1.

Calculate the resistance of a 10m-long wire with the diameter of 0.5 mm made of silver, copper, and aluminum.

TABLE OF ELECTRICAL RESISTIVITY

MATERIAL	ELECTRICAL RESISTIVITY AT 20°C $\times 10^{-8}$ (OHM M)
Aluminum	2.65
Copper	1.72
Gold	2.4
Iron	9.71
Lead	22
Silver	1.59

1.

SOLUTION

d = 0.5 mm = $5 \cdot 10^{-4}$ m / wire diameter

ρ ohm·m /resistivity is given in Tab

$$A = \pi \left(\frac{d}{2}\right)^2$$ m² /cross-sectional area

L = 10 m /wire length

$$R = \frac{L}{A}\rho$$ /resistance

TABLE OF ELECTRICAL RESISTIVITY

MATERIAL	ELECTRICAL RESISTIVITY AT 20°C $\times 10^{-8}$ (OHM M)
Aluminum	2.65
Copper	1.72
Gold	2.4
Iron	9.71
Lead	22
Silver	1.59

ANSWER

MATERIAL	ELECTRICAL RESISTANCE AT 20°C (OH M)
Aluminum	1.3496
Copper	0.8760
Silver	0.8098

2.

2.1 Find the mass of a 1km-long overhead power line with d = 30mm if it was made of silver, copper and aluminum, given their densities.

2.2 Find the cost of these wires, provided the price per kg in USD.

2.3 How much would the aluminum line cost if its diameter is to be increased so that the line has the same resistance with the copper line?

TABLE OF CONSTANTS

MATERIAL	ELECTRICAL RESISTIVITY AT 20°C $\times 10^{-8}$ (OH M)	DENSITY (KG/M³)	PRICE PER KG ($)
Aluminum	2.65	2700	2
Copper	1.72	8940	8
Silver	1.59	10500	819

SOLUTION 2.1

2. Find the mass of a 1km-long overhead power line with d = 30 mm if it was made of silver, copper and aluminum.

d = 30 mm = $3 \cdot 10^{-2}$ m /wire diameter

$$A = \pi \left(\frac{d}{2}\right)^2$$ m^2 /cross-sectional area

L = 1000 m /wire length

$$V = A \cdot L$$ m^3 /wire volume

D kg/m^3 /density given in Tab

$$m = D \cdot V$$ kg /mass of wire

TABLE OF CONSTANTS			ANSWER
MATERIAL	ELECTRICAL RESISTIVITY AT 20°C $\times 10^{-8}$ (OH M)	DENSITY (KG/M³)	MASS (TONS)
Aluminum	2.65	2700	1.91
Copper	1.72	8940	6.32
Silver	1.59	10500	7.42

SOLUTION 2.2

2. Find the cost of these wires, provided the price per kg in USD.

Pr \$/kg /wire price given in Tab

$C = Pr \cdot m$ \$ /cost of wire

TABLE OF CONSTANTS				ANSWER
MATERIAL	ELECTRICAL RESISTIVITY AT 20°C $\times 10^{-8}$ (OH M)	PRICE PER KG (\$)	MASS (TONS)	COST (\$ THOUSAND)
Aluminum	2.65	2	1.91	3.82
Copper	1.72	8	6.32	50.55
Silver	1.59	819	7.42	6078.63

SOLUTION 2.3

2. How much would the aluminum line cost if its diameter is to be increased so that the line has the same resistance with the copper line?

$$R_c = \frac{L}{A_c}\rho_c$$ ohm /resistance of copper wire

$$R_a = \frac{L}{A_a}\rho_a$$ ohm /resistance of aluminum wire

$$R_c = R_a; \quad \frac{L}{A_c}\rho_c = \frac{L}{A_a}\rho_a; \quad \frac{A_a}{A_c} = \frac{\rho_a}{\rho_c}; \quad \frac{d_a}{d_c} = \sqrt{\frac{\rho_a}{\rho_c}}; \quad d_a = 37.24;\ \text{mm}$$ /diameter of aluminum wire

$$C = Pr \cdot m = Pr \cdot D \cdot V = Pr \cdot D \cdot A \cdot L = Pr \cdot D \cdot \pi \left(\frac{d_a}{2}\right)^2 \cdot L = 5.88 \cdot 10^3\ \$$$ /cost of aluminum wire

TABLE OF CONSTANTS				ANSWER
MATERIAL	ELECTRICAL RESISTIVITY AT 20°C × 10^{-8} (OH M)	DENSITY (KG/M³)	PRICE PER KG ($)	COST ($ THOUSAND)
Aluminum	2.65	2700	2	5.88
Copper	1.72	8940	8	50.55

3. Find the total charge in a cylindrical conductor (solid wire) and compute the current flowing in the wire.

List of parameters:

Conductor length:	L = 1 m.
Conductor diameter:	$2r = 2 \times 10^{-3}$ m.
Charge density:	$n = 10^{29}$ carriers/m^3.
Charge of one electron:	$q_e = -1.602 \times 10^{-19}$ C.
Charge carrier velocity:	$u = 19.9 \times 10^{-6}$ m/s.

3.

Conductor length:	$L = 1$ m.
Conductor diameter:	$2r = 2 \times 10^{-3}$ m.
Charge density:	$n = 10^{29}$ carriers/m^3.
Charge of one electron:	$q_e = -1.602 \times 10^{-19}$ C.
Charge carrier velocity:	$u = 19.9 \times 10^{-6}$ m/s.

SOLUTION

$$V = L \times \pi r^2 = (1\,\mathrm{m})\left[\pi\left(\frac{2 \times 10^{-3}}{2}\right)^2 \mathrm{m}^2\right] = \pi \times 10^{-6}\ \mathrm{m}^3$$ /Volume = length × cross-sectional area

$$N = V \times n = (\pi \times 10^{-6}\,\mathrm{m}^3)\left(10^{29}\,\frac{\text{carriers}}{\mathrm{m}^3}\right) = \pi \times 10^{23}\ \text{carriers}$$ /Number of carriers

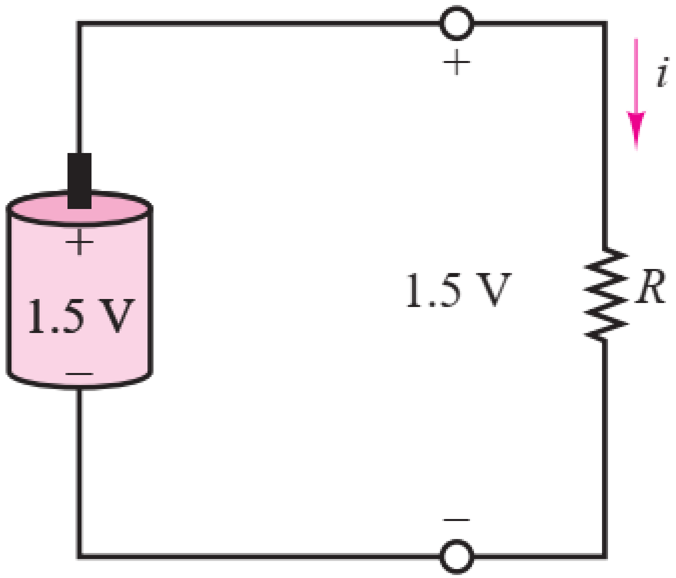
$$Q = N \times q_e = (\pi \times 10^{23}\ \text{carriers}) \times \left(-1.602 \times 10^{-19}\,\frac{\mathrm{C}}{\text{carrier}}\right) = -50.33 \times 10^3\ \mathrm{C}$$ /Charge

$$I = \left(\frac{Q}{L}\ \frac{\mathrm{C}}{\mathrm{m}}\right) \times \left(u\ \frac{\mathrm{m}}{\mathrm{s}}\right) = \left(-50.33 \times 10^3\,\frac{\mathrm{C}}{\mathrm{m}}\right)\left(19.9 \times 10^{-6}\,\frac{\mathrm{m}}{\mathrm{s}}\right) = -1\ \mathrm{A}$$ /Current

Answer: the total charge is -50.33×10^3 C; the current is -1 A.

4.

Determine the minimum resistor size that can be connected to a given battery without exceeding the resistor’s (1/4) -W power rating.



4.

Determine the minimum resistor size that can be connected to a given battery without exceeding the resistor’s (1/4) -W power rating.

Resistor power rating: 0.25 W

Battery voltages: 1.5 V

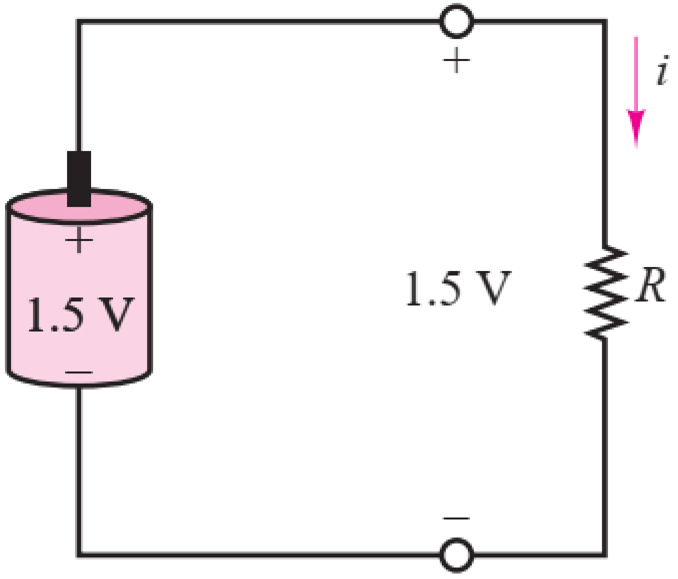
SOLUTION

Since $P = VI$ and that $V = IR$. Thus, the power dissipated by any resistor is

$$P_R = V \times I = V \times \frac{V}{R} = \frac{V^2}{R}$$

$V^2/R \leq 0.25$ / maximum power

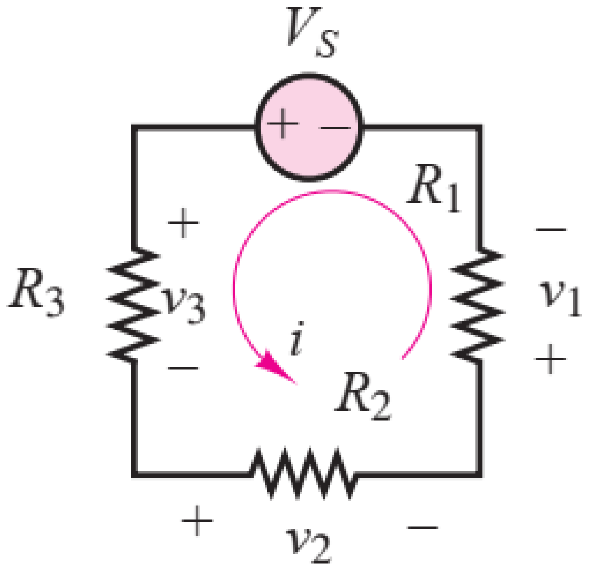
$R = 1.5^2/0.25 = 9\,\Omega$.



Answer: the minimum resistor size is 9 ohm

5.

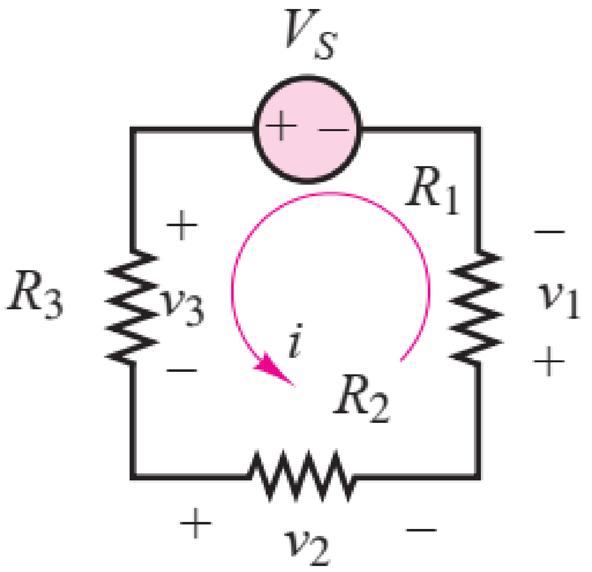
Determine the voltage v_3 in the circuit of Figure, where $R_1 = 10\ \Omega$; $R_2 = 6\ \Omega$; $R_3 = 8\ \Omega$; $V_S = 3\ \text{V}$.



5.

Determine the voltage v_3 in the circuit of Figure, where $R_1 = 10\ \Omega;\ R_2 = 6\ \Omega;\ R_3 = 8\ \Omega;\ V_S = 3$ V.

SOLUTION

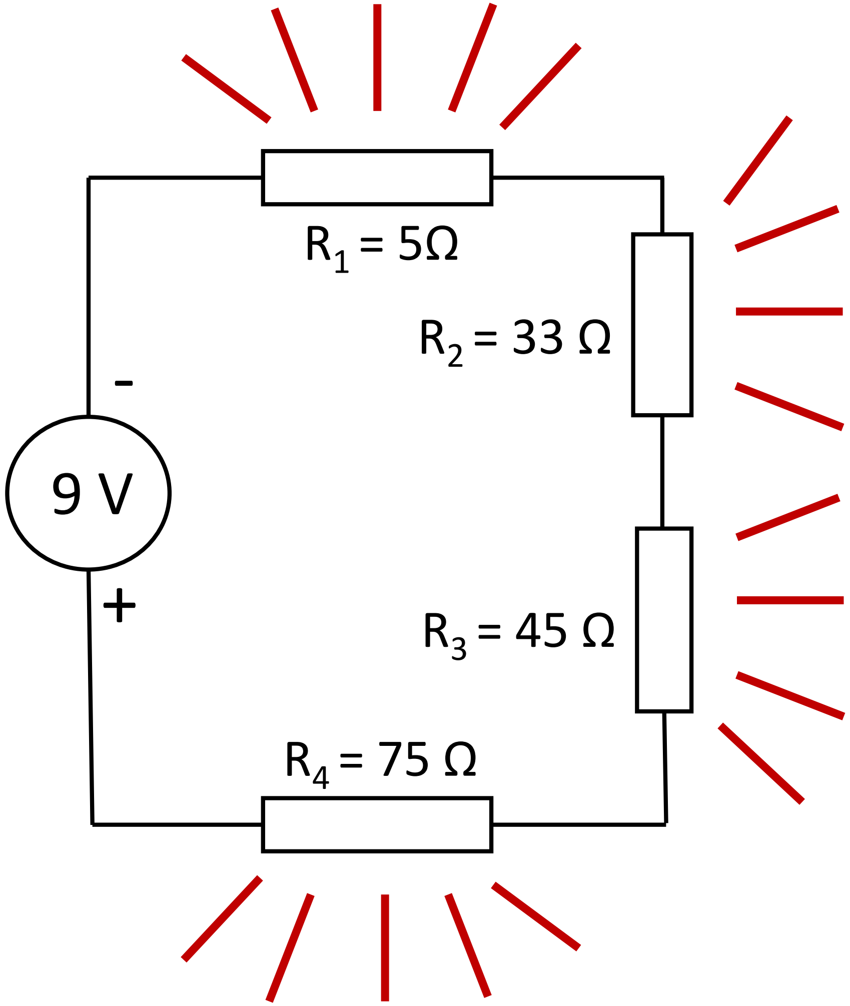


$$v_3 = V_S \times \frac{R_3}{R_1 + R_2 + R_3} = 3 \times \frac{8}{10 + 6 + 8} = 1 \text{ V}$$ /The voltage divider rule

Answer: the voltage v_3 is 1V

1.

Find electric power in all resistors in the circuit below.



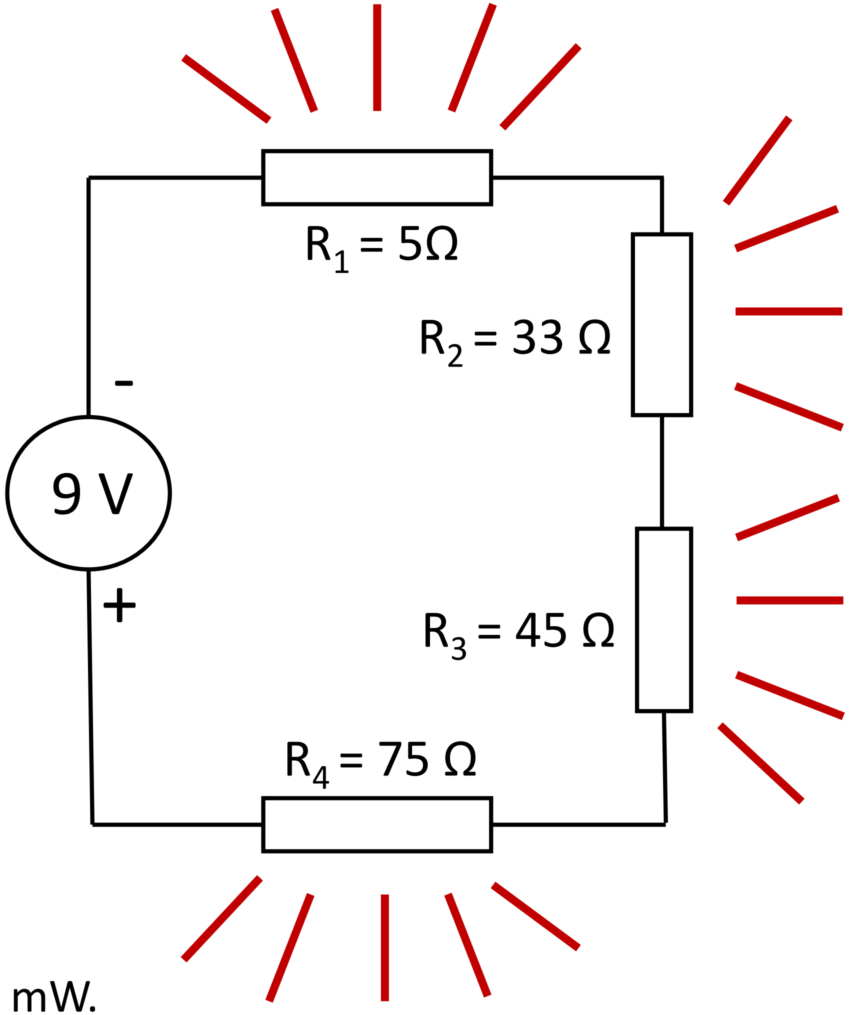
1.

Find electric power in all resistors in the circuit below.

SOLUTION

$$i = \frac{V}{R_1 + R_2 + R_3 + R_4} = 57\ mA$$ / Ohm's law, the current in the circuit

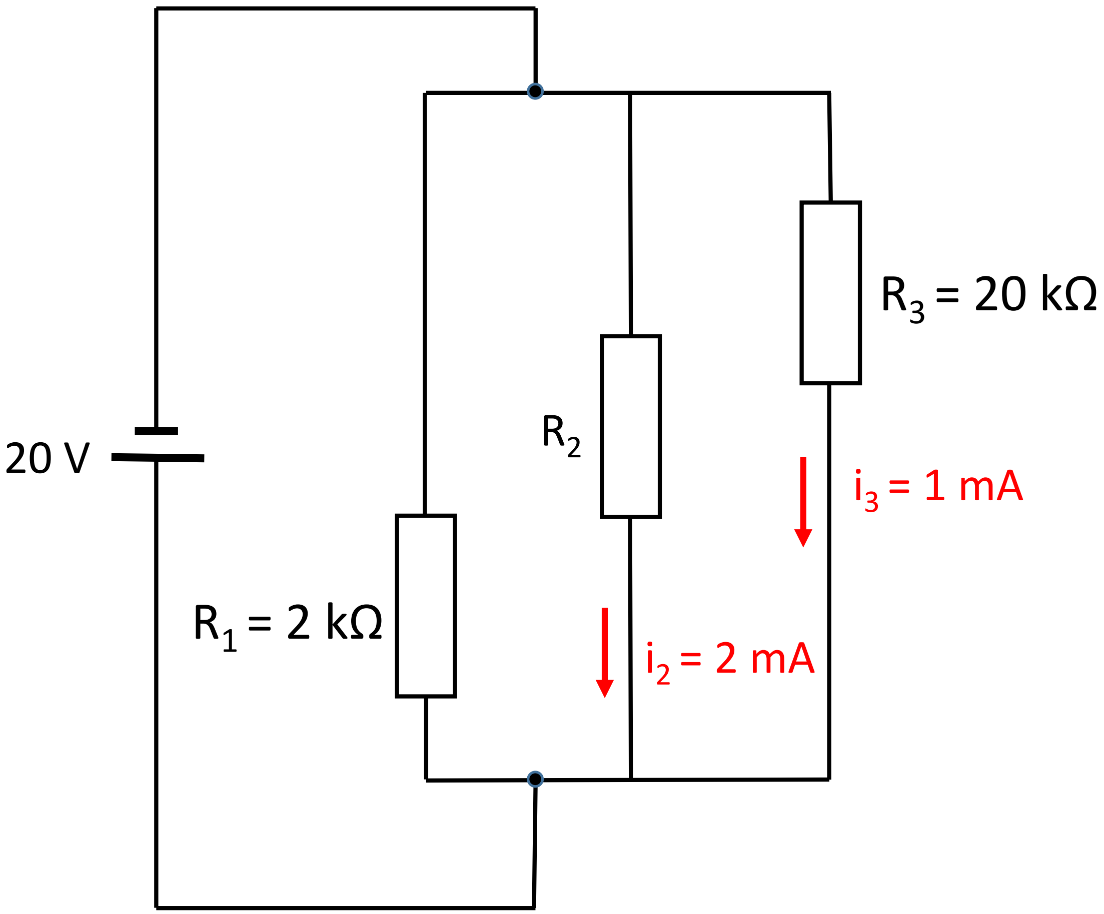
$$P = i \cdot V = i^2 R$$ /Electric power in the resistor



Answer: $P_1 = 16$ mW; $P_2 = 107$ mW; $P_3 = 146$ mW; $P_4 = 243$ mW.

2.

Find powers on all elements



2.

Find powers on all elements

SOLUTION

$$R_2 = \frac{V}{i_2} = 10\ k\Omega$$

/ Ohm's law

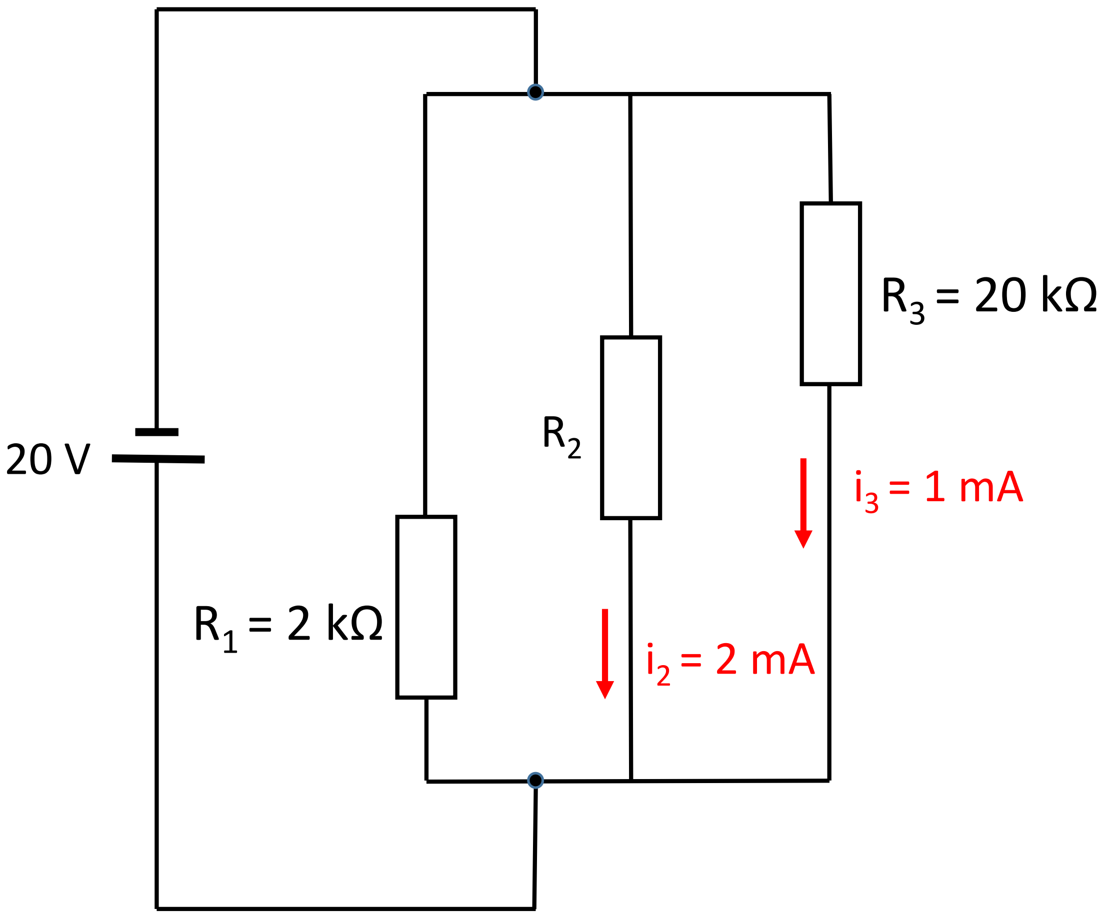
$$i_1 = \frac{V}{R_1} = 10\ mA$$

$$P_1 = \frac{V^2}{R_1} = 0.2\ \mathrm{W}$$

$$P_2 = V \cdot i_2 = 0.04\ W$$

$$P_3 = V \cdot i_3 = 0.02\ W$$

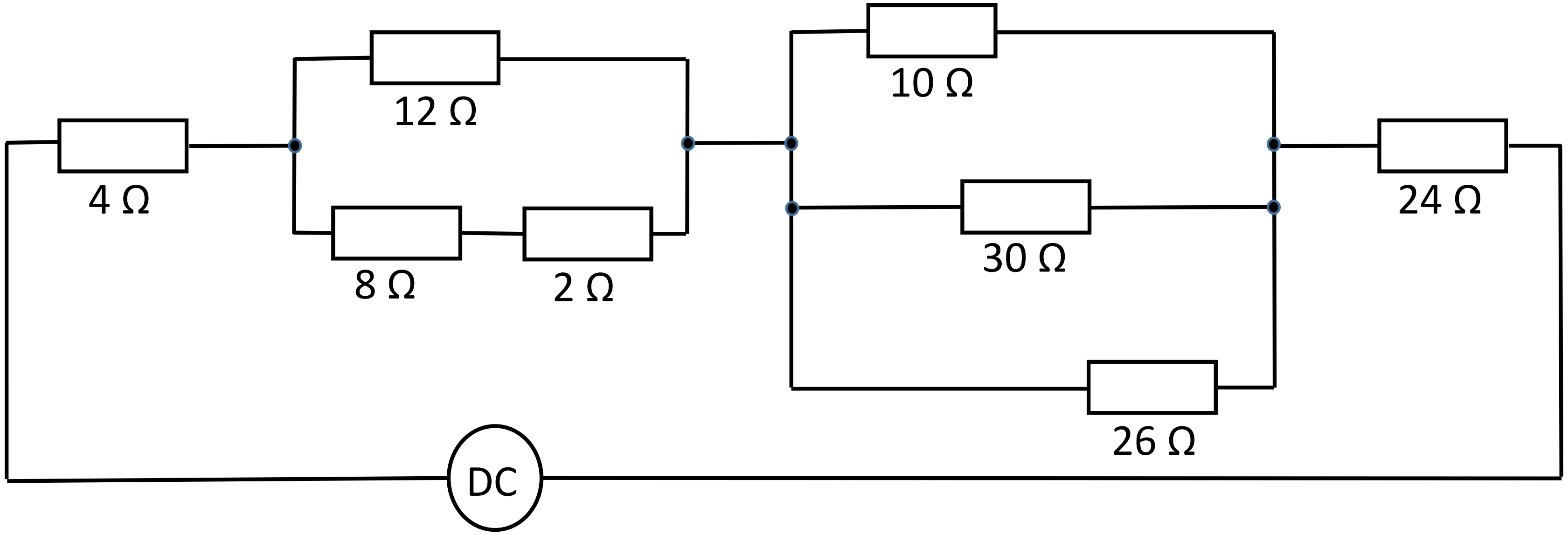
$$P = P_1 + P_2 + P_3 = 0.26\ W$$



Answer: P_1 = 0.2 W; P_2 = 0.04 W; P_3 = 0.01 W. Total power is 0.26 W

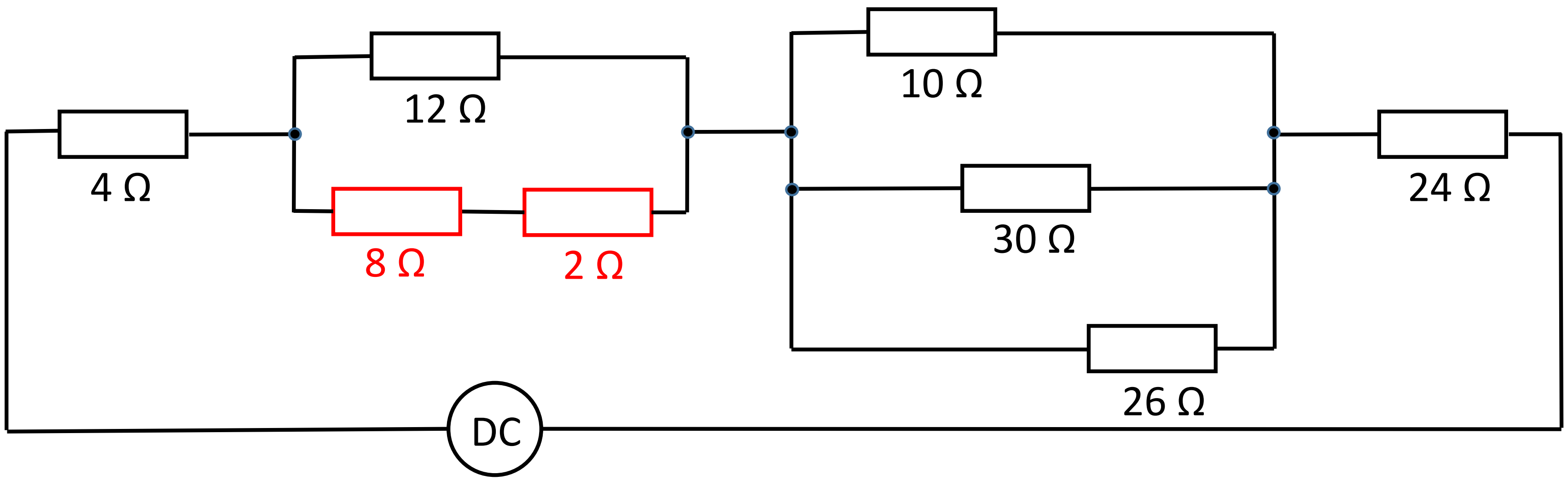
3.

Find the equivalent resistance

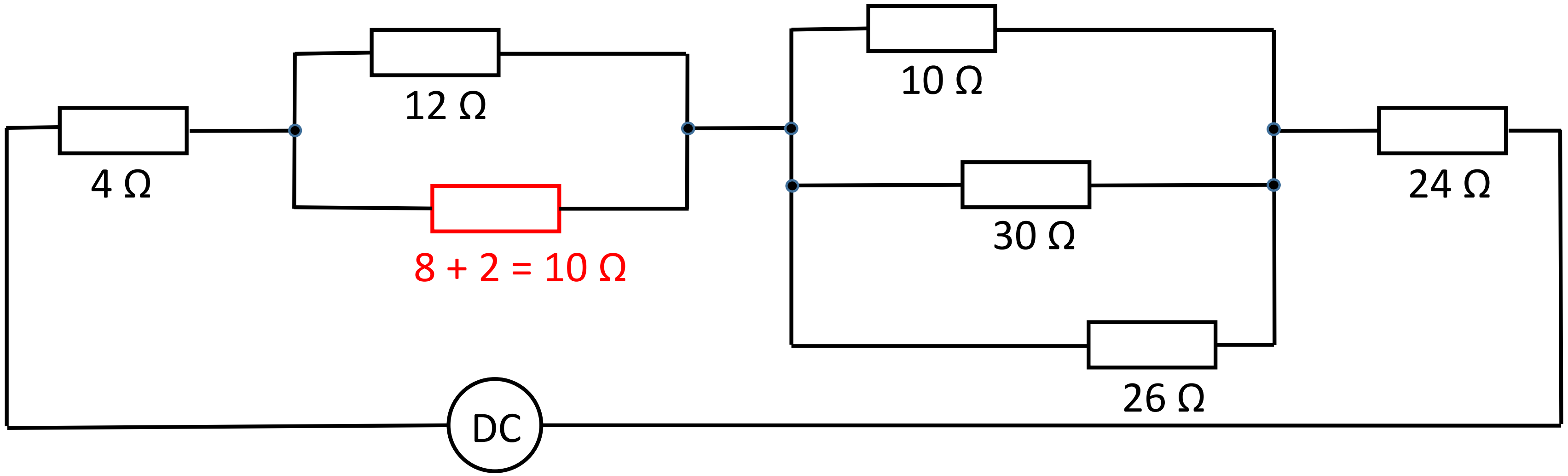


3.

Find the equivalent resistance

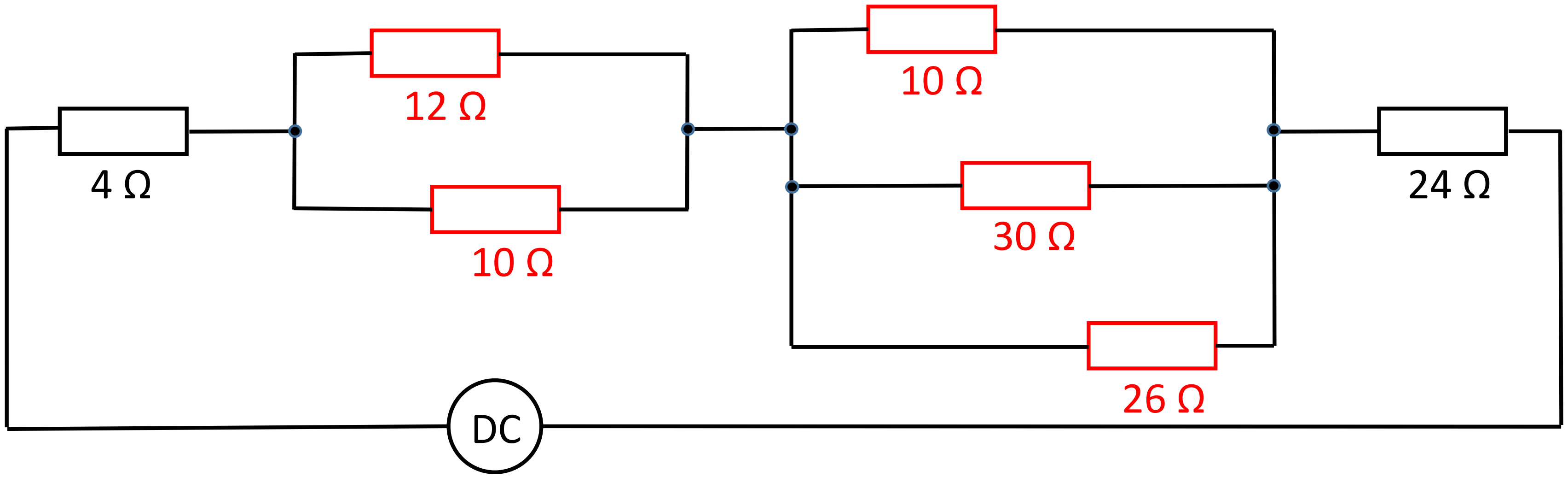


SOLUTION

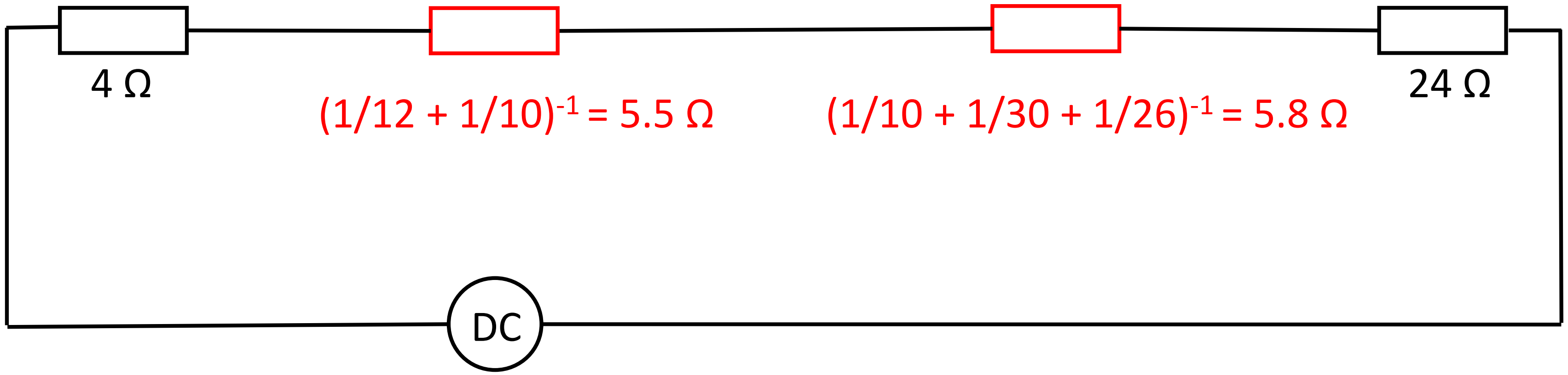


3.

Find the equivalent resistance

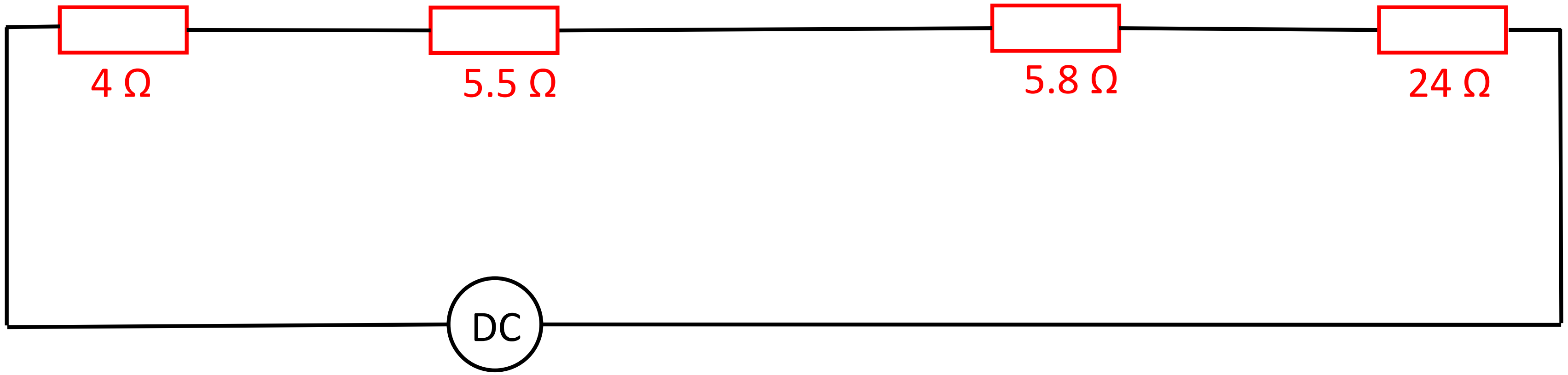


SOLUTION

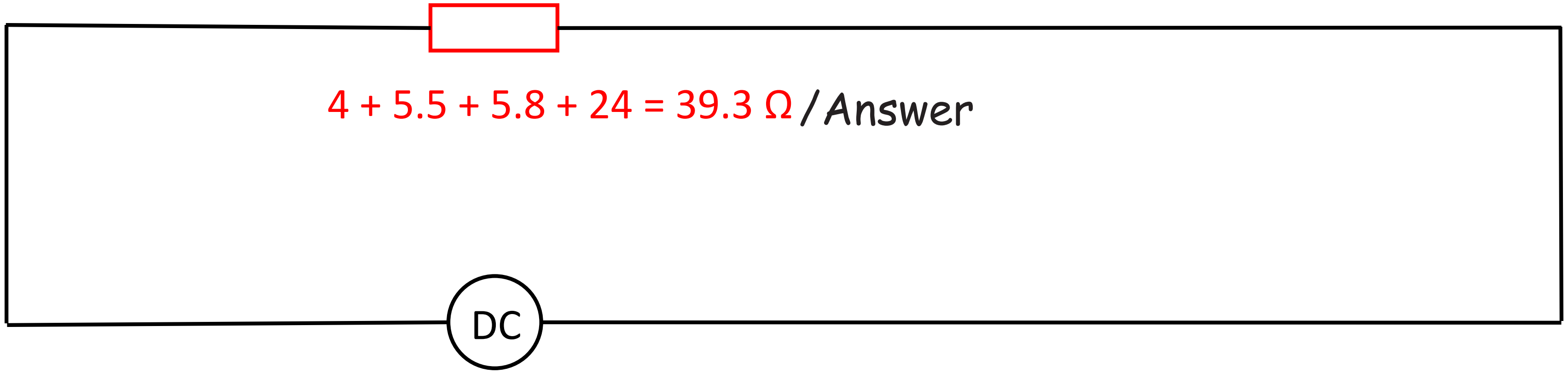


3.

Find the equivalent resistance



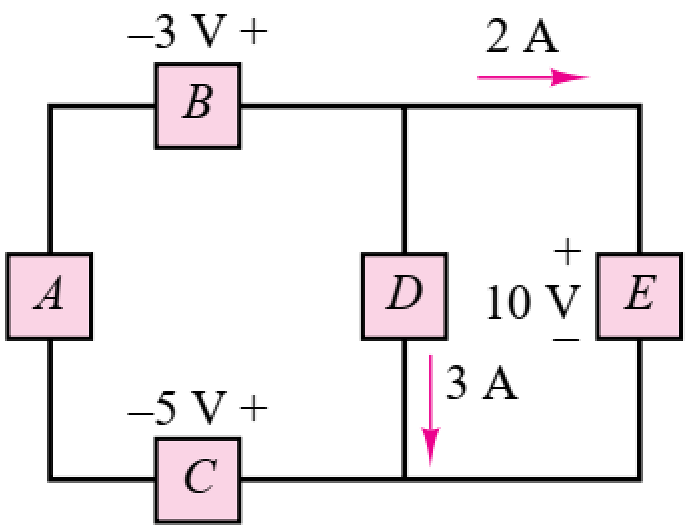
SOLUTION



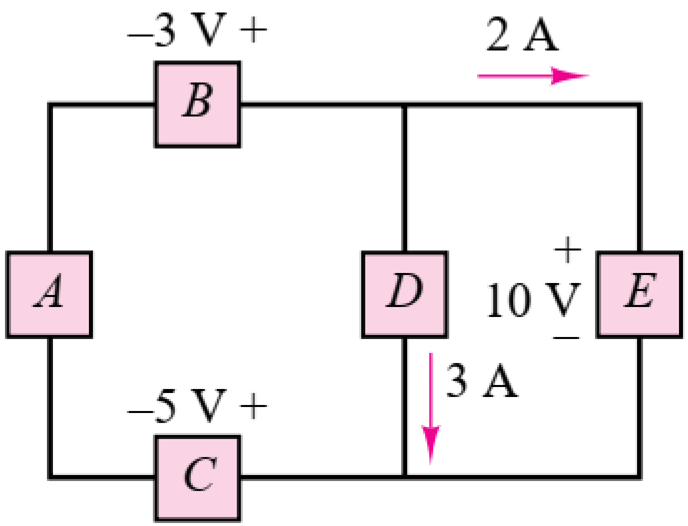
4 + 5.5 + 5.8 + 24 = 39.3 Ω / *Answer*

4.

Determine which components are absorbing power and which are delivering power



4.



By KCL, the current through element B is 5 A, to the right.

$-v_a - 3 + 10 + 5 = 0$ / By KVL

$v_a = 12$ V

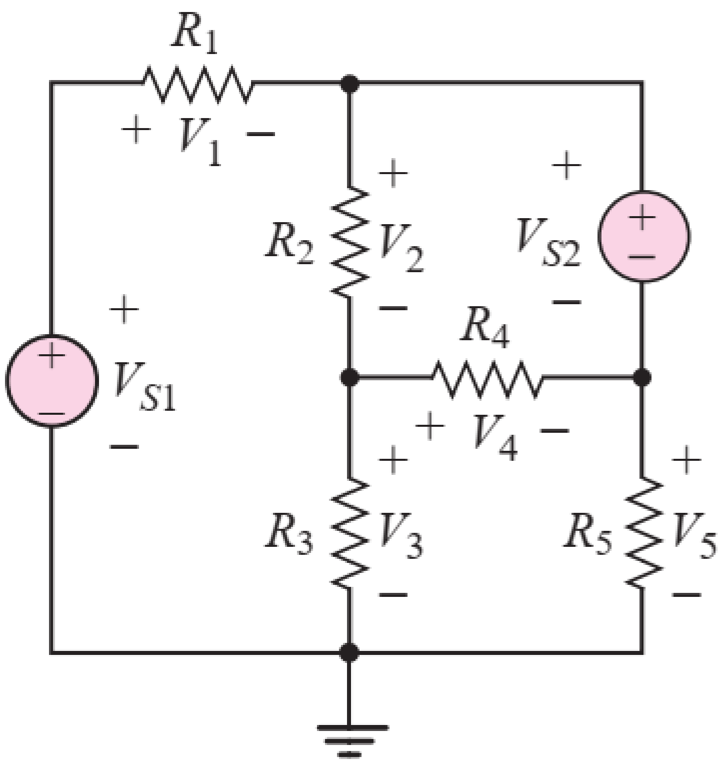
SOLUTION

Answer:

A supplies (12 V)(5 A) = 60 W
B supplies (3 V)(5 A) = 15 W
C absorbs (5 V)(5 A) = 25 W
D absorbs (10 V)(3 A) = 30 W
E absorbs (10 V)(2 A) = 20 W
Total power supplied = 60 W + 15 W = 75 W
Total power absorbed = 25 W + 30 W + 20 W = 75 W
Total power supplied = Total power absorbed, so conservation of power is satisfied

5.

Use KVL to determine the unknown voltages V_1 and V_4 in the circuit.



Given:
$V_{S1} = 12$ V
$V_{S2} = -4$ V
$V_2 = 2$ V
$V_3 = 6$ V
$V_5 = 12$ V

5.

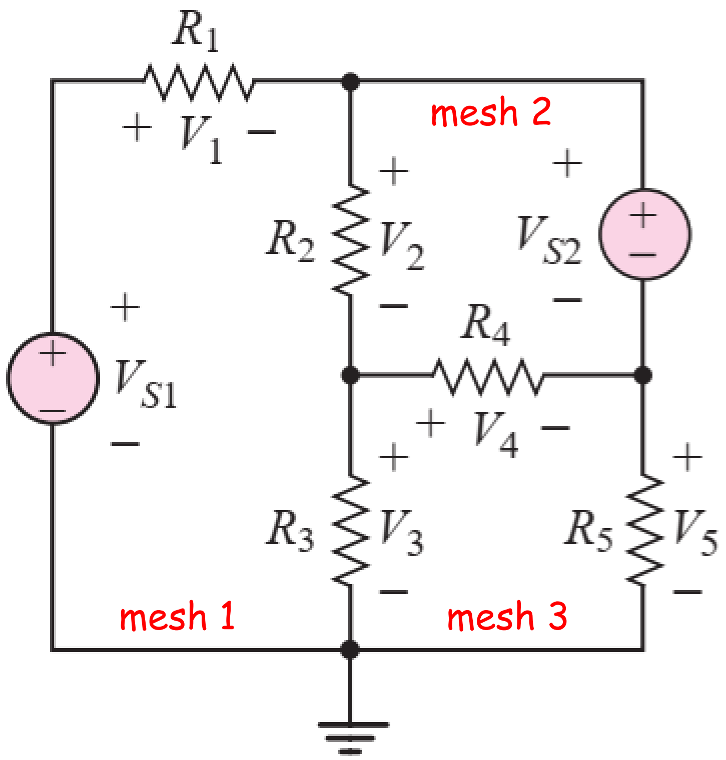
SOLUTION

Application of KVL clockwise
around each of the three meshes:

$$V_{S1} - V_1 - V_2 - V_3 = 0 \quad \text{/mesh 1}$$

$$V_2 - V_{S2} + V_4 = 0 \quad \text{/mesh 2}$$

$$V_3 - V_4 - V_5 = 0 \quad \text{/mesh 3}$$



Given:

$V_{S1} = 12$ V

$V_{S2} = -4$ V

$V_2 = 2$ V

$V_3 = 6$ V

$V_5 = 12$ V

$$12 - V_1 - 2 - 6 = 0$$

$$V_1 = 4\text{ V} \quad \text{/Answer}$$

$$2 - (-4) + V_4 = 0$$

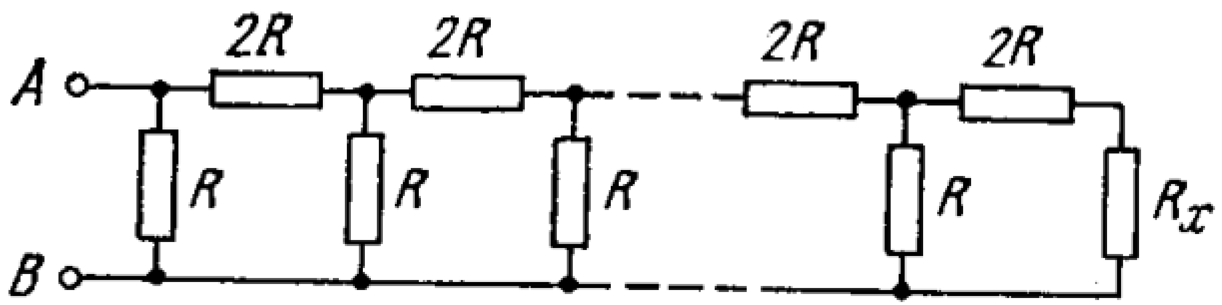
$$V_4 = -6\text{ V} \quad \text{/Answer}$$

$$6 - (-6) - V_5 = 0$$

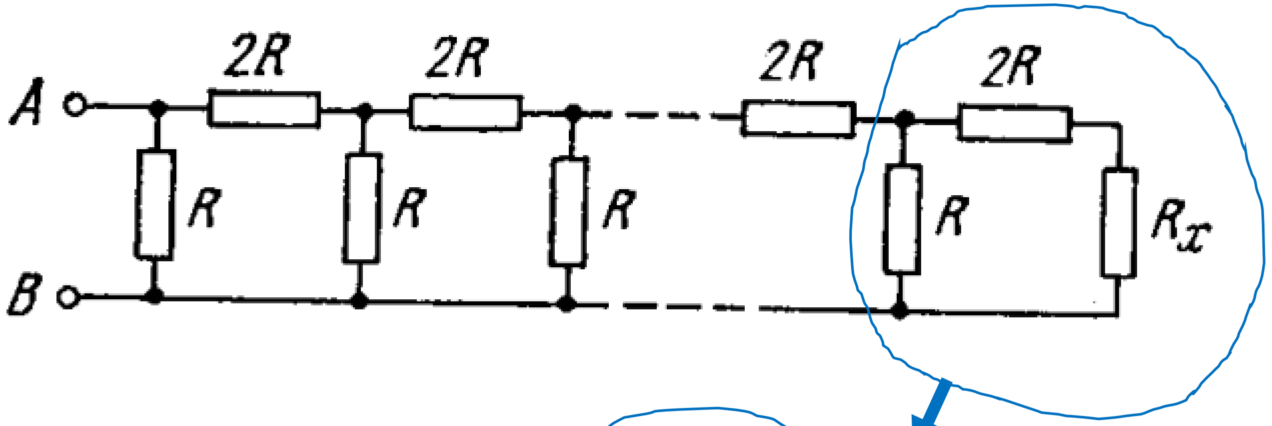
$$V_5 = 12\text{ V}$$

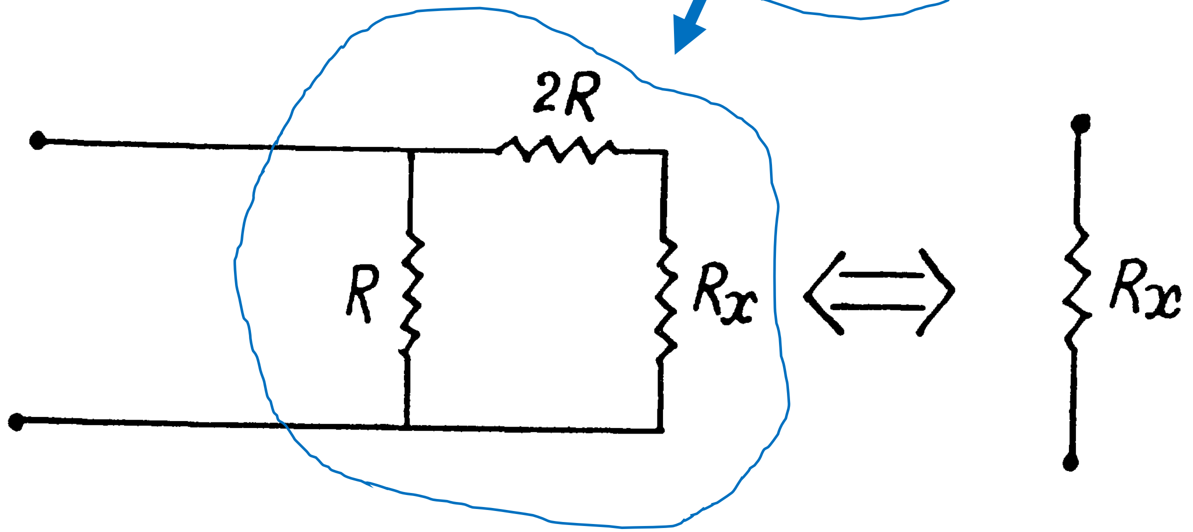
6.

At what size of the resistor R_x the equivalent resistance between points *A* and *B* is independent on the number of meshes?



6.





$$R_x = \frac{(R_x + 2R)\,R}{R_x + 2R + R}$$

$$R_x^2 + 2R\,R_x - 2\,R^2 = 0$$

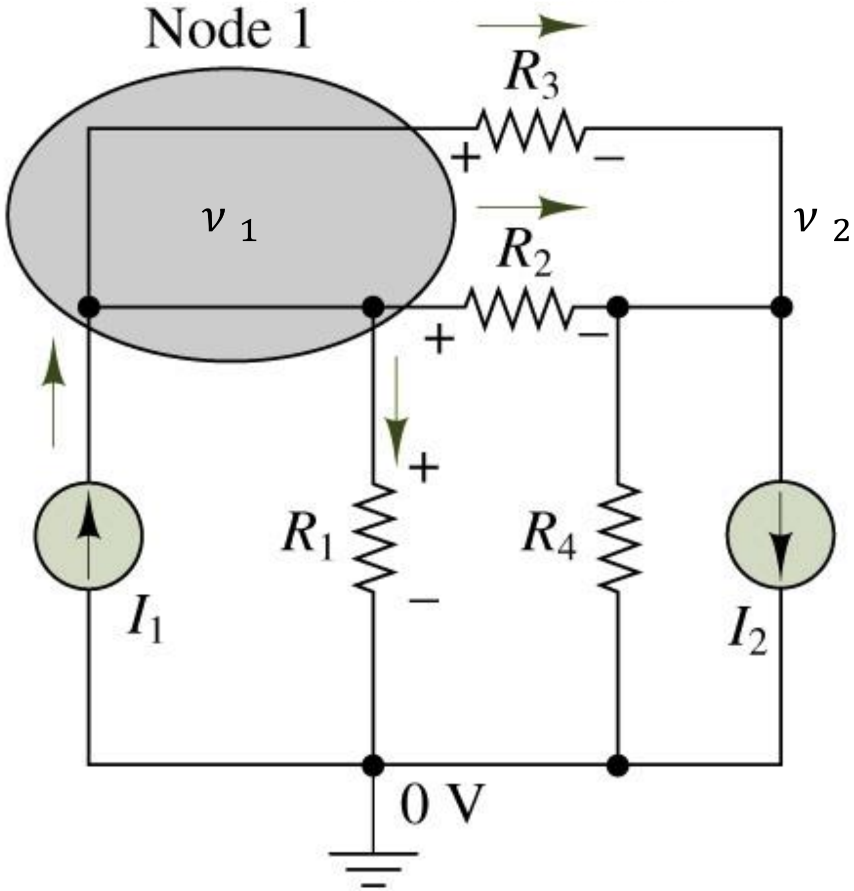
On solving and rejecting the negative root of the quadratic equation, we have,

$$R_x = R\left(\sqrt{3} - 1\right) \text{ /Answer}$$

Problem 1 : NVM

The circuit with following quantities is given:

$$I_1 = 10mA,\ I_2 = 50mA$$
$$R_1 = 1\,k\Omega,\quad R_2 = 2\,k\Omega,$$
$$R_3 = 10\,k\Omega,\quad R_4 = 2\,k\Omega,$$



Find the voltages v_1 and v_2.

Problem 1 : NVM

$$I_1 - \frac{v_1 - 0}{R_1} - \frac{v_1 - v_2}{R_2} - \frac{v_1 - v_2}{R_3} = 0 \quad \text{node 1}$$

$$\frac{v_1 - v_2}{R_2} + \frac{v_1 - v_2}{R_3} - \frac{v_2 - 0}{R_4} - I_2 = 0 \quad \text{node 2}$$

$$\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right) v_1 + \left(-\frac{1}{R_2} - \frac{1}{R_3}\right) v_2 = I_1$$

$$\left(-\frac{1}{R_2} - \frac{1}{R_3}\right) v_1 + \left(\frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}\right) v_2 = -I_2$$

Solving this system of equations, we obtain

$$v_1 = -13.57 \text{ V}$$

$$v_2 = -52.86 \text{ V}$$

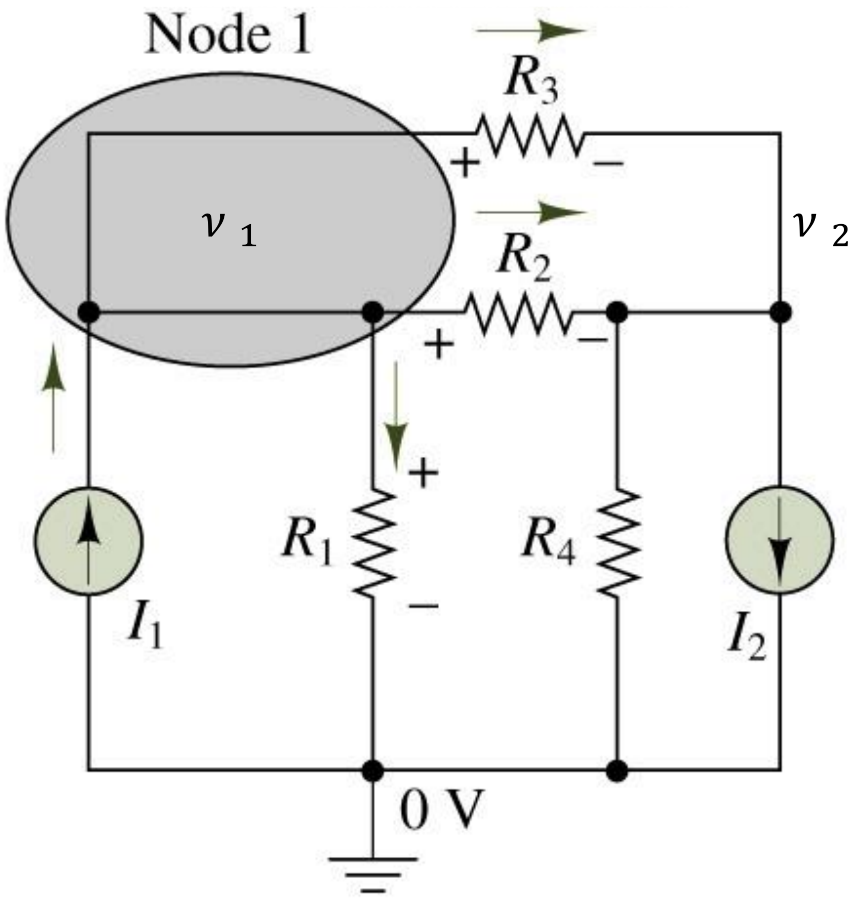
$$i_{R3} = \frac{v_1 - v_2}{10{,}000} = 3.93 \text{ mA}$$

$$i_{R1} = \frac{v_1}{1{,}000} = -13.57 \text{ mA}$$

$$I_1 = 10mA, \; I_2 = 50mA$$

$$R_1 = 1\,k\Omega, \quad R_2 = 2\,k\Omega,$$

$$R_3 = 10\,k\Omega, \quad R_4 = 2\,k\Omega,$$



Problem 2: NVM

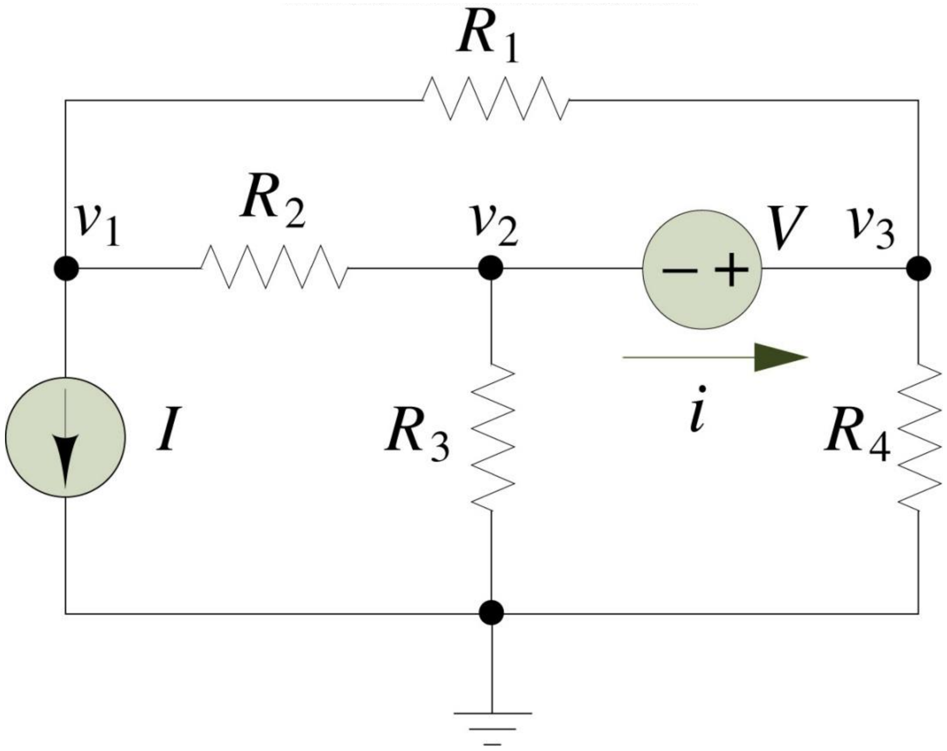
The circuit with following quantities is given:

$$R_1 = R_2 = 2\,\Omega,$$

$$R_3 = 4\,\Omega,\ R_4 = 3\,\Omega$$

$$I = 2\ \text{A},\ V = 3\ \text{V}$$

Find the current i.



Problem 2: NVM

System of equations:

$$\begin{cases} \dfrac{v_3 - v_1}{R_1} + \dfrac{v_2 - v_1}{R_2} - I = 0 \qquad \text{node 1} \\ \dfrac{v_1 - v_2}{R_2} - \dfrac{v_2}{R_3} - i = 0 \qquad \text{node 2} \\ i = \dfrac{v_3 - v_1}{R_1} + \dfrac{v_3}{R_4} \\ v_3 = v_2 + 3\text{ V} \end{cases}$$

solution:

$$v_1 = -5.64\text{ V}$$

$$v_2 = -5.14\text{ V}$$

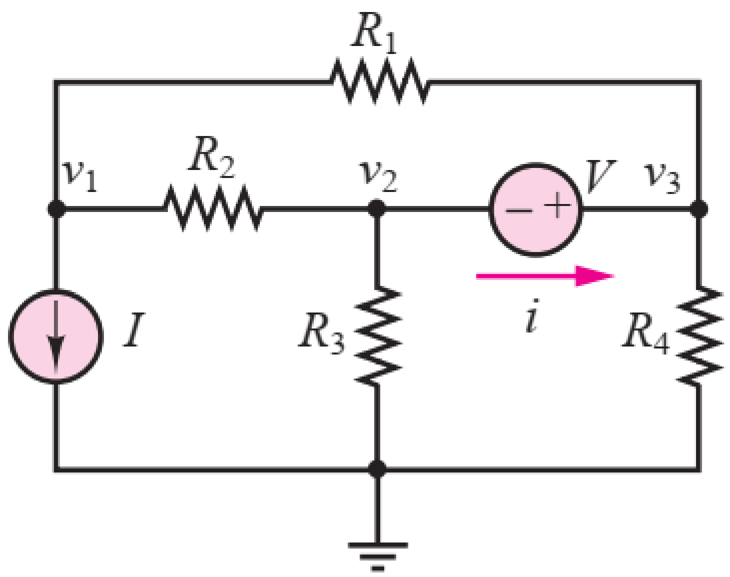
$$v_3 = v_2 + 3\text{ V} = -2.14\text{ V}$$

Answer: $$i = \frac{v_3 - v_1}{R_1} + \frac{v_3}{R_4} = \frac{-2.14 + 5.64}{2} + \frac{-2.14}{3} = 1.04\text{ A}$$

$R_1 = R_2 = 2\,\Omega$,

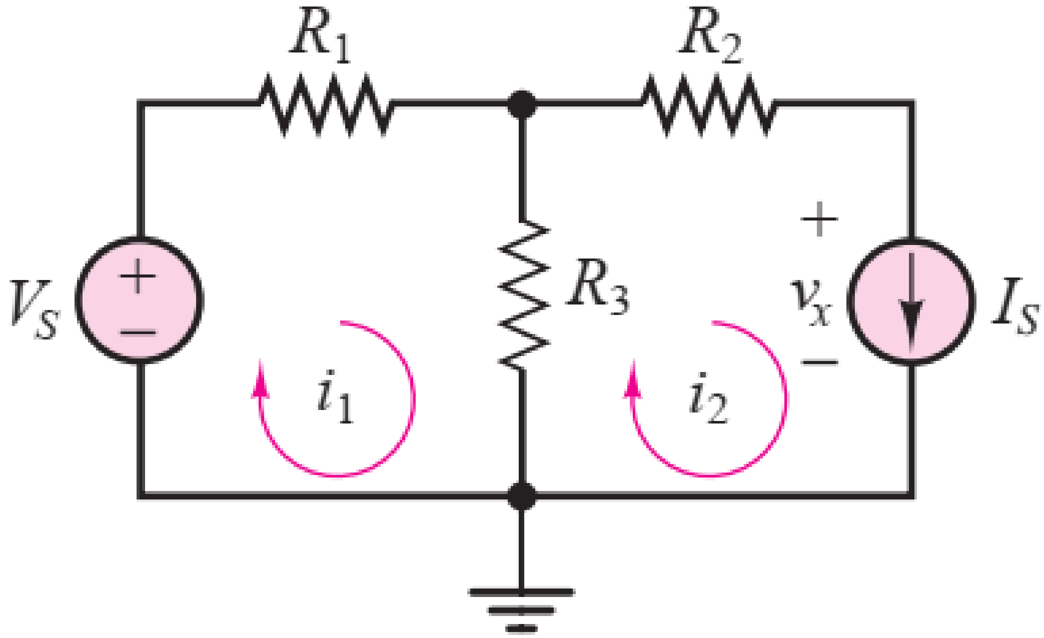
$R_3 = 4\,\Omega$, $R_4 = 3\,\Omega$

$I = 2\text{ A}$, $V = 3\text{ V}$



Problem 3: MCM

Find unknown current i_1 in the circuit



$V_S = 10$ V; $I_S = 2$ A; $R_1 = 5\ \Omega$; $R_2 = 2\ \Omega$; and $R_3 = 4\ \Omega$.

Problem 3: MCM

Find unknown current i_1 in the circuit

$$i_2 = I_S$$

Thus, the unknown voltage, v_x, can be obtained applying KVL to mesh 2:

$$(i_1 - i_2)R_3 - i_2 R_2 - v_x = 0$$

$$v_x = (i_1 - i_2)R_3 - i_2 R_2 = i_1 R_3 - i_2 (R_2 + R_3)$$

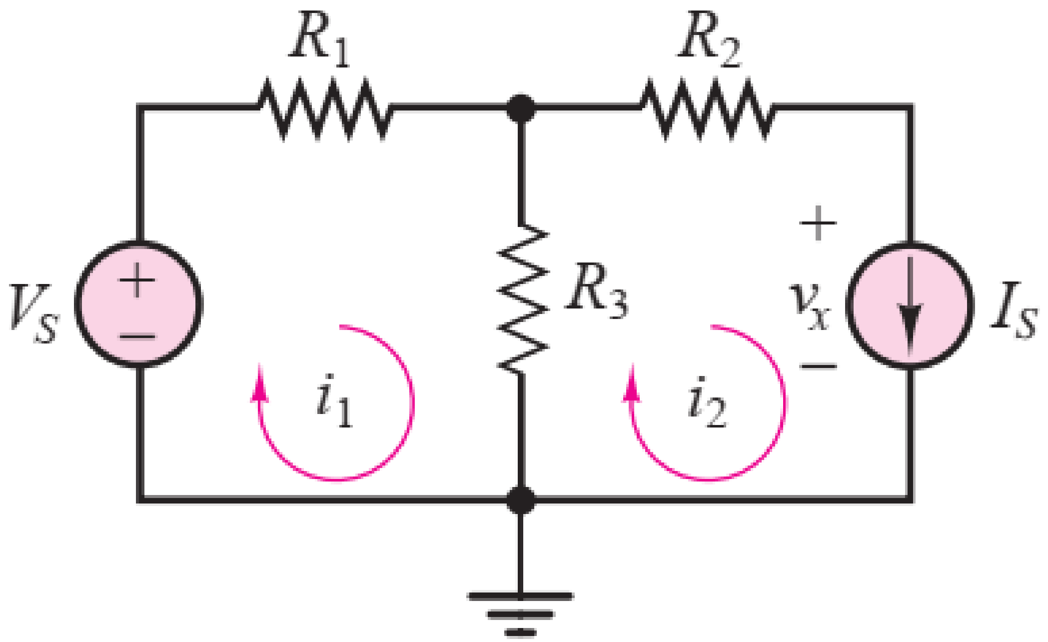
To find the current i_1 we apply KVL to mesh 1:

$$V_S - i_1 R_1 - (i_1 - i_2) R_3 = 0$$

$$V_S + i_2 R_3 = i_1 (R_1 + R_3)$$

but since $i_2 = I_S$

$$i_1 = \frac{V_S + I_S R_3}{(R_1 + R_3)} = \frac{10 + 2 \times 4}{5 + 4} = 2 \text{ A}$$

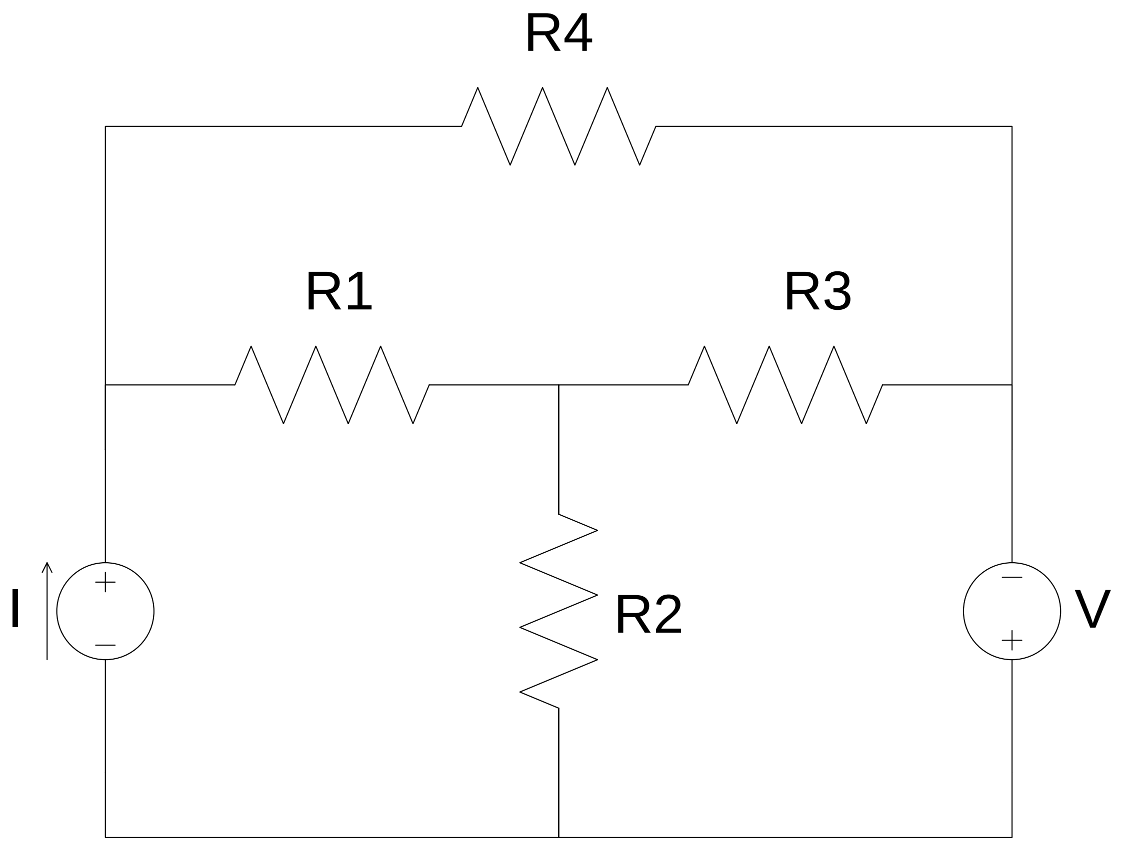


$V_S = 10$ V; $I_S = 2$ A; $R_1 = 5\ \Omega$; $R_2 = 2\ \Omega$; and $R_3 = 4\ \Omega$.

Answer: $i_1 = 2\ A$

Problem 4: MCM

Find the mesh currents

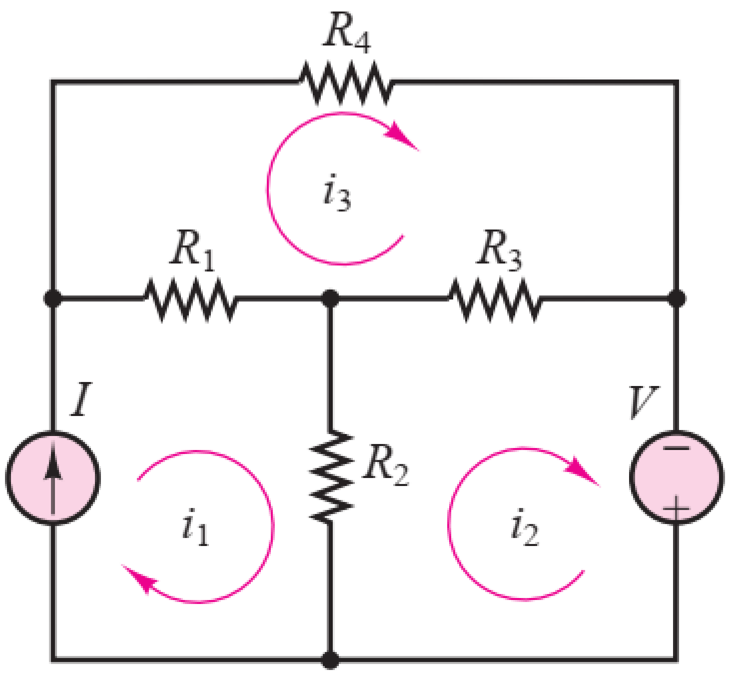


$I = 0.5$ A; $V = 6$ V; $R_1 = 3\ \Omega$; $R_2 = 8\ \Omega$; $R_3 = 6\ \Omega$; $R_4 = 4\ \Omega$.

Problem 4: MCM

$$I = 0.5\ \text{A};\ V = 6\ \text{V};\ R_1 = 3\ \Omega;$$

$$R_2 = 8\ \Omega;\ R_3 = 6\ \Omega;\ R_4 = 4\ \Omega.$$



$$i_1 = I$$

$$-R_2(i_2 - i_1) - R_3(i_2 - i_3) + V = 0 \qquad \text{mesh 2}$$
$$-R_1(i_3 - i_1) - R_4 i_3 - R_3(i_3 - i_2) = 0 \qquad \text{mesh 3}$$

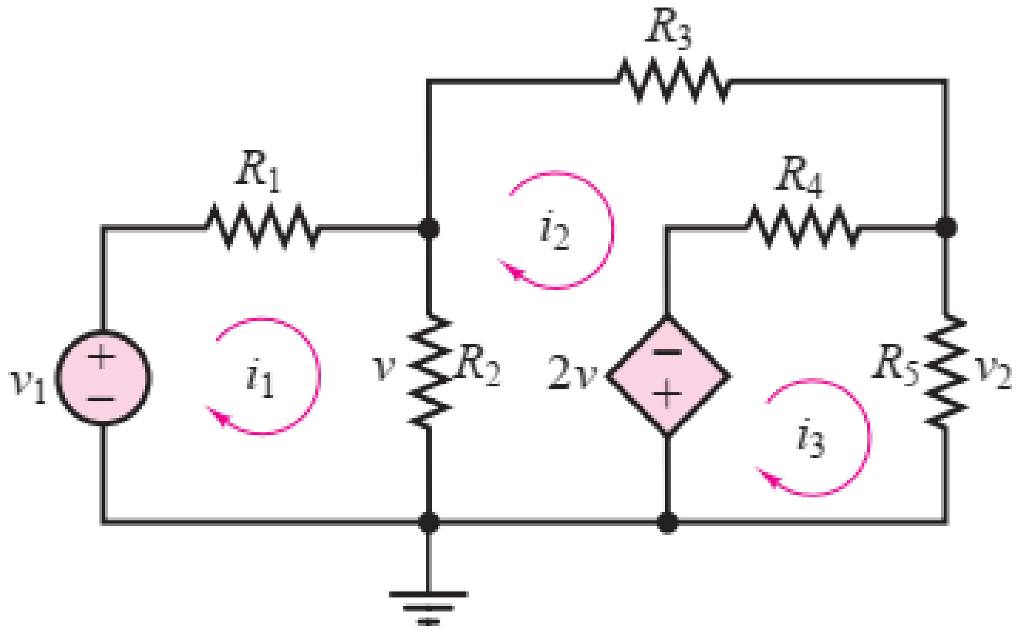
or

$$14 i_2 - 6 i_3 = 10$$
$$-6 i_2 + 13 i_3 = 1.5$$

Answer: $i_2 = 0.95\ \text{A}$ $\qquad$ $i_3 = 0.55\ \text{A}$

Problem 5: MCM with Dependent Source

Find the voltage "gain" $A_v = {}^{v_2}/_{v_1}$ if the voltages v and v_2 determined as $v = R_2(i_1 - i_2)$ and $v_2 = R_5 i_3$



$$R_1 = 1\ \Omega;\ R_2 = 0.5\ \Omega;\ R_3 = 0.25\ \Omega;\ R_4 = 0.25\ \Omega;\ R_5 = 0.25\ \Omega.$$

Problem 5: MCM with Dependent Source

$v = R_2(i_1 - i_2)$, and $v_2 = R_5 i_3$

For mesh 1:

$$v_1 - R_1 i_1 - R_2(i_1 - i_2) = 0$$

or rearranging the equation gives

$$(R_1 + R_2)i_1 + (-R_2)i_2 + (0)i_3 = v_1$$

For mesh 2:

$$v - R_3 i_2 - R_4(i_2 - i_3) + 2v = 0$$

Rearranging the equation and substituting the expression $v = -R_2(i_2 - i_1)$, we obtain

$$-R_2(i_2 - i_1) - R_3 i_2 - R_4(i_2 - i_3) - 2R_2(i_2 - i_1) = 0$$

$$(-3R_2)i_1 + (3R_2 + R_3 + R_4)i_2 - (R_4)i_3 = 0$$

For mesh 3:

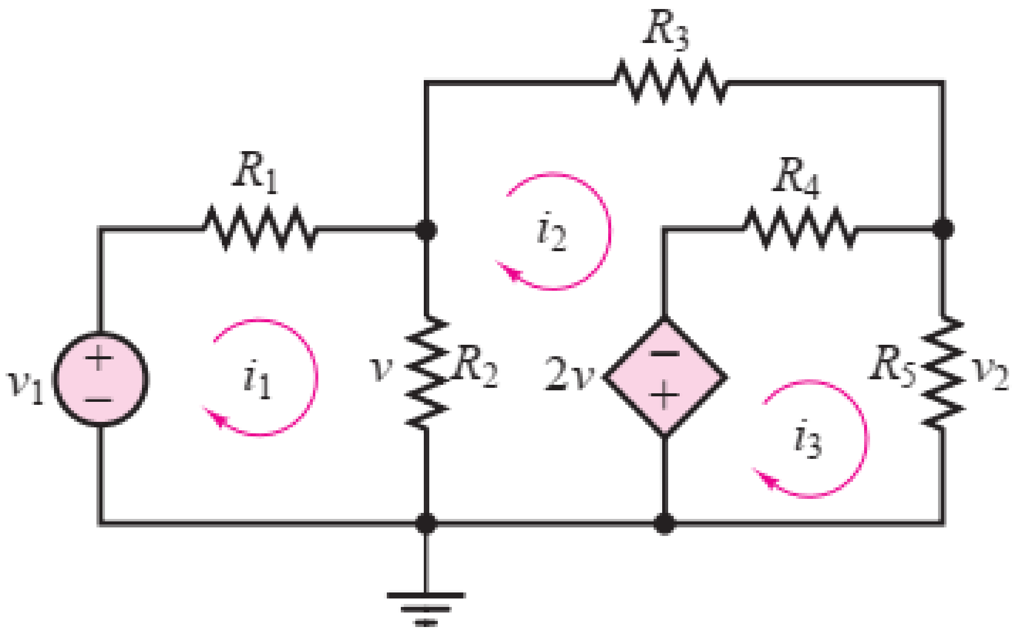
$$-2v - R_4(i_3 - i_2) - R_5 i_3 = 0$$

substituting the expression for $v = R_2(i_1 - i_2)$ and rearranging, we obtain

$$-2R_2(i_1 - i_2) - R_4(i_3 - i_2) - R_5 i_3 = 0$$

$$2R_2 i_1 - (2R_2 + R_4)i_2 + (R_4 + R_5)i_3 = 0$$

$R_1 = 1\ \Omega;\ R_2 = 0.5\ \Omega;\ R_3 = 0.25\ \Omega;$



Problem 5: MCM with Dependent Source

$$R_1 = 1\ \Omega;\ R_2 = 0.5\ \Omega;\ R_3 = 0.25\ \Omega;$$
$$R_4 = 0.25\ \Omega;\ R_5 = 0.25\ \Omega.$$

Physics:

$v = R_2(i_1 - i_2)$, and $v_2 = R_5 i_3$

For mesh 1:

$$v_1 - R_1 i_1 - R_2(i_1 - i_2) = 0$$

or rearranging the equation gives

$$(R_1 + R_2)i_1 + (-R_2)i_2 + (0)i_3 = v_1$$

For mesh 2:

$$v - R_3 i_2 - R_4(i_2 - i_3) + 2v = 0$$

Rearranging the equation and substituting the expression $v = -R_2(i_2 - i_1)$, we obtain

$$-R_2(i_2 - i_1) - R_3 i_2 - R_4(i_2 - i_3) - 2R_2(i_2 - i_1) = 0$$
$$(-3R_2)i_1 + (3R_2 + R_3 + R_4)i_2 - (R_4)i_3 = 0$$

For mesh 3:

$$-2v - R_4(i_3 - i_2) - R_5 i_3 = 0$$

substituting the expression for $v = R_2(i_1 - i_2)$ and rearranging, we obtain

$$-2R_2(i_1 - i_2) - R_4(i_3 - i_2) - R_5 i_3 = 0$$
$$2R_2 i_1 - (2R_2 + R_4)i_2 + (R_4 + R_5)i_3 = 0$$

Mathematics:

$$\begin{bmatrix} (R_1 + R_2) & (-R_2) & 0 \\ (-3R_2) & (3R_2 + R_3 + R_4) & (-R_4) \\ (2R_2) & -(2R_2 + R_4) & (R_4 + R_5) \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} v_1 \\ 0 \\ 0 \end{bmatrix}$$

$$\begin{bmatrix} 1.5 & -0.5 & 0 \\ -1.5 & 2 & -0.25 \\ 1 & -1.25 & 0.5 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} v_1 \\ 0 \\ 0 \end{bmatrix}$$

$$[R][i] = [v] \qquad [i] = [R]^{-1}[v]$$

$$[R]^{-1} = \begin{bmatrix} 0.88 & 0.32 & 0.16 \\ 0.64 & 0.96 & 0.48 \\ -0.16 & 1.76 & 2.88 \end{bmatrix}$$

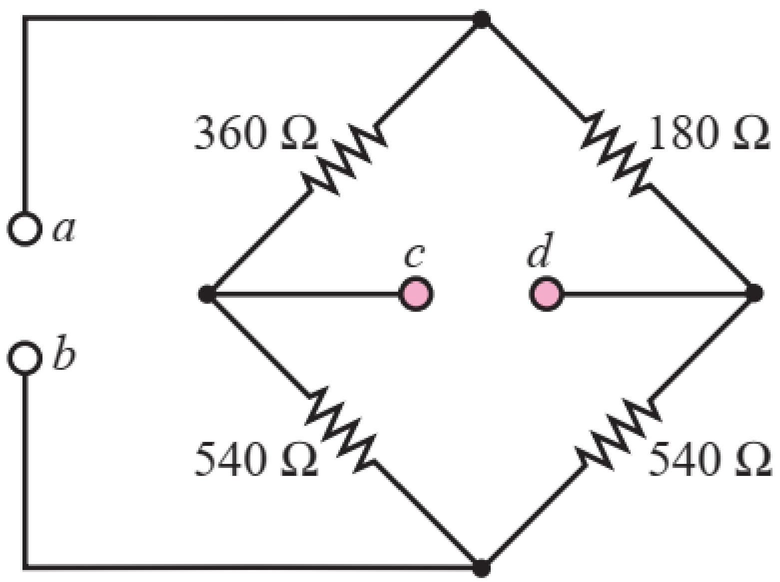
$$i_1 = 0.88v_1$$
$$i_2 = 0.64v_1$$
$$i_3 = -0.16v_1$$

$$v_2 = R_5 i_3 = R_5(-0.16v_1) = 0.25(-0.16v_1)$$

$$A_v = \frac{v_2}{v_1} = \frac{-0.04v_1}{v_1} = -0.04$$ /Answer

1.

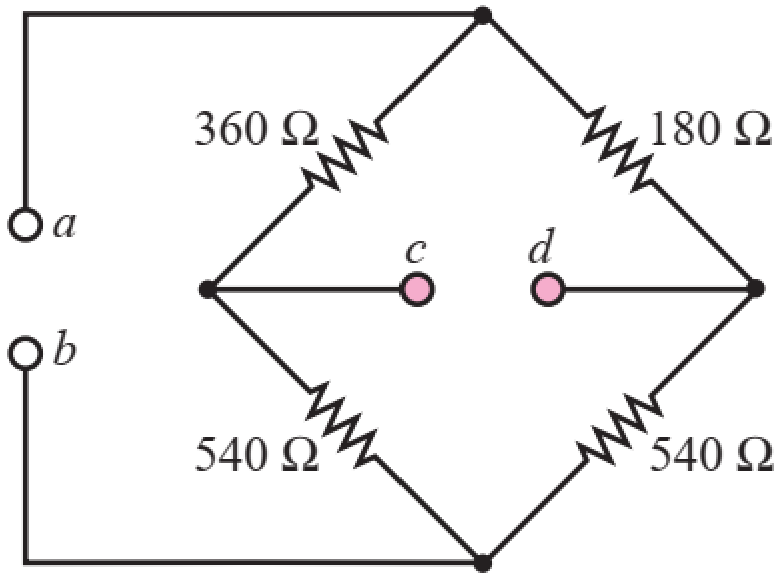
Find the equivalent resistance looking in at terminals *a* and *b* if terminals *c* and *d* are open and again if terminals *c* and *d* are shorted together. Also, find the equivalent resistance looking in at terminals *c* and *d* if terminals *a* and *b* are open and if terminals *a* and *b* are shorted together.



1.

Terminals (c – d) open

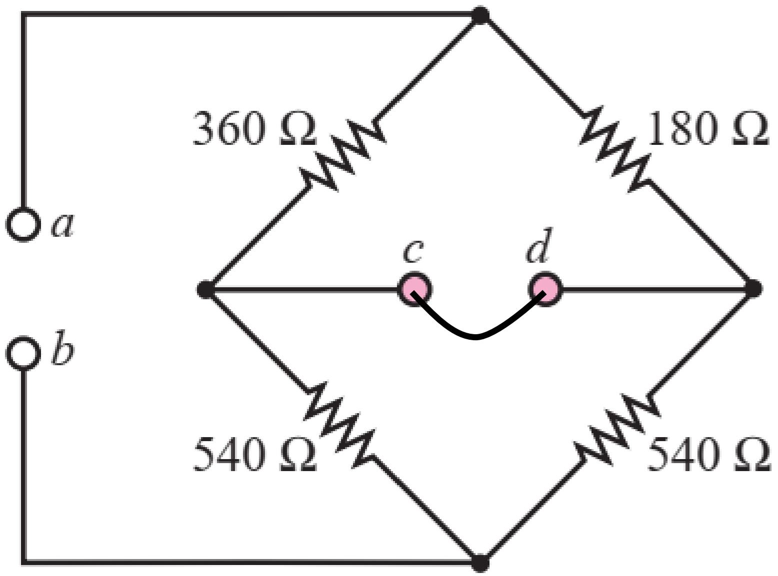
$$R_{eq} = \left(\frac{1}{360 + 540} + \frac{1}{180 + 540} \right)^{-1} = 400 \ \Omega$$



1.

Terminals (c – d) shorted

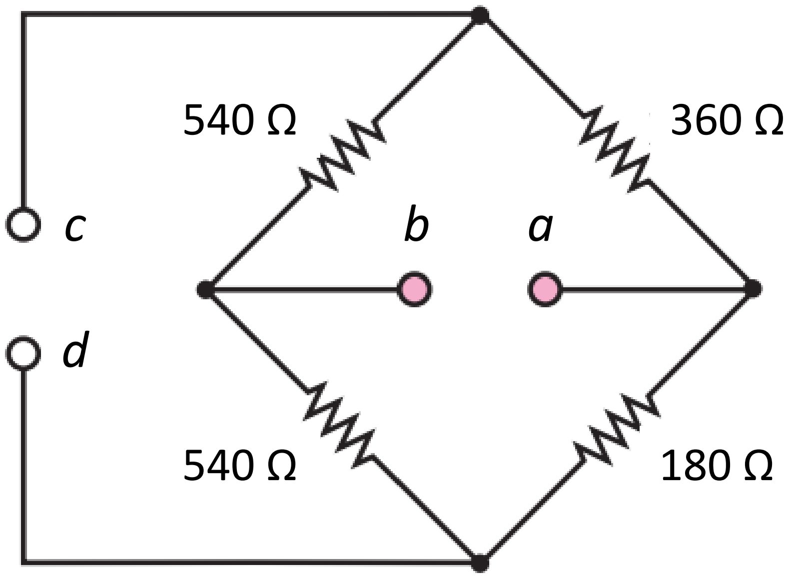
$$R_{eq} = \left(\frac{1}{360} + \frac{1}{180}\right)^{-1} + \left(\frac{1}{540} + \frac{1}{540}\right)^{-1} = 390 \ \Omega$$



1.

$$R_{eq} = \left(\frac{1}{540 + 540} + \frac{1}{360 + 180} \right)^{-1} = 360 \ \Omega$$

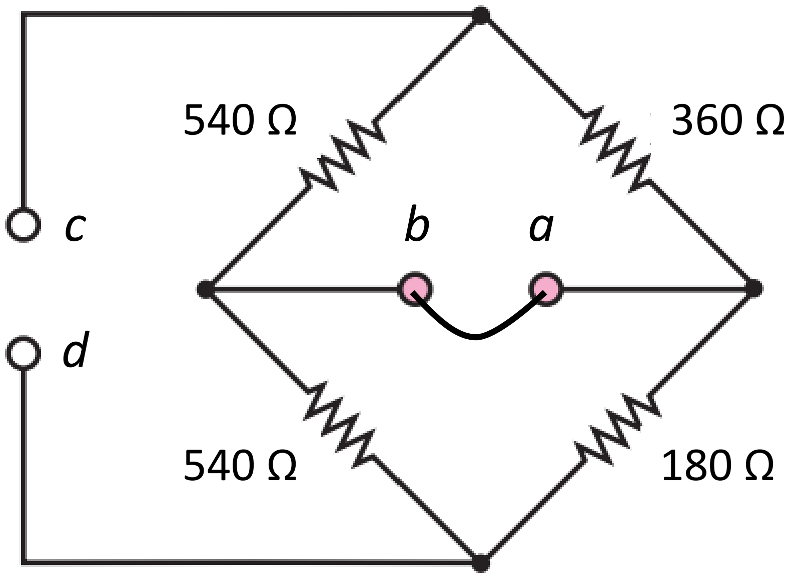
terminals (a – b) open



1.

$$R_{eq} = \left(\frac{1}{540} + \frac{1}{360}\right)^{-1} + \left(\frac{1}{540} + \frac{1}{180}\right)^{-1} = 351\ \Omega$$

Terminals (a – b) shorted

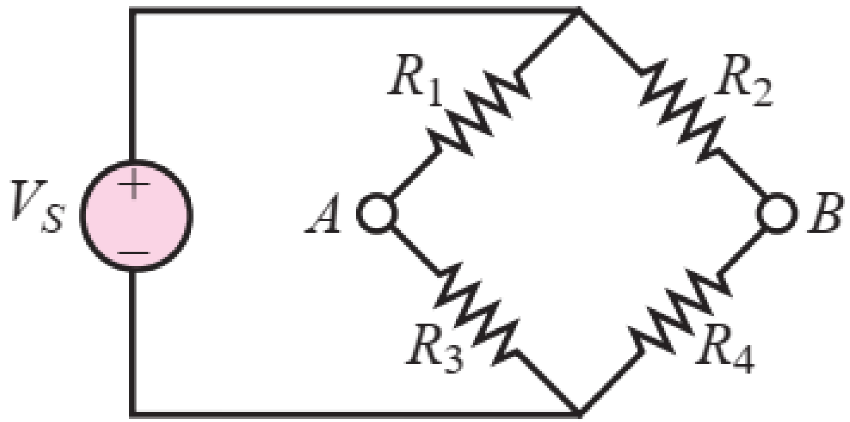


2.

Determine the voltage between nodes *A* and *B* in the circuit

$V_S = 12$ V

$R_1 = 11$ kΩ	$R_3 = 6.8$ kΩ
$R_2 = 220$ kΩ	$R_4 = 0.22$ MΩ



2.

Determine the voltage between nodes *A* and *B* in the circuit

$$V_3 := V_S \cdot \frac{R_3}{R_1 + R_3} = 4.584 \text{ V}$$

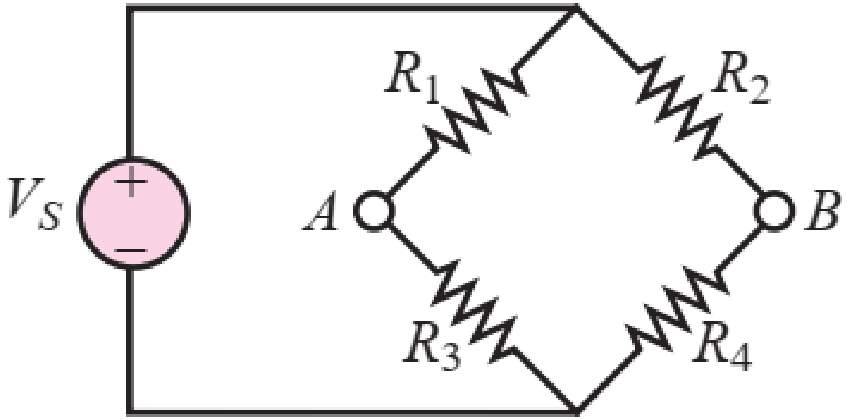
$$V_4 := V_S \cdot \frac{R_4}{R_2 + R_4} = 6 \text{ V}$$

Answer: $V_3 - V_4 = -1.41$ V

$V_S = 12$ V

$R_1 = 11$ kΩ $R_3 = 6.8$ kΩ

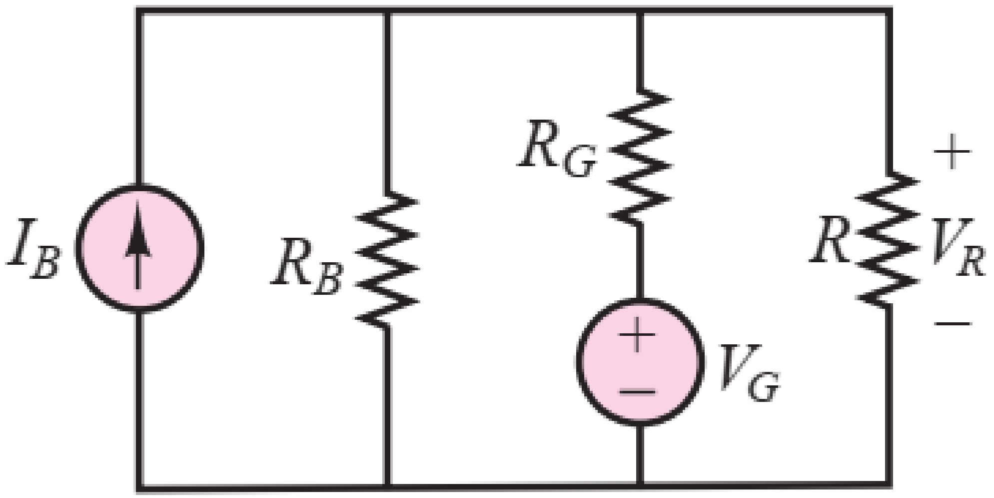
$R_2 = 220$ kΩ $R_4 = 0.22$ MΩ



3.

Determine the voltage across resistor *R* in the circuit

$I_B = 12$ A; $V_G = 12$ V; $R_B = 1\ \Omega$; $R_G = 0.3\ \Omega$; $R = 0.23\ \Omega$

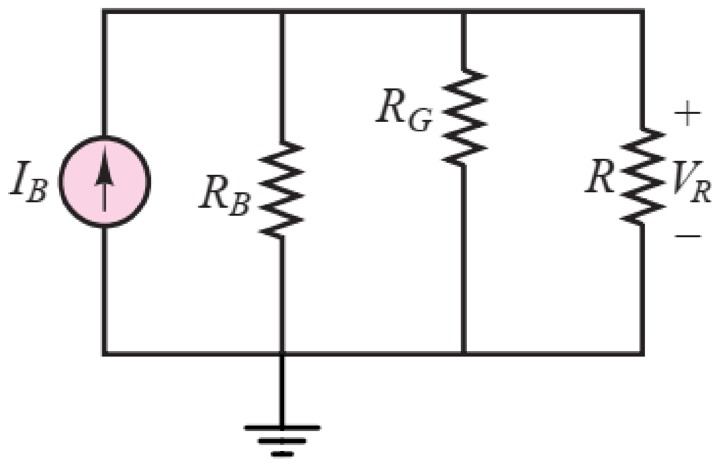


3.

$$I_B = 12\ \text{A};\ V_G = 12\ \text{V};\ R_B = 1\ \Omega;\ R_G = 0.3\ \Omega;\ R = 0.23\ \Omega$$

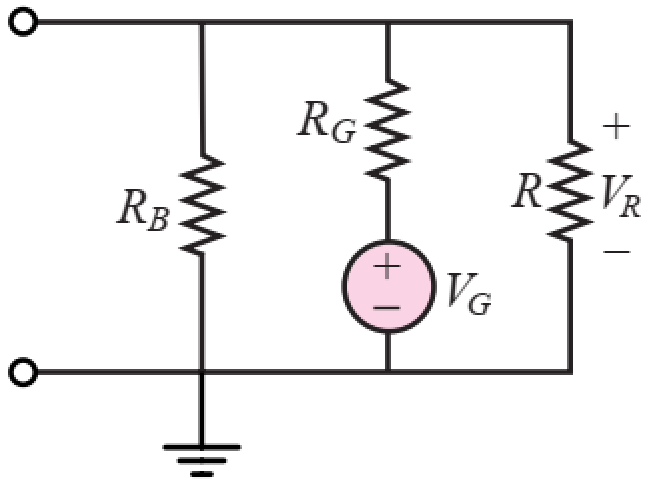
$$-I_B + \frac{V_{R-I}}{R_B} + \frac{V_{R-I}}{R_G} + \frac{V_{R-I}}{R} = 0$$

$$V_{R-I} = \frac{I_B}{1/R_B + 1/R_G + 1/R} = \frac{12}{1/1 + 1/0.3 + 1/0.23} = 1.38\ \text{V}$$



$$\frac{V_{R-V}}{R_B} + \frac{V_{R-V} - V_G}{R_G} + \frac{V_{R-V}}{R} = 0$$

$$V_{R-V} = \frac{V_G/R_G}{1/R_B + 1/R_G + 1/R} = \frac{12/0.3}{1/1 + 1/0.3 + 1/0.23} = 4.61\ \text{V}$$



Answer: $V_R = V_{R-I} + V_{R-V} = 5.99\ \text{V}$

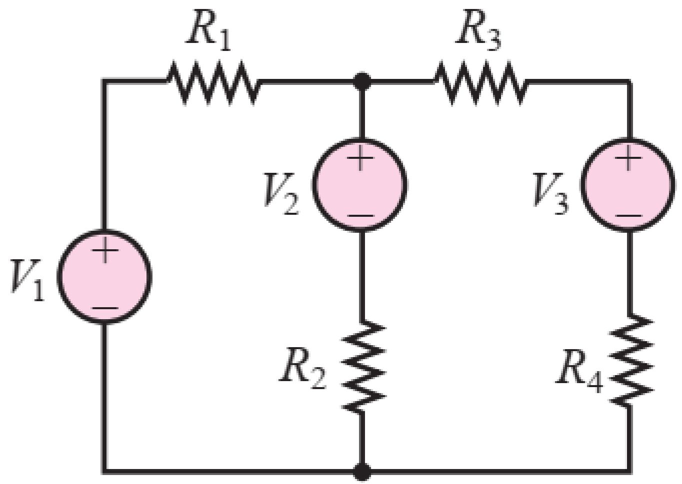
4.

Find the mesh currents in the circuit using superposition

$V_1 = 10$ V; $V_2 = 9$ V; $V_3 = 1$ V;

$R_1 = 5\ \Omega$; $R_2 = 10\ \Omega$; $R_3 = 5\ \Omega$;

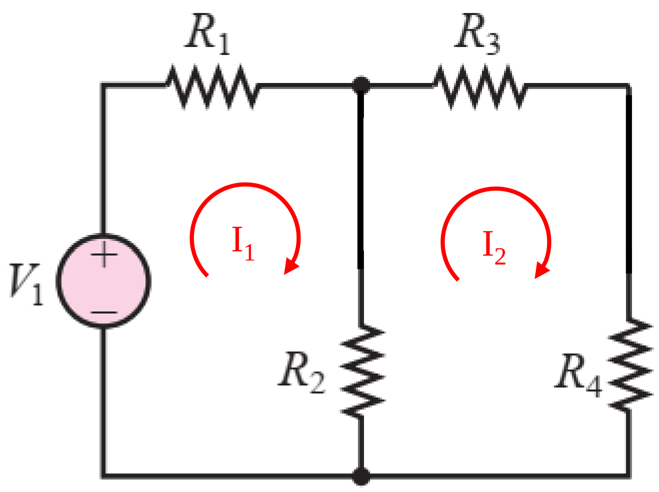
$R_4 = 5\ \Omega$.

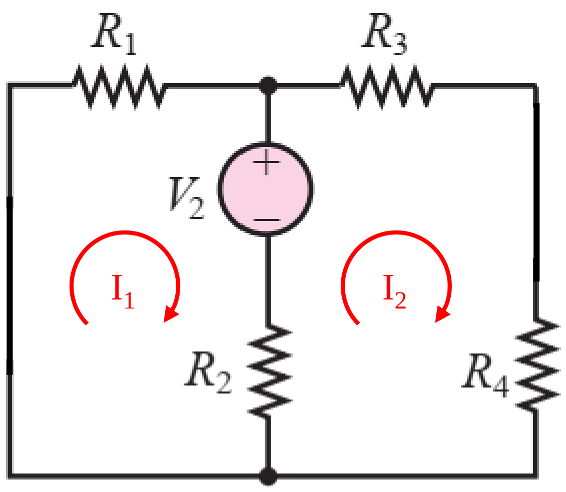


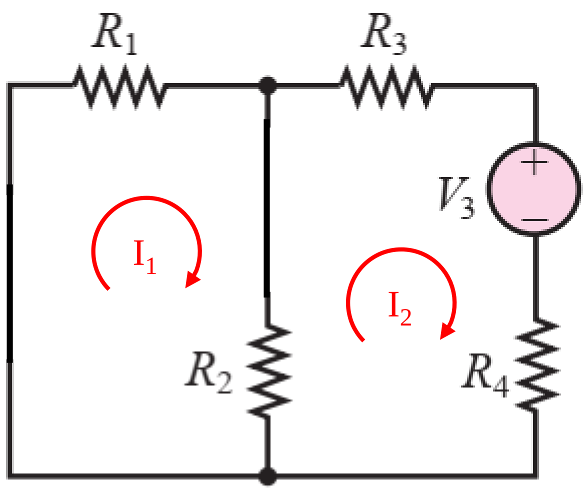
4.

Find the mesh currents in the circuit using superposition

$V_1 = 10$ V; $V_2 = 9$ V; $V_3 = 1$ V;
$R_1 = 5\ \Omega$; $R_2 = 10\ \Omega$; $R_3 = 5\ \Omega$;
$R_4 = 5\ \Omega$.







$$\begin{cases} V_1 - R_1\cdot I1 - R_2(I1 - I2) = 0 \\ R_2\cdot(I2 - I1) + R_3\cdot I2 + R_4\cdot I2 = 0 \end{cases}$$

I1 = 1 A

I2 = 0.5 A

$$\begin{cases} -R_1\cdot I1 - V_2 - R_2\cdot(I1 - I2) = 0 \\ -R_2\cdot(I2 - I1) + V_2 - R_3\cdot I2 - R_4\cdot I2 = 0 \end{cases}$$

I1 = -0.45 A

I2 = 0.225 A

$$\begin{cases} R_1\cdot I1 + R_2\cdot(I1 - I2) = 0 \\ -R_2\cdot(I2 - I1) - R_3\cdot I2 - V_3 - R_4\cdot I2 = 0 \end{cases}$$

I1 = -0.05 A

I2 = -0.075 A

Answer: $I1_{tot} = 1 - 0.45 - 0.05 = 0.5$ A

$I2_{tot} = 0.5 + 0.225 - 0.075 = 0.65$ A

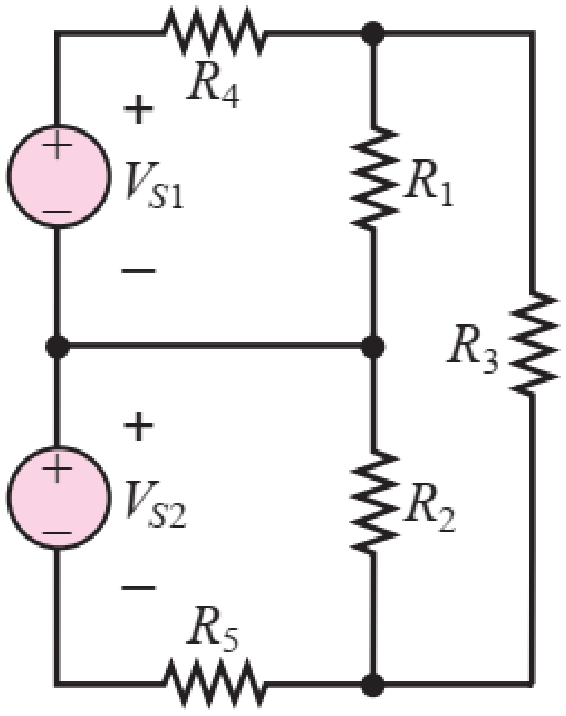
5.

Using superposition, determine the component of the current through R_3 that is due to V_{S2}.

$V_{S1} = V_{S2} = 450\ \text{V}$

$R_1 = 7\ \Omega \qquad R_2 = 5\ \Omega$

$R_3 = 10\ \Omega \qquad R_4 = R_5 = 1\ \Omega$



5.

Using superposition, determine the component of the current through R_3 that is due to V_{S2}.

$$R_{41} := \left(\frac{1}{R_4} + \frac{1}{R_1}\right)^{-1} = 0.875\ \Omega$$

$$\begin{cases} V_{S2} - (I1 - I2)\cdot R_2 - I1\cdot R_5 = 0 \\ R_{41}\cdot I2 + R_3\cdot I2 + (I2 - I1)\cdot R_2 = 0 \end{cases}$$

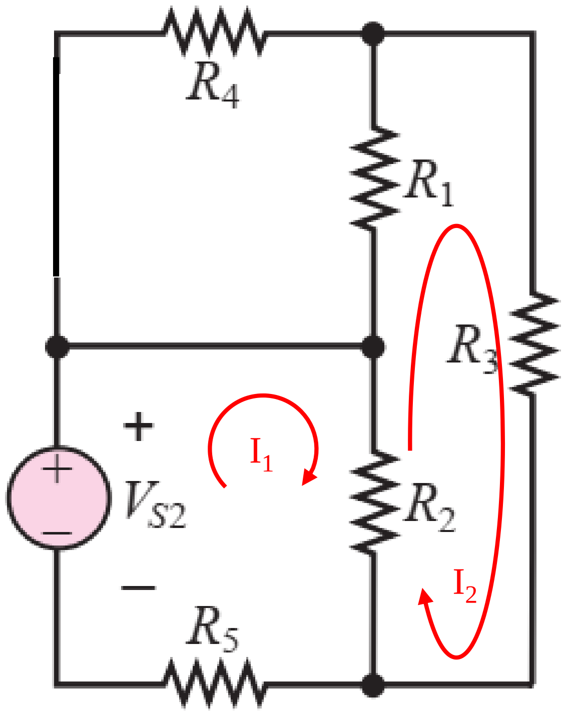
Answer: $I1 = 101.7\ A$

$I2 = 32.0\ A$

$V_{S1} = V_{S2} = 450\ V$

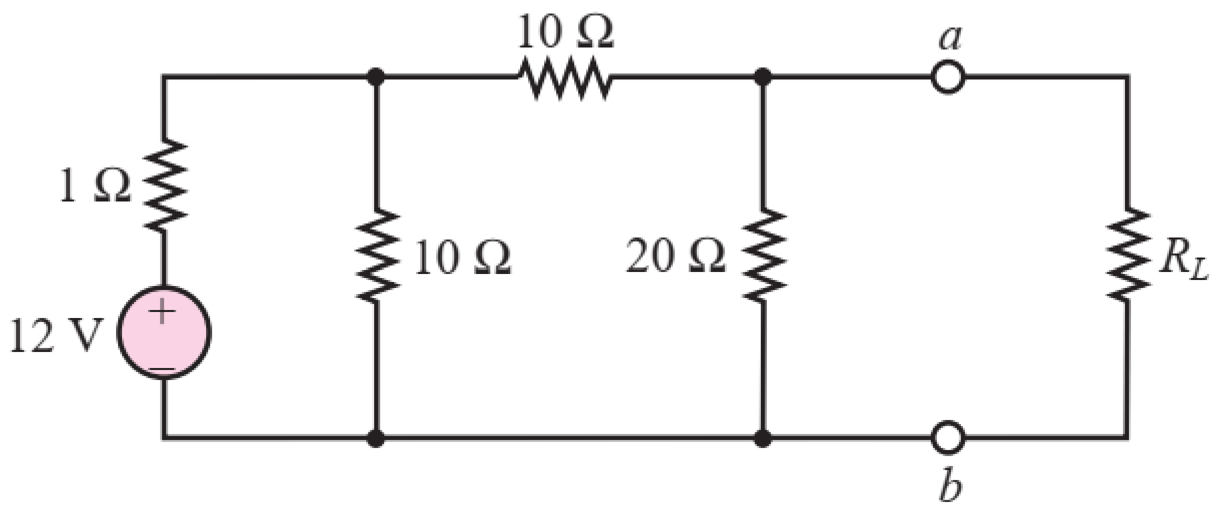
$R_1 = 7\ \Omega \qquad R_2 = 5\ \Omega$

$R_3 = 10\ \Omega \qquad R_4 = R_5 = 1\ \Omega$



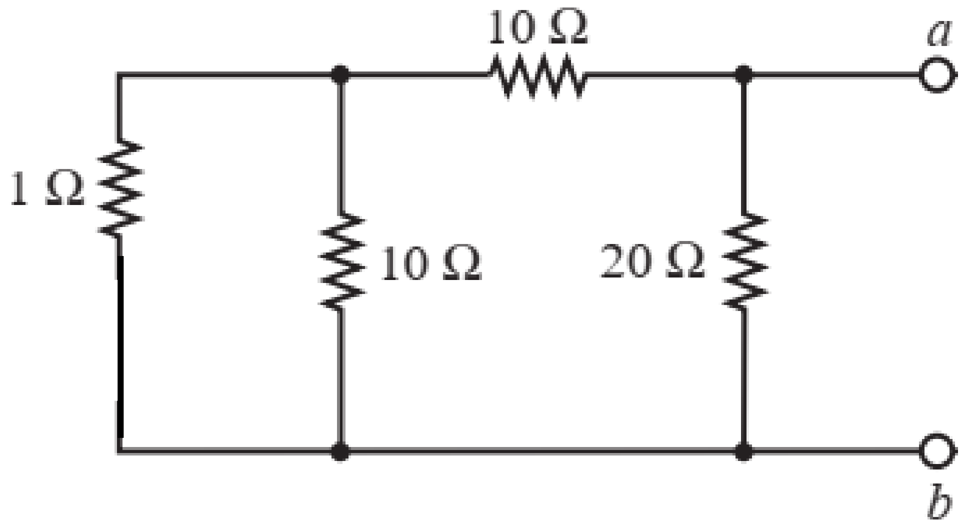
1.

For the circuit below, find the Thévenin equivalent resistance seen by the load resistor R_L.



1.

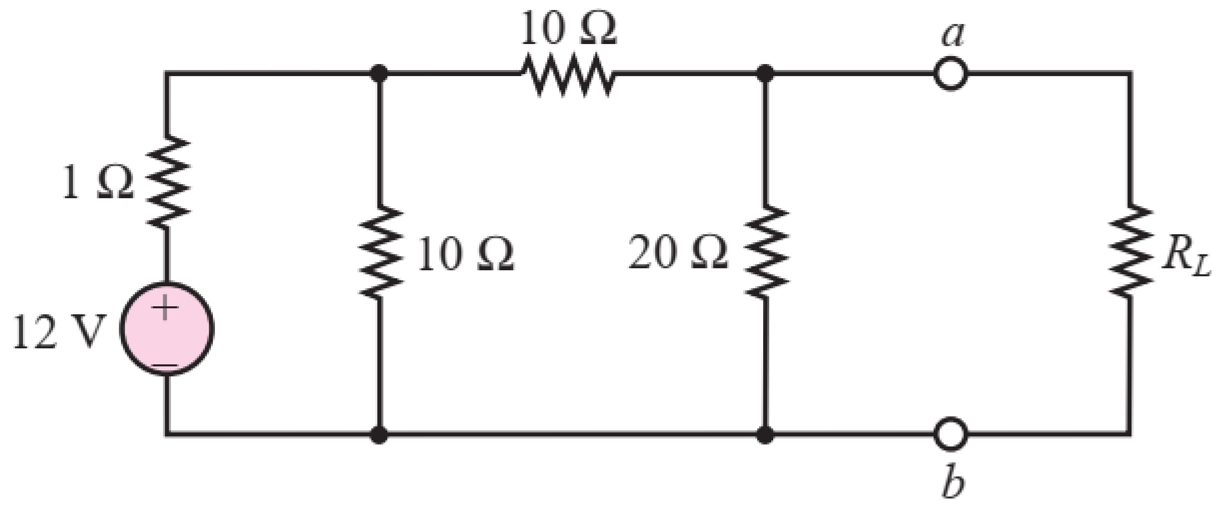
For the circuit below, find the Thévenin equivalent resistance seen by the load resistor R_L.



$$R_T = ((1\Omega \,||\, 10\Omega) + 10\,\Omega) \,||\, 20\,\Omega = \left[\frac{1}{\left[\left(1+\frac{1}{10}\right)^{-1}+10\right]}+\frac{1}{20}\right]^{-1} = 7.059\ \Omega$$

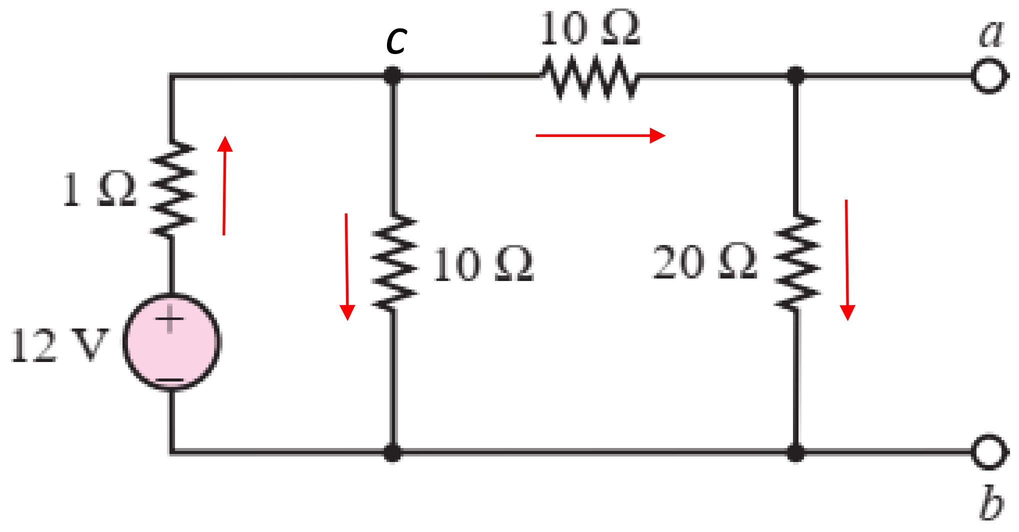
1.

Find the Thevenin voltage V_T.



1.

Find the Thevenin voltage V_T.



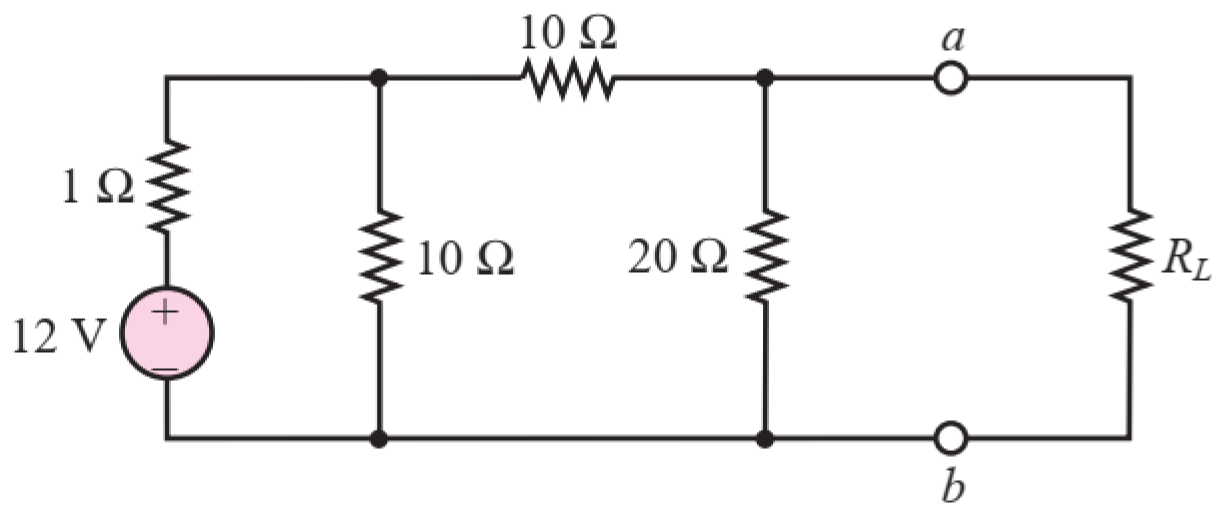
Vb = 0

$$\begin{cases} \dfrac{12 - Vc}{1} - \dfrac{Vc - Va}{10} - \dfrac{Vc}{10} = 0 \\ \dfrac{Vc - Va}{10} - \dfrac{Va}{20} = 0 \end{cases}$$

Answer: $V_T = Va = 7.059$ V

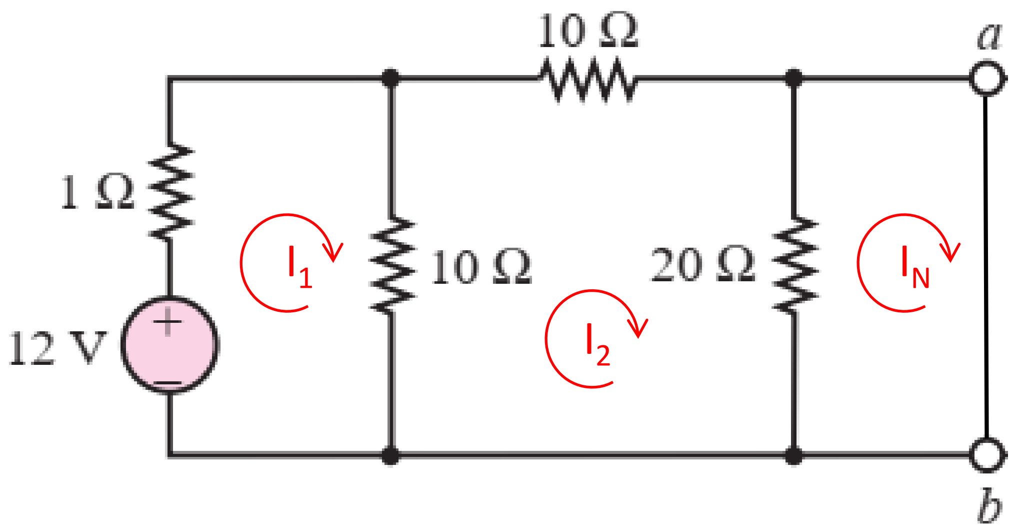
1.

Find the Norton Current I_N.

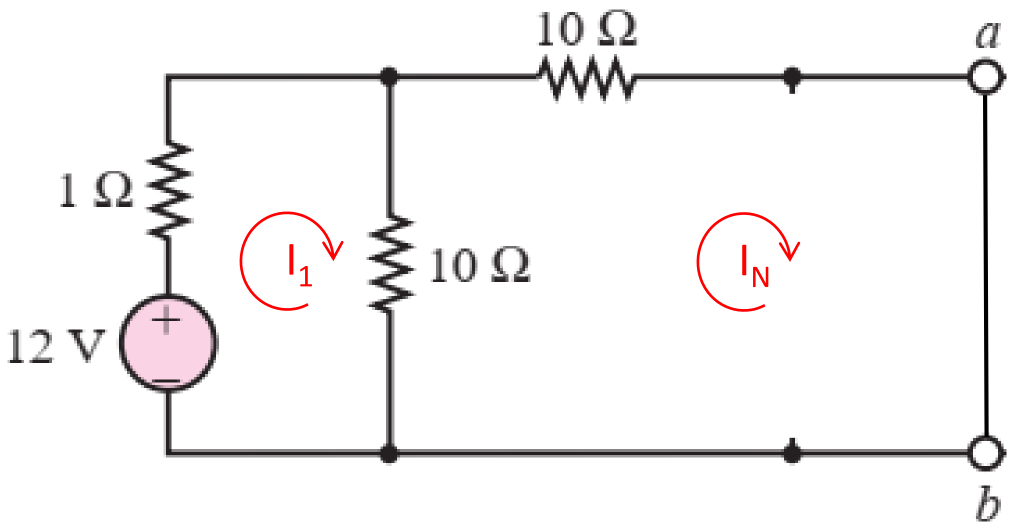


2.

Find the Norton Current I_N.



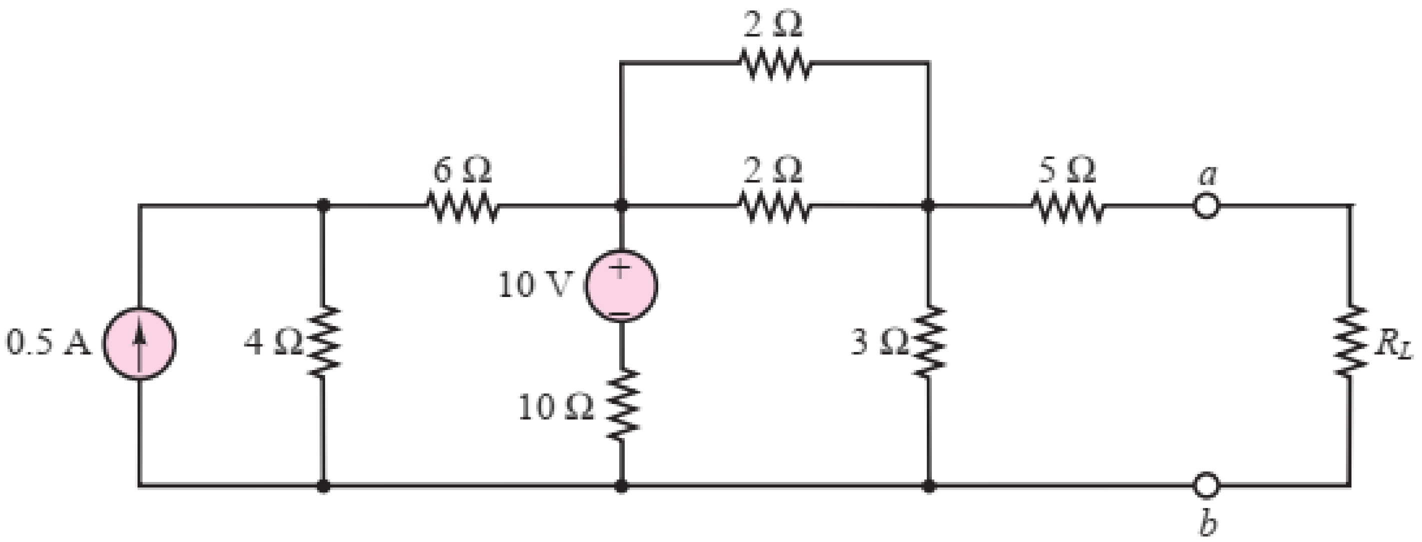
$$\begin{cases} 12 - I_1 \cdot 1 - (I_1 - I_N) \cdot 10 = 0 \\ -(I_N - I_1) \cdot 10 - I_N \cdot 10 = 0 \end{cases}$$



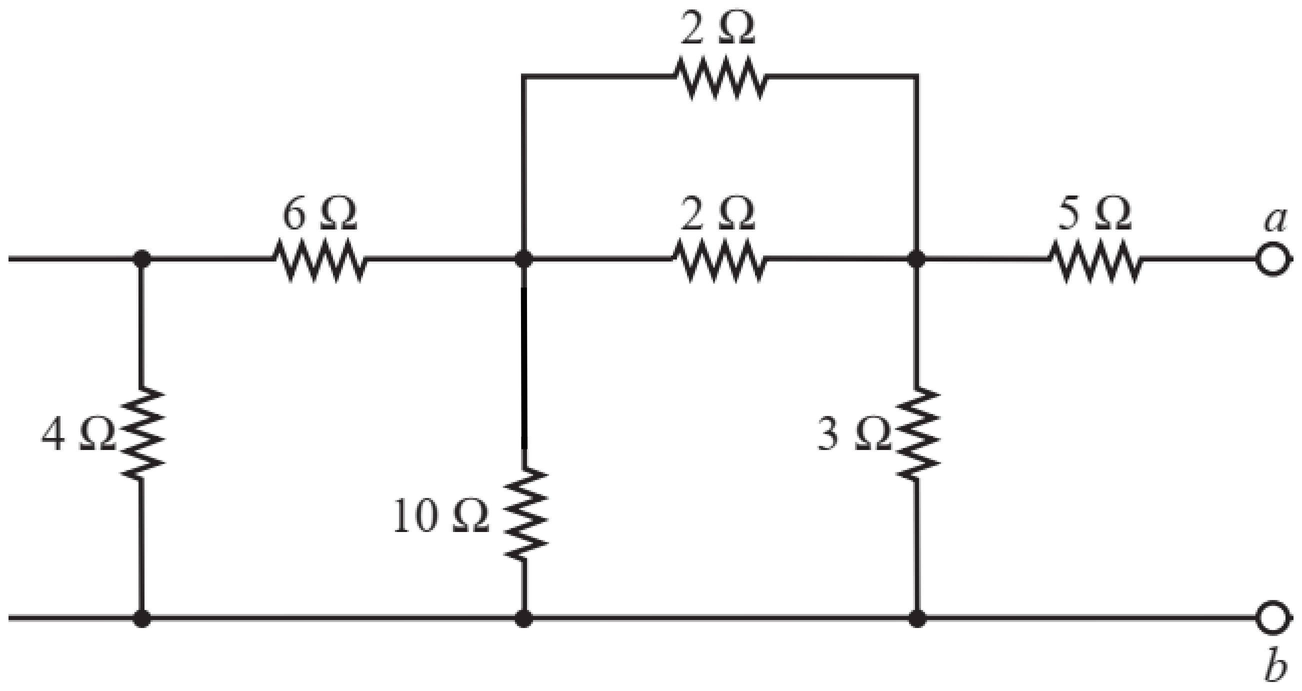
$$\left.\begin{array}{l} \text{Answer: } I_N = 1\text{ A} \\ V_T = 7.059\text{ V} \\ R_T = 7.059\ \Omega \end{array}\right\} \quad V_T = I_N R_T$$

2.

Find the Thévenin equivalent resistance seen by the load resistor R_L in the following circuit.



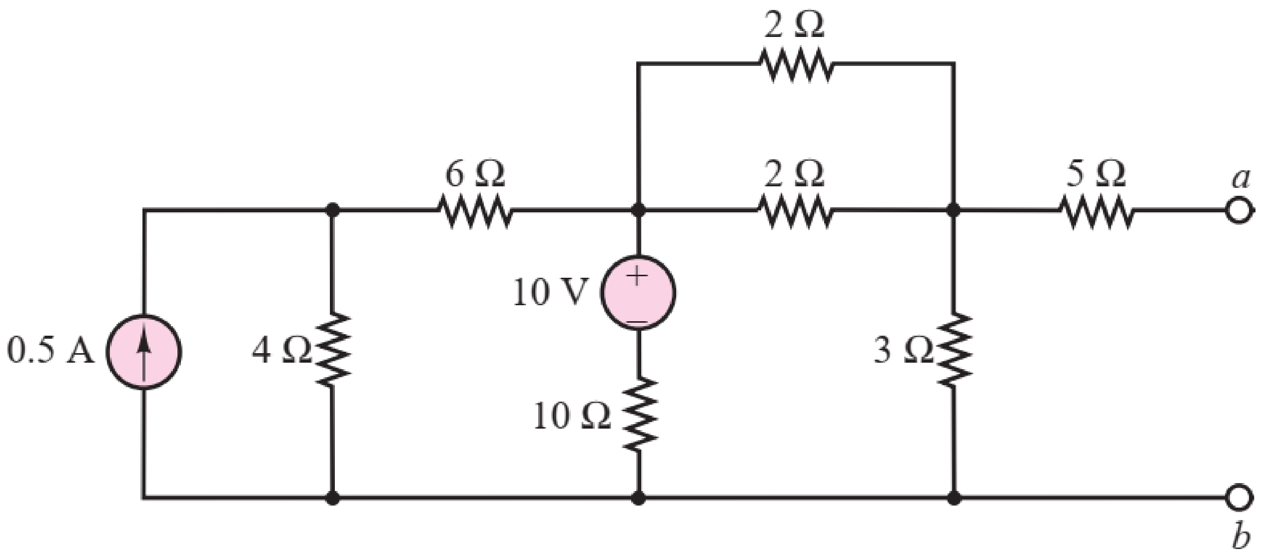
2.



$$R_T = ((4\Omega + 6\Omega) \,||\, 10\ \Omega) + (2\ \Omega||2\ \Omega) \,||\, 3\ \Omega + 5\ \Omega = \left[\frac{1}{\left[\left(\frac{1}{4+6}+\frac{1}{10}\right)^{-1}+\left(\frac{1}{2}+\frac{1}{2}\right)^{-1}\right]}+\frac{1}{3}\right]^{-1}+5=7\ \ \Omega$$

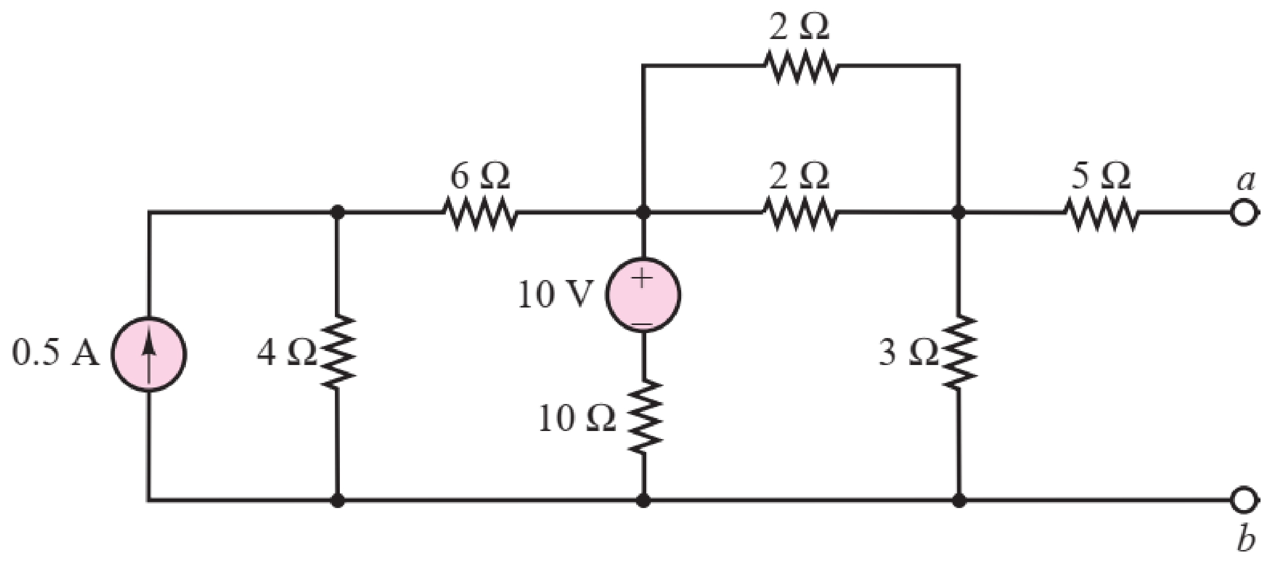
2.

Find the Thevenin voltage V_T.



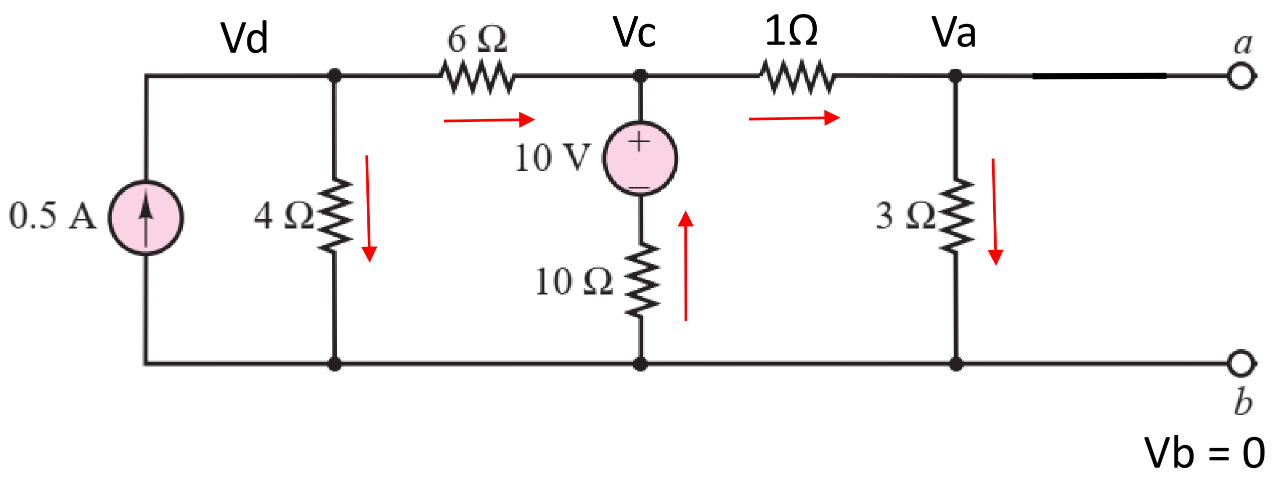
2.

Find the Thevenin voltage V_T.



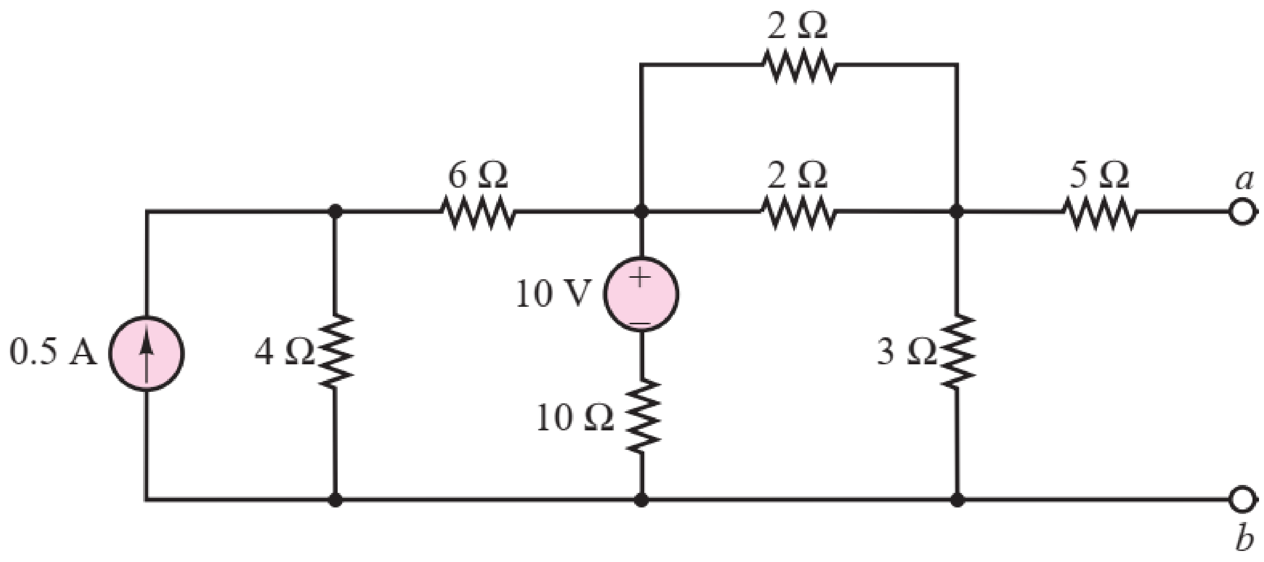
$$\begin{cases} 0.5 - \dfrac{Vd}{4} - \dfrac{Vd - Vc}{6} = 0 \\ \dfrac{Vd - Vc}{6} + \dfrac{10 - Vc}{10} - \dfrac{Vc - Va}{1} = 0 \\ \dfrac{Vc - Va}{1} - \dfrac{Va}{3} = 0 \end{cases}$$

Answer: $V_T = Va = 2$ V



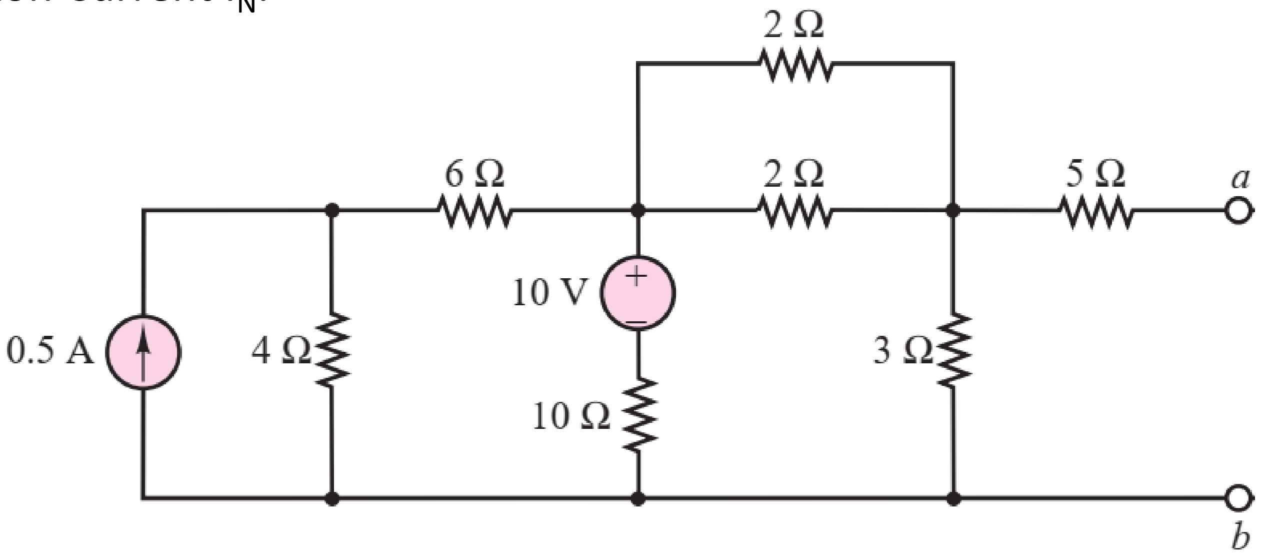
2.

Find the Norton Current I_N.

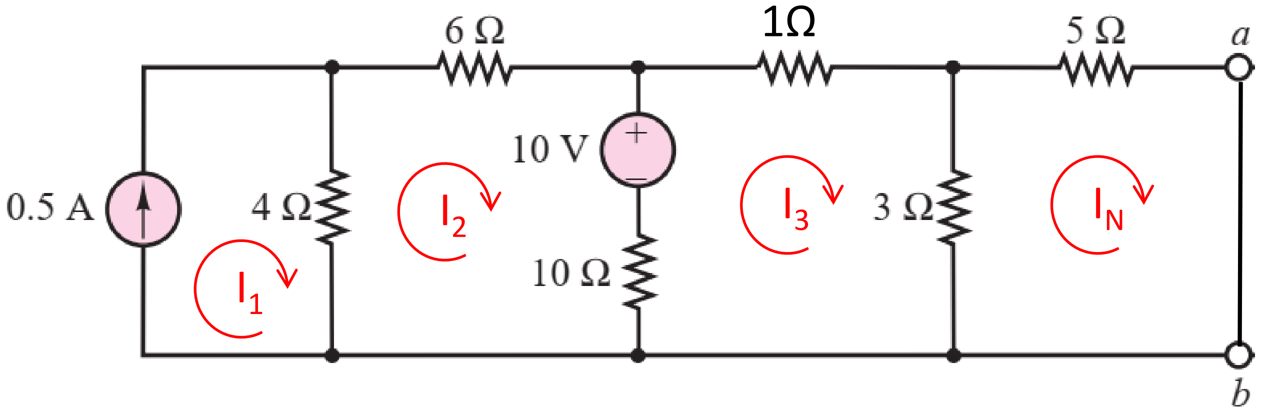


2.

Find the Norton Current I_N.



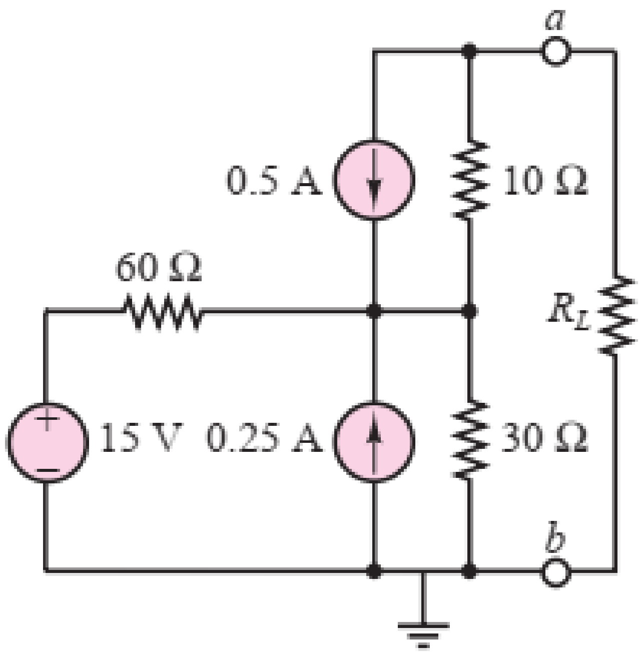
$$\begin{cases} -(I_2 - I_1)\cdot 4 - I_2\cdot 6 - 10 - (I_2 - I_3)\cdot 10 = 0 \\ -(I_3 - I_3)\cdot 10 + 10 - I_3\cdot 1 - (I_3 - I_N)3 = 0 \\ -(I_N - I_3)\cdot 3 - I_N\cdot 5 = 0 \end{cases}$$



$$\left.\begin{array}{l} \text{Answer: } I_N = 0.286 \text{ A} \\ V_T = 2 \text{ V} \\ R_T = 7\ \Omega \end{array}\right\} \quad V_T = I_N R_T$$

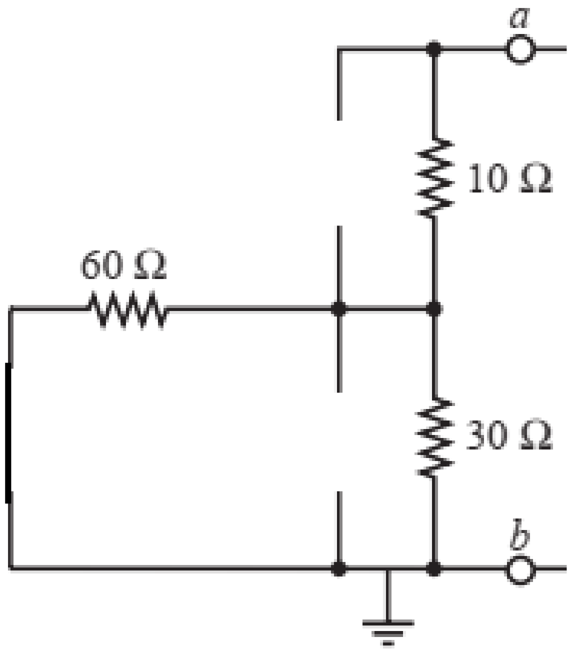
3.

Find the Thevenin equivalent circuit for the circuit in the figure below



3.

Find the Thevenin Resistance R_T.



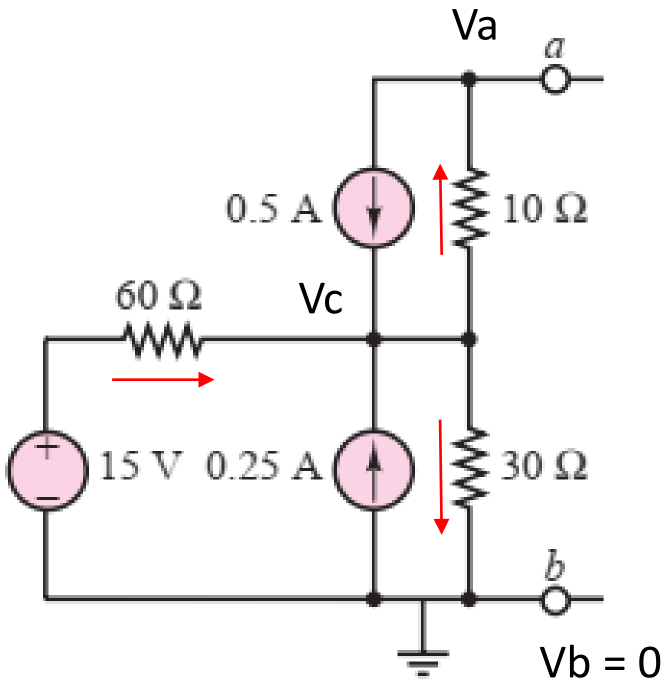
$R_T = (60\ \Omega)\ ||\ 30\ \Omega) + 10\ \Omega = 20\ \Omega + 10\ \Omega = 30\ \Omega$

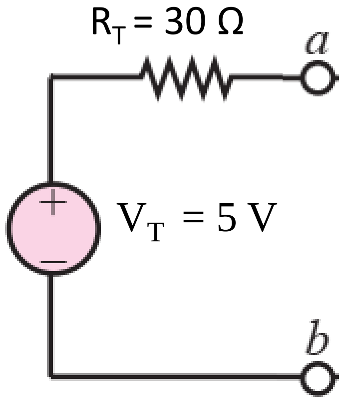
3.

Find the Thevenin voltage V_T.

$$\begin{cases} \dfrac{15 - Vc}{60} + 0.5 + 0.25 - \dfrac{Vc - Va}{10} - \dfrac{Vc}{30} = 0 \\ -0.5 + \dfrac{Vc - Va}{10} = 0 \end{cases}$$

Answer: $V_T = Va = 5$ V



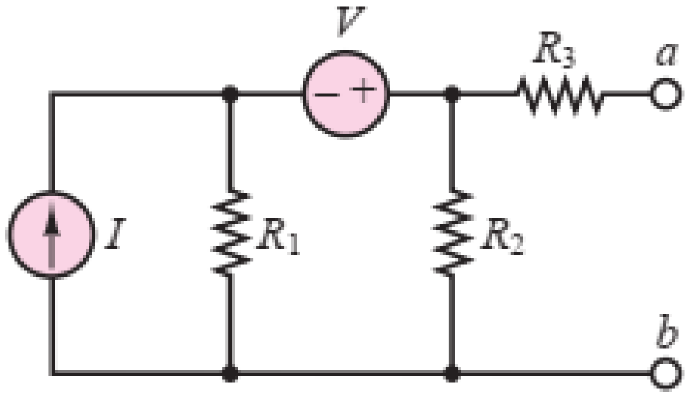


Thevenin equivalent circuit

4.

Determine the Norton current and the Norton equivalent for the circuit of Figure

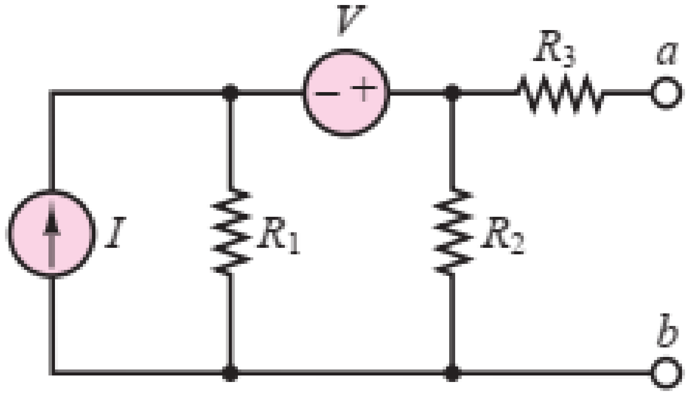
$V = 6$ V; $I = 2$ A; $R_1 = 6\ \Omega$; $R_2 = 3\ \Omega$; $R_3 = 2\ \Omega$.

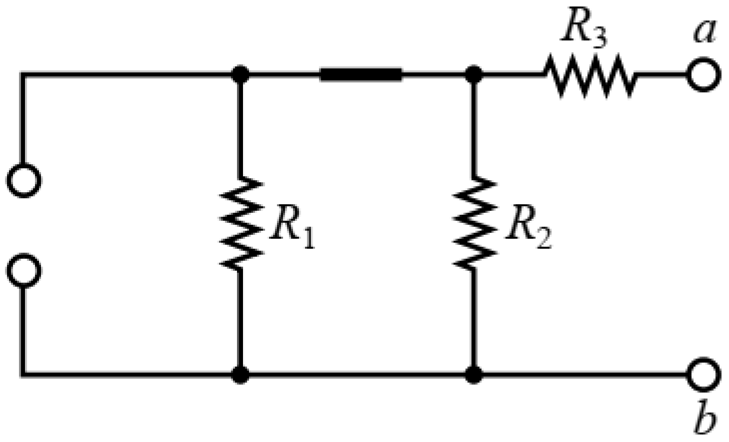


4.

Determine the Norton current and the Norton equivalent for the circuit of Figure

$V = 6$ V; $I = 2$ A; $R_1 = 6\ \Omega$; $R_2 = 3\ \Omega$; $R_3 = 2\ \Omega$.



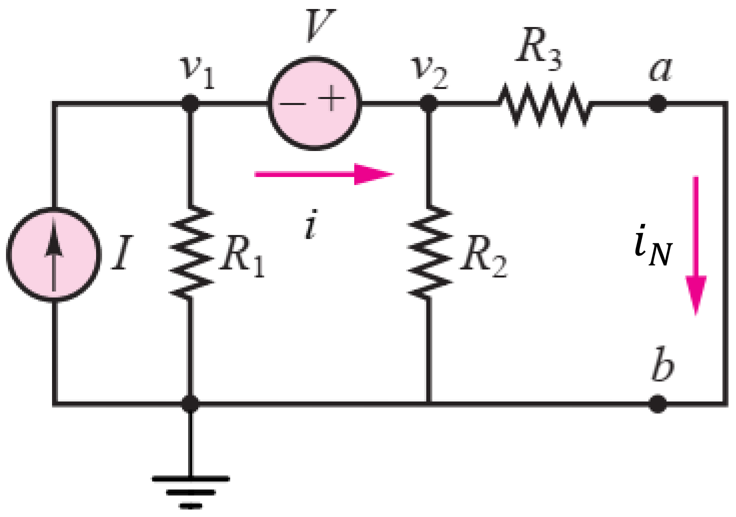


$$R_T = R_1 \| R_2 + R_3 = 6 \| 3 + 2 = 4\ \Omega$$

4.

Determine the Norton current and the Norton equivalent for the circuit of Figure

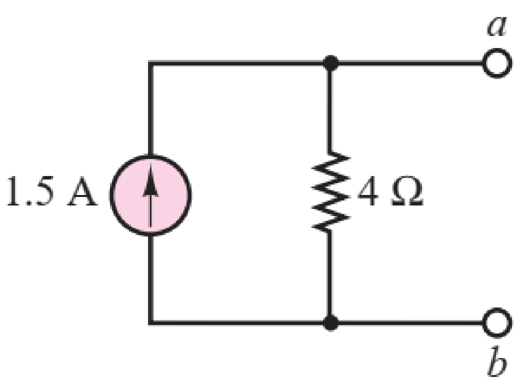
$V = 6$ V; $I = 2$ A; $R_1 = 6\ \Omega$; $R_2 = 3\ \Omega$; $R_3 = 2\ \Omega$.



$$\begin{cases} I - \frac{v_1}{R_1} - i = 0 & \text{node 1} \\ i - \frac{v_2}{R_2} - \frac{v_2}{R_3} = 0 & \text{node 2} \\ v_1 = v_2 - V \end{cases}$$

$i = 2.5$ A

$v_2 = 3$ V.



Norton equivalent circuit

Answer: $$i_N = i\frac{\frac{1}{R_3}}{\frac{1}{R_2}+\frac{1}{R_3}} = 1.5\text{ A}$$