5I_1 + 10I_2 + 0 = 0$$
$$\Rightarrow \quad 5(I_2 - I_1) + 5I_2 = 0 \quad ...(2)$$
$$-I_1 + 0 + 7I_3 = 115$$
$$\Rightarrow \quad (I_3 - I_1) + 6I_3 = 115 \quad ...(3)$$

On the basis of equation (1), (2) and (3), we can draw the network as,



Q.8 Find mesh currents in the circuit,



Solution:

$$i_1 - i_3 = 3 \text{ A} \quad ...(1)$$

BY KVL for super mesh,

$$2(i_1 - i_2) + 4(i_3 - i_2) + 8i_3 = 6$$
$$2i_1 - 6i_2 + 12i_3 = 6 \quad ...(2)$$

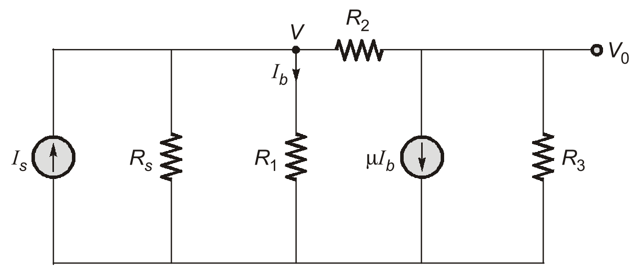
By KVL for second mesh,

$$2i_2 + 4(i_2 - i_3) + 2(i_2 - i_1) = 0$$
$$8i_2 - 4i_3 - 2i_1 = 0 \quad ...(3)$$

Solving equations (1), (2) and (3), we get

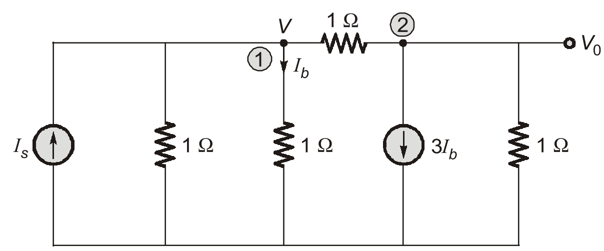
$$i_1 = 3.473 \text{ A}$$
$$i_2 = 1.105 \text{ A}$$
$$i_3 = 0.473 \text{ A}$$

Q.9 For the circuit shown in the figure determine V_0/I_S using nodal analysis.



$R_1 = R_2 = R_3 = R_s = 1\ \Omega$, $\mu = 3$

Solution:



$R_1 = R_2 = R_3 = R_s = 1\ \Omega$, $\mu = 3$

$$V = I_b \quad \text{...(1)}$$

Node (1),

$$\frac{V}{1} + \frac{V}{1} + \frac{V - V_0}{1} - I_s = 0$$

$$3V - V_0 = I_s \quad \text{...(2)}$$

Node (2),

$$\frac{V_0}{1} + \frac{V_0 - V}{1} + 3I_b = 0$$

$$2V_0 - V = -3I_b \quad \text{...(3)}$$

From equation (1), $I_b = V$ put in equation (3)

$$2V_0 - V = -3\ V$$

$$2V_0 = -2\ V$$

$\Rightarrow$ $V = -V_0$

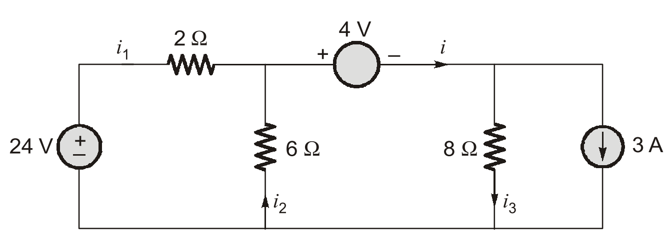
Putting, $V = -V_0$ in equation (2)

$$3(-V_0) - V_0 = I_s$$

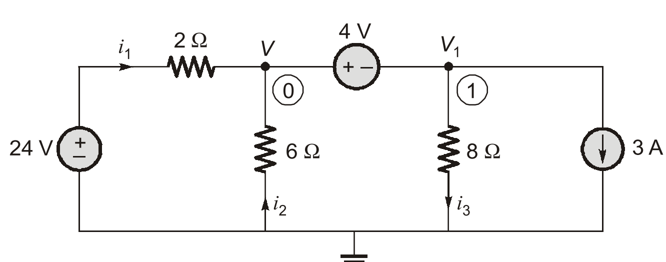
$$-4V_0 = I_s$$

$$\frac{V_0}{I_s} = -\frac{1}{4} = -0.25$$

Q.10 For the circuit shown in figure, determine the currents i_1, i_2 and i_3 using nodal analysis.



Solution:



By nodal analysis,

$$-i_1 - i_2 + i = 0$$

$$-\left(\frac{24-V}{2}\right)+\left[-\frac{0-V}{6}\right]+i = 0$$

$$\frac{V-24}{2}+\frac{V}{6}+i = 0 \quad ...(1)$$

$$V_1 = V-4$$

KCL at node 1,

$$-i+\frac{V_1}{8}+3 = 0$$

$$i = \left(\frac{V-4}{8}+3\right) \quad ...(2)$$

Combining (1) and (2),

$$\frac{V-24}{2}+\frac{V}{6}+\frac{V-4}{8}+3 = 0$$

Solving,

$$V = 12\text{ V}$$

$$V_1 = 8\text{ V}$$

$$i_1 = \frac{24-12}{2} = 6\text{ A}$$

$$i_2 = -\frac{12}{6} = -2\text{ A}$$

$$i_3 = 1\text{ A}$$

Q.11 Find all branch currents in the network shown in figure below.

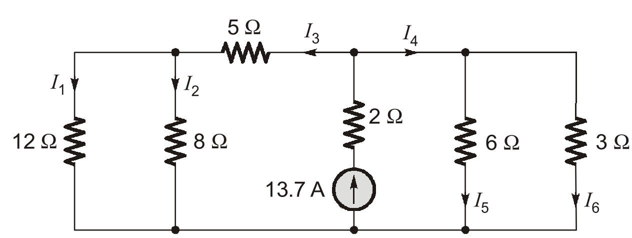


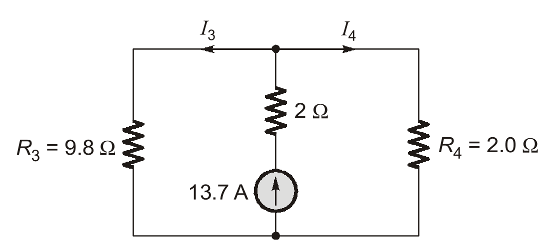
Fig. 1

Solution:

On simplifying the above circuit,

$$R_3 = 5+\frac{(12)(8)}{20} = 9.8\ \Omega$$

$$R_4 = \frac{(6)(3)}{9} = 2\ \Omega$$



By current division rule,

$$I_3 = \frac{2}{9.8+2}\times 13.7 = 2.32\text{ A}$$

$$I_4 = 13.7-2.32 = 11.38\text{ A}$$

Referring original network (Fig. 1),

$$I_1 = \frac{8}{(12+8)}(2.32) = 0.93\text{ A}$$

$$I_2 = 2.32-0.93 = 1.39\text{ A}$$