Electronics
Section 02

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Fall 2021

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Ohm's Law: The voltage across the resistor is directly proportional to the current.

$v \propto i$

$$\boxed{v = iR}$$

$$R = \frac{v}{i}$$

The Resistance (R): denotes the material's ability to resist.

$$R = \rho \frac{\ell}{A}$$

Where; R → Is the Resistance (Ω)

A → the cross sectional area (m^2)

ƒ → The resistivity of the material (Ω.m)

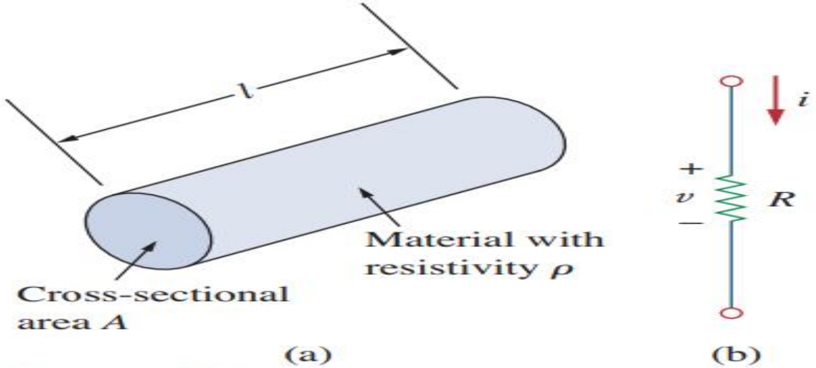

Figure 2.1
(a) Resistor, (b) Circuit symbol for resistance.

Conductance (G): which is the ability of the material to conduct electricity or electrical current and is measured in (mhos) or (Siemens) (℧).

$$i = Gv$$

The power by conductance will be given by :

$$p = vi = v^2G = \frac{i^2}{G}$$

Electrical conductivity or specific conductance: is the reciprocal of electrical resistivity. It represents a material's ability to conduct electric current. The SI unit of electrical conductivity is siemens per meter (S/m).

$$\sigma = \frac{1}{\rho}.$$

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Nodes, Branches, and Loops:

A **branch** represents a single element such as a voltage source or a resistor.

A **node** is the point of connection between two or more branches.

A **loop** is any closed path in a circuit.

Two or more elements are in **series** if they exclusively share a single node and consequently carry the same current.
Two or more elements are in **parallel** if they are connected to the same two nodes and consequently have the same voltage across them.

$$b = l + n - 1$$

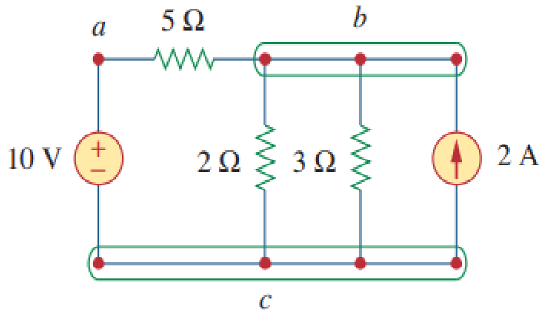


Figure
Nodes, branches, and loops.

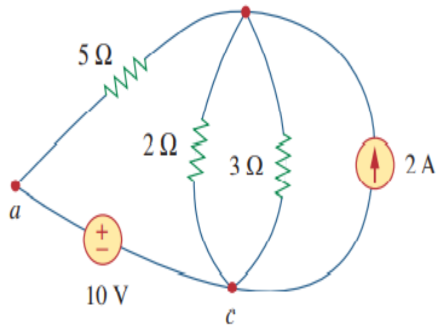
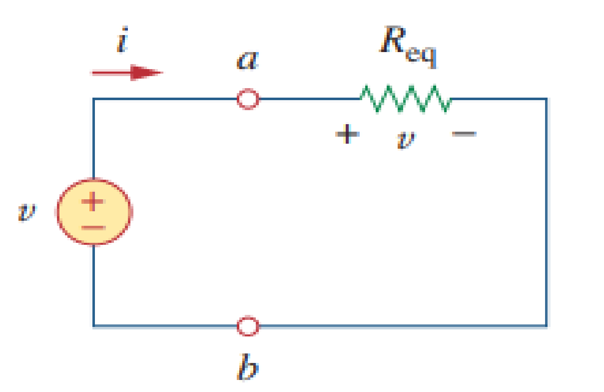
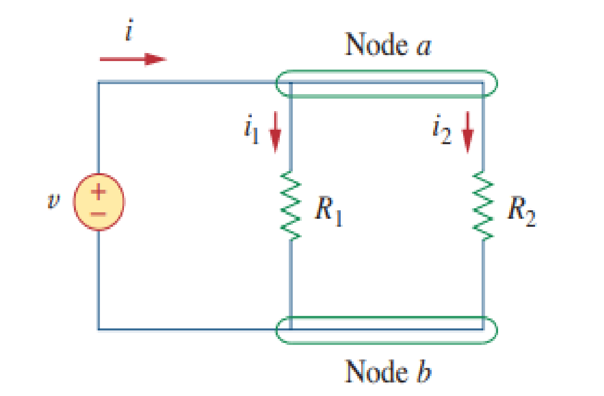


Figure
The three-node circuit of Fig. 2.10 is redrawn.

Series VS Parallel Connection:

SERIES RESISTORS AND VOLTAGE DIVISION	PARALLEL RESISTORS AND CURRENT DIVISION
$\sum V = I \sum R$	$\sum I = \frac{V}{\sum R}$
$R_{eq} = R_1 + R_2 + \cdots + R_n$	$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n}$
$\frac{1}{G_{eq}} = \frac{1}{G_1} + \frac{1}{G_2} + \cdots + \frac{1}{G_n}$	$G_{eq} = G_1 + G_2 + \cdots + G_n$





Kirchhoff's Laws:

Kirchhoff's current law (KCL) states that the algebraic sum of currents entering a node (or a closed boundary) is zero.

Mathematically, KCL implies that

$$\boxed{\sum_{n=1}^{N} i_n = 0} \qquad (2.13)$$

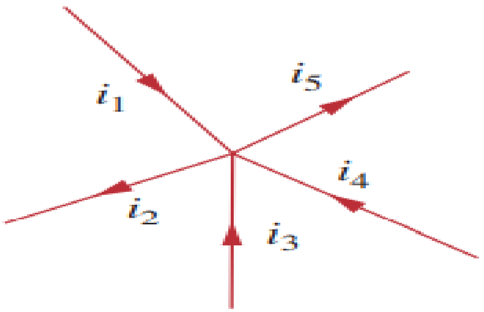


Figure 2.16
Currents at a node illustrating KCL.

Kirchhoff's voltage law (KVL) states that the algebraic sum of all voltages around a closed path (or loop) is zero.

Expressed mathematically, KVL states that

$$\boxed{\sum_{m=1}^{M} v_m = 0} \qquad (2.19)$$

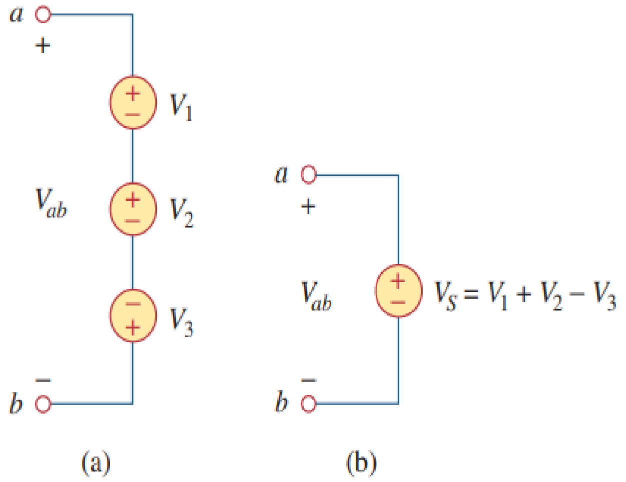


Figure 2.20
Voltage sources in series: (a) original circuit, (b) equivalent circuit.

Q1: An electric iron draws 2 A at 120 V. Find its resistance.

Solution:

From Ohm's law,

$$R = \frac{v}{i} = \frac{120}{2} = 60\ \Omega$$

Q2: A voltage source of $20\ sin\pi t\ V$ is connected across a 5 kΩ resistor. Find the current through the resistor and the power dissipated.

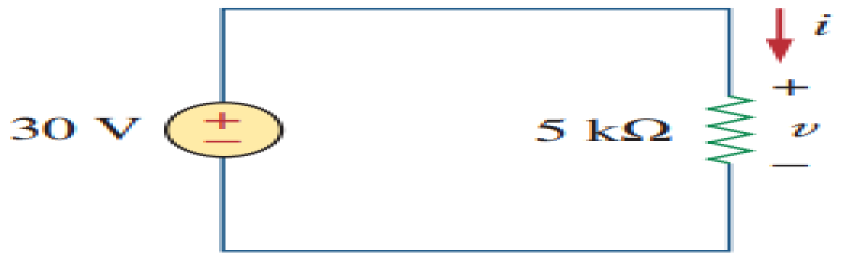
Solution:

$$i = \frac{v}{R} = \frac{20 \sin \pi t}{5 \times 10^3} = 4 \sin \pi t \text{ mA}$$

Hence,

$$p = vi = 80 \sin^2 \pi t \text{ mW}$$

Q3: In the circuit shown in Figure, calculate the current i, the conductance G, and the power p.



Solution:

The voltage across the resistor is the same as the source voltage (30 V) because the resistor and the voltage source are connected to the same pair of terminals. Hence, the current is

$$i = \frac{v}{R} = \frac{30}{5 \times 10^3} = 6 \text{ mA}$$

The conductance is

$$G = \frac{1}{R} = \frac{1}{5 \times 10^3} = 0.2 \text{ mS}$$

Now for the power, we can use several solutions such as:

$$p = vi = 30(6 \times 10^{-3}) = 180 \text{ mW}$$

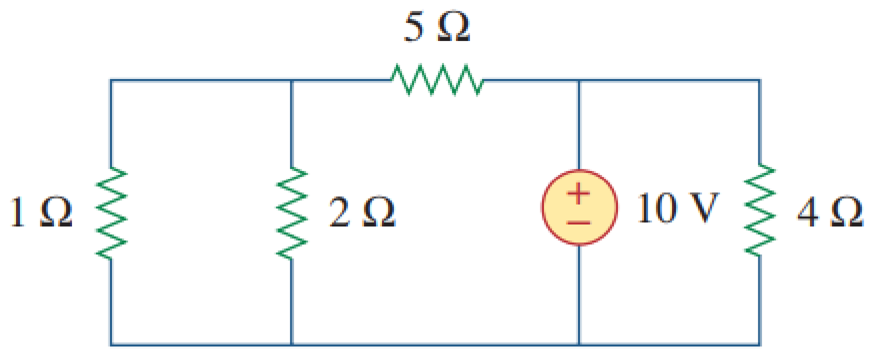
or

$$p = i^2R = (6 \times 10^{-3})^2 5 \times 10^3 = 180 \text{ mW}$$

or

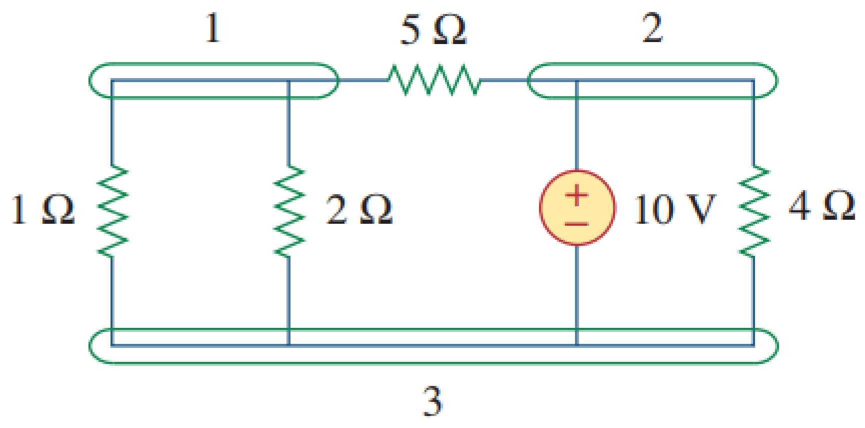
$$p = v^2G = (30)^2 0.2 \times 10^{-3} = 180 \text{ mW}$$

Q4: How many branches and nodes does the circuit in Figure have? Identify the elements that are in series and in parallel.



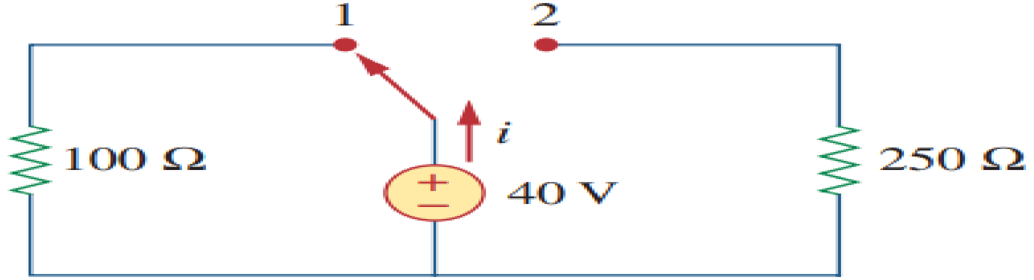
Solution

Five branches and three nodes are identified in Figure. The 1- and 2- resistors are in parallel. The 4- resistor and 10-V source are also in parallel.



Q5: (a) Calculate current i in Fig. when the switch is in position 1.

(b) Find the current when the switch is in position 2.

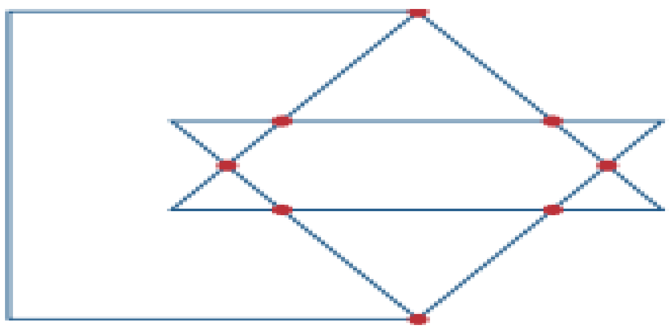


Solution

(a) $\mathbf{i} = 40/100 = \mathbf{400\ mA}$

(b) $\mathbf{i} = 40/250 = \mathbf{160\ mA}$

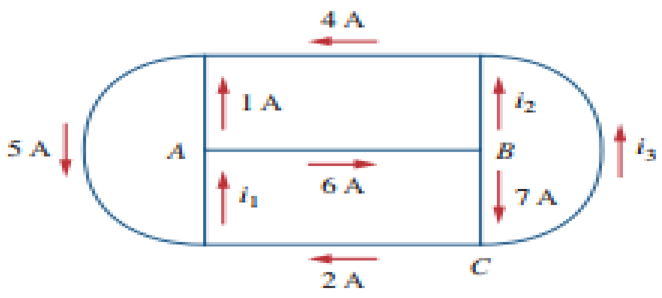
Q6: In the network graph shown in Fig. determine the number of branches and nodes.



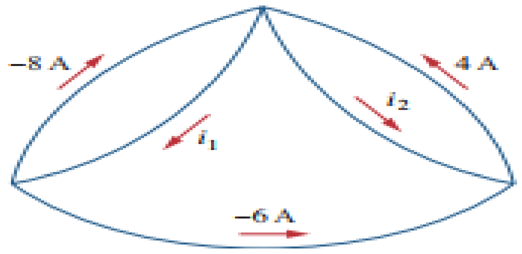
Solution

$n = 12; \quad l = 8; \quad \mathbf{b} = n + l - 1 = \underline{\mathbf{19}}$

Q7: Find i_1, i_2, and i_3 in Fig.



Q8: Determine i_1 and i_2 in the circuit of Fig.



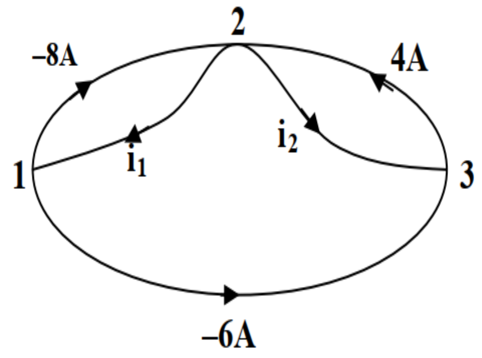
Solution

At A, $1+6-i_1 = 0$ or $i_1 = 1+6 = \mathbf{7\ A}$

At B, $-6+i_2+7 = 0$ or $i_2 = 6-7 = \mathbf{-1\ A}$

At C, $2+i_3-7 = 0$ or $i_3 = 7-2 = \mathbf{5\ A}$

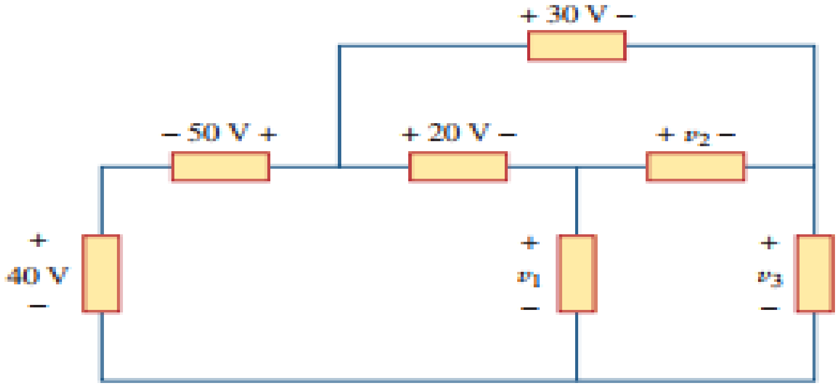
Solution



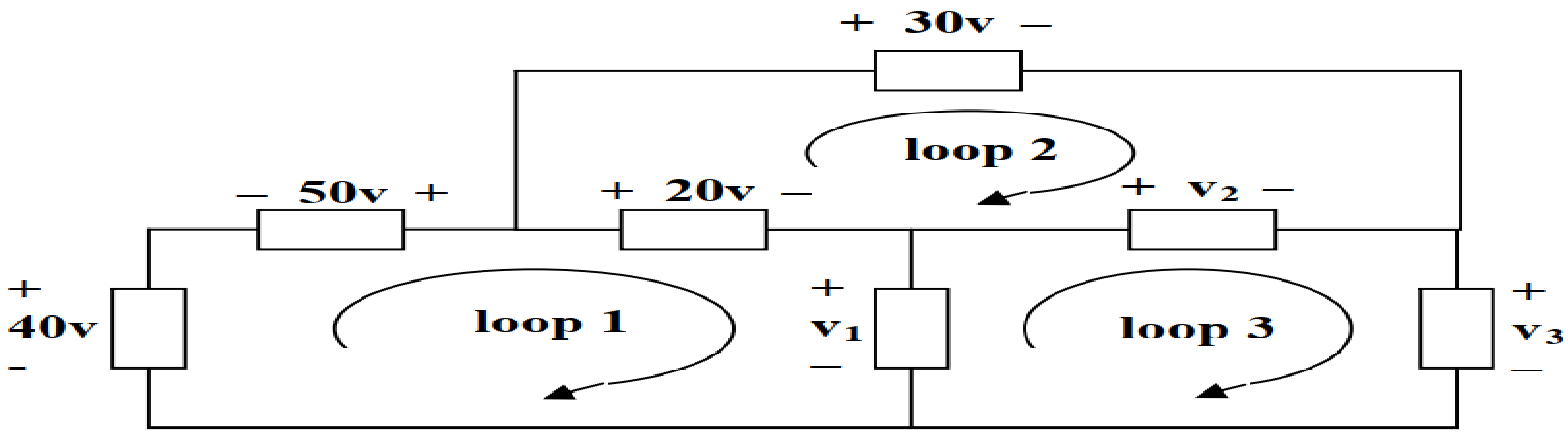
At node 1, $-8-i_1-6 = 0$ or $i_1 = -8-6 = \mathbf{-14\ A}$

At node 2, $-(-8)+i_1+i_2-4 = 0$ or $i_2 = -8-i_1+4 = -8+14+4 = \mathbf{10\ A}$

Q9: **2.12** In the circuit in Fig. obtain v_1, v_2, and v_3.



Solution



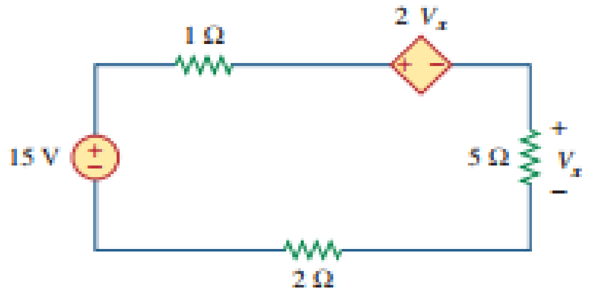
For loop 1, $-40 - 50 + 20 + v_1 = 0$ or $v_1 = 40 + 50 - 20 =$ **70 V**

For loop 2, $-20 + 30 - v_2 = 0$ or $v_2 = 30 - 20 =$ **10 V**

For loop 3, $-v_1 + v_2 + v_3 = 0$ or $v_3 = 70 - 10 =$ **60 V**

Q10:

Find V_x in the circuit of Fig.



Solution

Applying KVL,

$$-15 + (1+5+2)I + 2V_x = 0$$

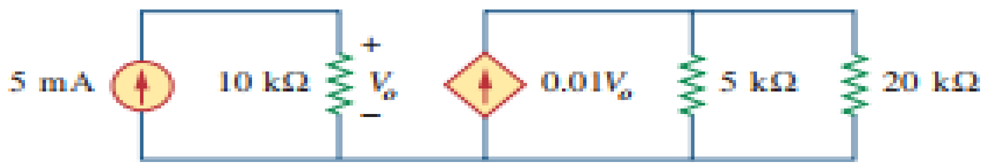
But $V_x = 5I$,

$$-15 + 8I + 10I = 0, \qquad I = 5/6$$

$$V_x = 5I = 25/6 = 4.167\text{ V}$$

Q11:

2.25 For the network in Fig. find the current, voltage, and power associated with the 20-kΩ resistor.



Solution

$$V_0 = 5 \text{ x } 10^{-3} \text{ x } 10 \text{ x } 10^3 = 50\text{V}$$

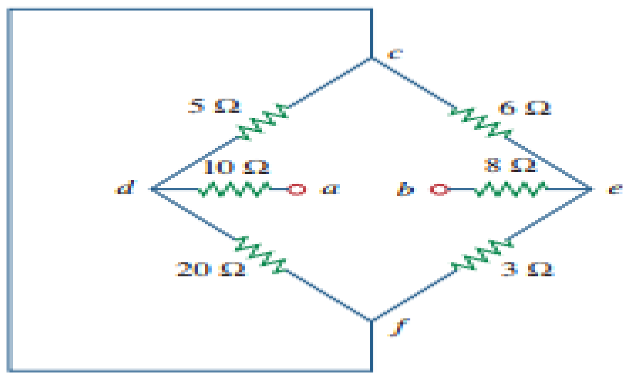
Using current division,

$$I_{20} = \frac{5}{5+20}(0.01x50) = \mathbf{0.1\ A}$$

$$V_{20} = 20 \text{ x } 0.1 \text{ kV} = \mathbf{2\ kV}$$

$$p_{20} = I_{20}\, V_{20} = \mathbf{0.2\ kW}$$

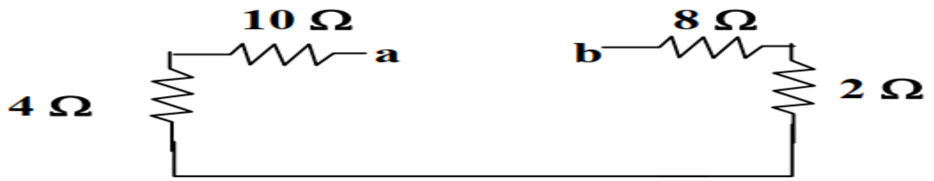
Q12: Find the equivalent resistance R_{ab} in the circuit of Fig.



Solution

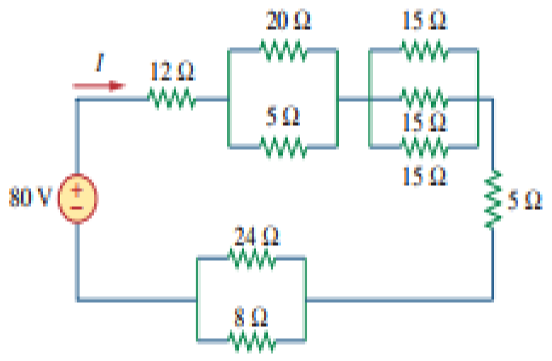
$$5\|20 = \frac{5x20}{25} = 4\Omega$$

$$6\|3 = \frac{6x3}{9} = 2\Omega$$



$$R_{ab} = 10 + 4 + 2 + 8 = \mathbf{24\ \Omega}$$

Q13: 2.46 Find I in the circuit of Fig.



Solution

$$R_{eq} = 12 + 5\|20 + [1/((1/15)+(1/15)+(1/15))] + 5 + 24\|8$$
$$= 12 + 4 + 5 + 5 + 6 = 32\ \Omega$$

$$I = 80/32 = \mathbf{2.5\ A}$$

MCQ

(1) The reciprocal of resistance is:

(a) voltage (b) current

(c) conductance (d) coulombs

(2) An electric heater draws 10 A from a 120-V line. The resistance of the heater is:

(a) 1200 Ω (b) 120 Ω

(c) 12 Ω (d) 1.2 Ω

(3) The voltage drop across a 1.5-kW toaster that draws 12 A of current is:

(a) 18 kV (b) 125 V

(c) 120 V (d) 10.42 V

(4) The maximum current that a 2W, 80 kΩ resistor can safely conduct is:

(a) 160 kA (b) 40 kA

(c) 5 mA (d) 25 μA

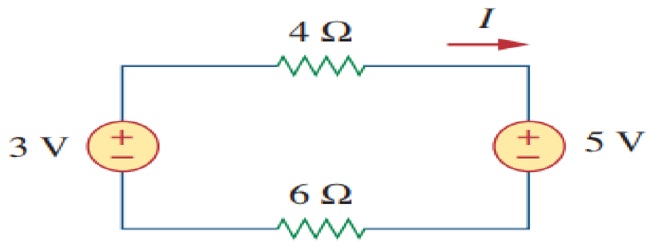
(5) A network has 12 branches and 8 independent loops. How many nodes are there in the network?

(a) 19 (b) 17 (c) 5 (d) 4

(6) The current I in the circuit of Fig. is:

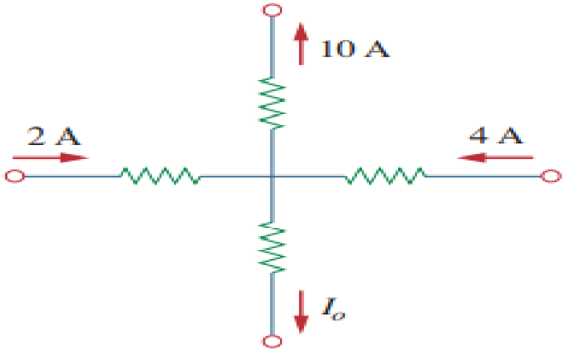
(a) -0.8 A (b) -0.2 A

(c) 0.2 A (d) 0.8 A



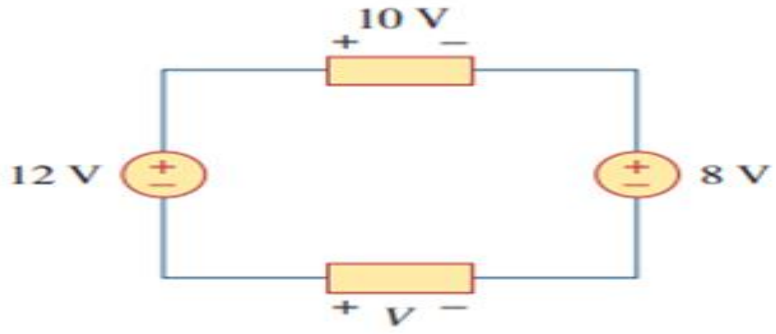
(7) The current I_o of Fig. is:

(a) −4 A (b) −2 A (c) 4 A (d) 16 A

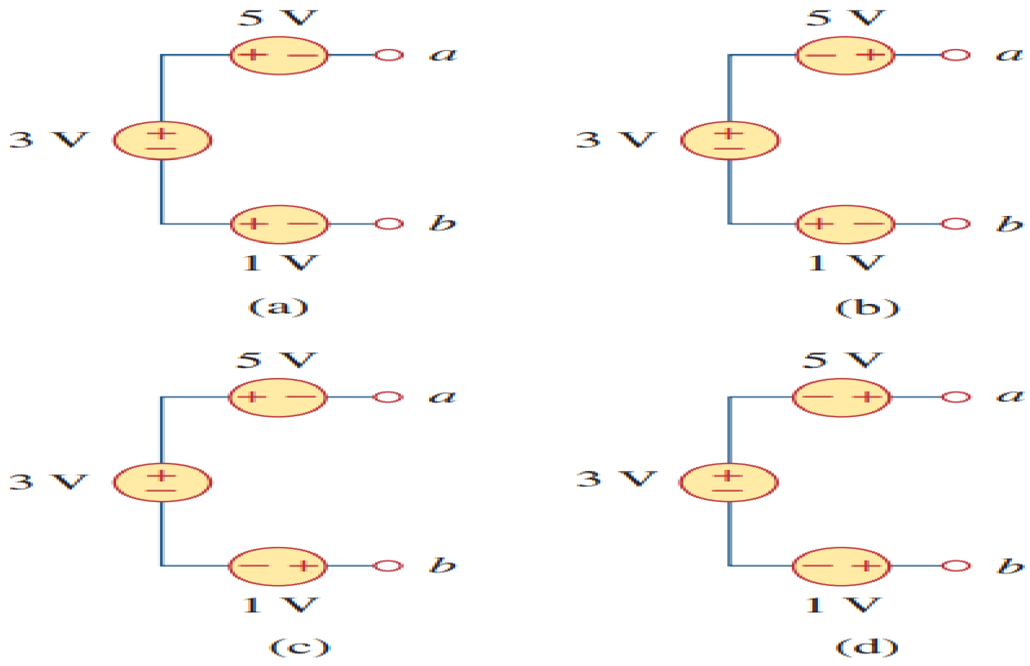


(8) In the circuit in Fig. V is:

(a) 30 V (b) 14 V (c) 10 V (d) 6 V



(9) Which of the circuits in Fig. will give you $V_{ab} = 7$ V?



(10) In the circuit of Fig. a decrease in R_3 leads to a decrease of, select all that apply:

(a) current through R_3
(b) voltage across R_3
(c) voltage across R_1
(d) power dissipated in R_2
(e) none of the above