Basic Electrical and Electronics Engineering

LECTURE 1.8

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BEEE102L

Basic Electrical and Electronics Engineering

1. <u>DC Circuits</u>
2. AC Circuits
3. Magnetic Circuits
4. Electrical Machines
5. Semiconductor Devices and Applications
6. Digital Systems
7. Sensors and Transducers

Books

Text Books

- Allan R. Hambley, “Electrical Engineering -Principles & Applications”, 2019, 6th Edition, Pearson Education
- V. D. Toro, Electrical Engineering Fundamentals, 2nd edition. PHI, 2014

Reference Books

- R. L. Boylestad and L. Nashelsky, Electronic Devices and Circuit Theory, 11th edition. Pearson, 2012
- DP Kothari & Nagrath, “Basic Electric Engineering”, 2019, Tata McGraw Hill

Superposition Theorem - Definition

- The superposition principle states that the **response** in any **passive** element in a **linear network** **containing multiple sources** is same as the **algebraic sum of the response** due to the each source.

$$V_x = \sum_{i=1}^{n} V_{xi}$$

n = no of sources

$$I_x = \sum_{i=1}^{n} I_{xi}$$

x = element

Superposition Theorem

- **Superposition theorem is one of the important method that takes a complex circuit and simplifies it in a way that makes a perfect sense and make that circuit a simple one and easy to understand.**

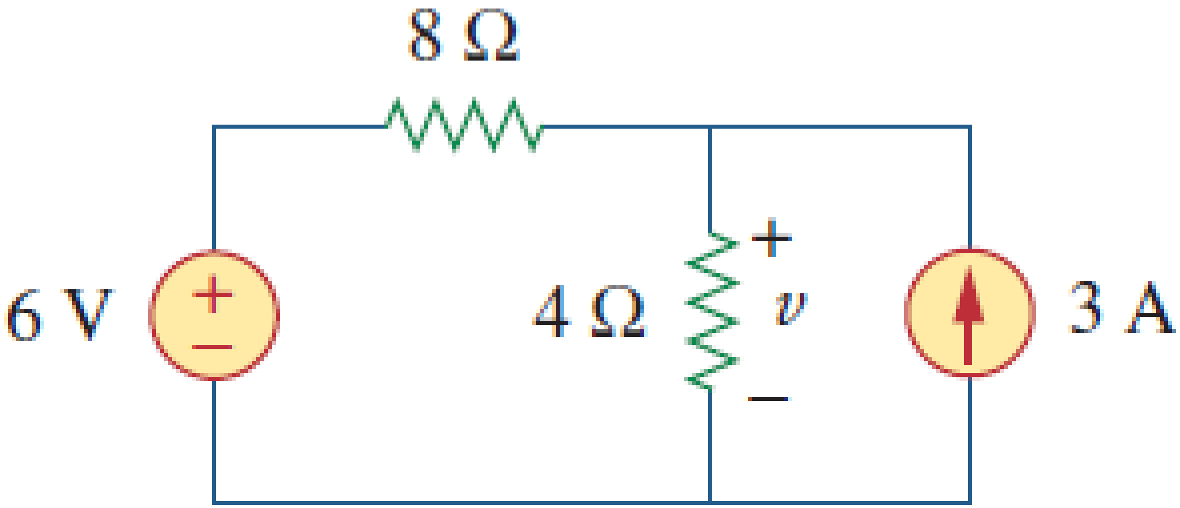
- **Superposition theorem helps to analyze a complex circuit with multiple sources to determine the net current/voltage in a desire component when all sources are connected**

The strategy used in the Superposition Theorem is to eliminate all but one source of power within a network at a time, using series/parallel analysis to determine voltage drops and/or currents within the modified network for each power source separately.

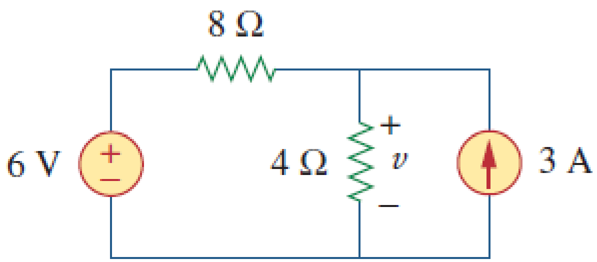
Turning Off Sources

- **Voltage sources should be replaced with short circuits.**
- **A short circuit will allow current to flow across it, but the voltage across a short circuit is equal to 0V.**
- **Current sources should be replaced with open circuits.**
- **An open circuit can have a non-zero voltage across it, but the current is equal to 0A.**

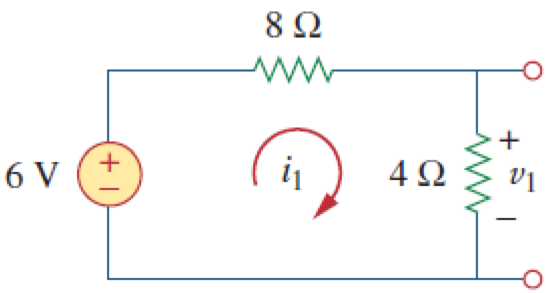
Superposition Theorem - Application



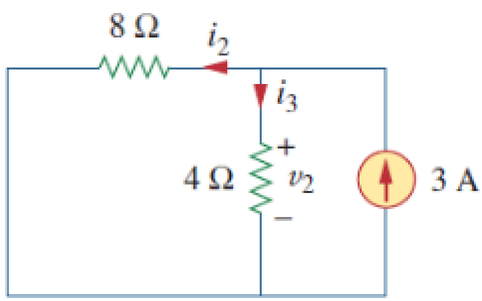
Superposition Theorem - Application



$$v = v_1 + v_2 = 2 + 8 = 10\text{ V}$$



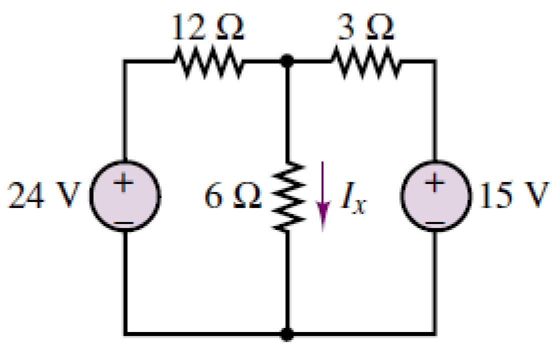
$$v_1 = \frac{4}{4+8}(6) = 2\text{ V}$$



$$i_3 = \frac{8}{4+8}(3) = 2\text{ A}$$

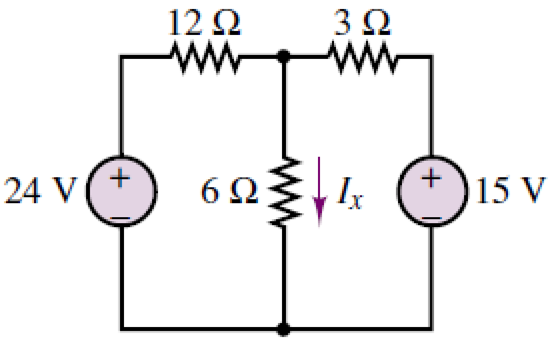
$$v_2 = 4i_3 = 8\text{ V}$$

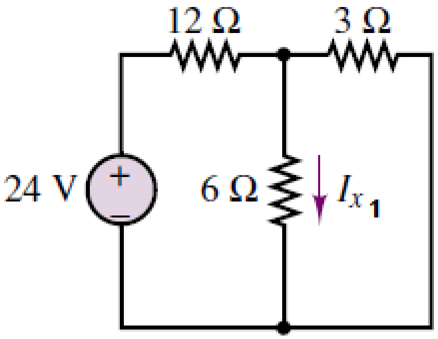
Problem 1

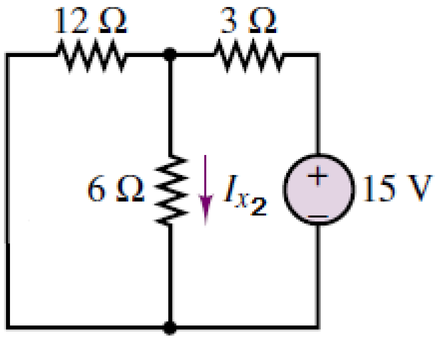


$$I_x = I_{x1} + I_{x2}$$

Problem 1

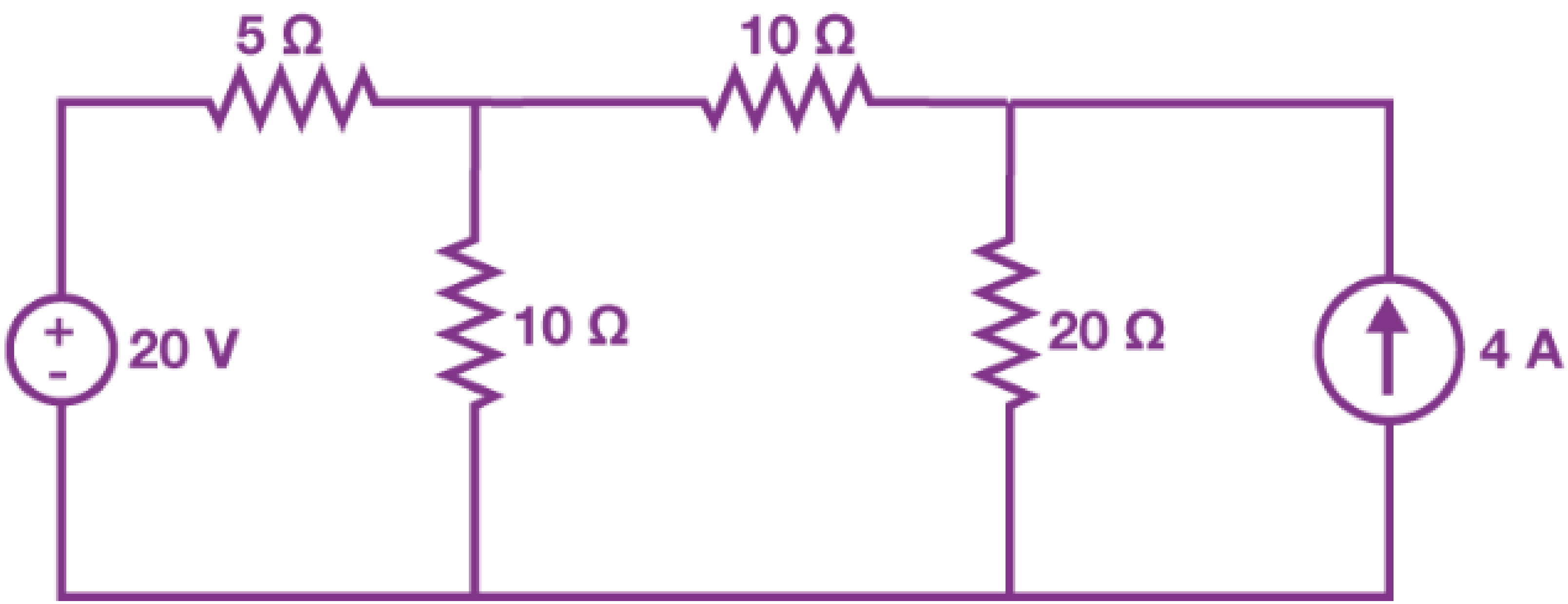




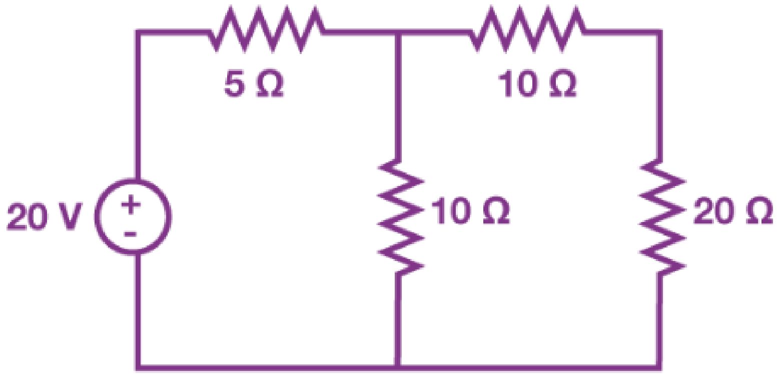


$$I_x = I_{x1} + I_{x2}$$

Example 1: Find the current flowing through 20 Ω using the superposition theorem.

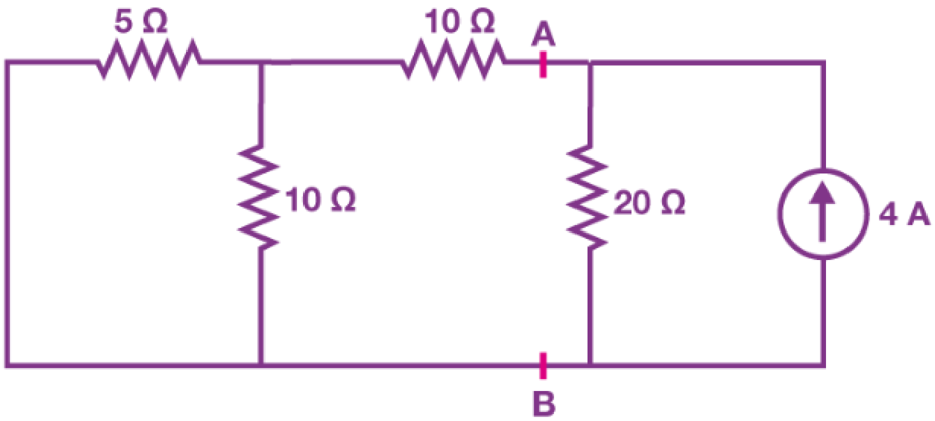


SOURCE 1



$$I_1 = 0.4\ A$$

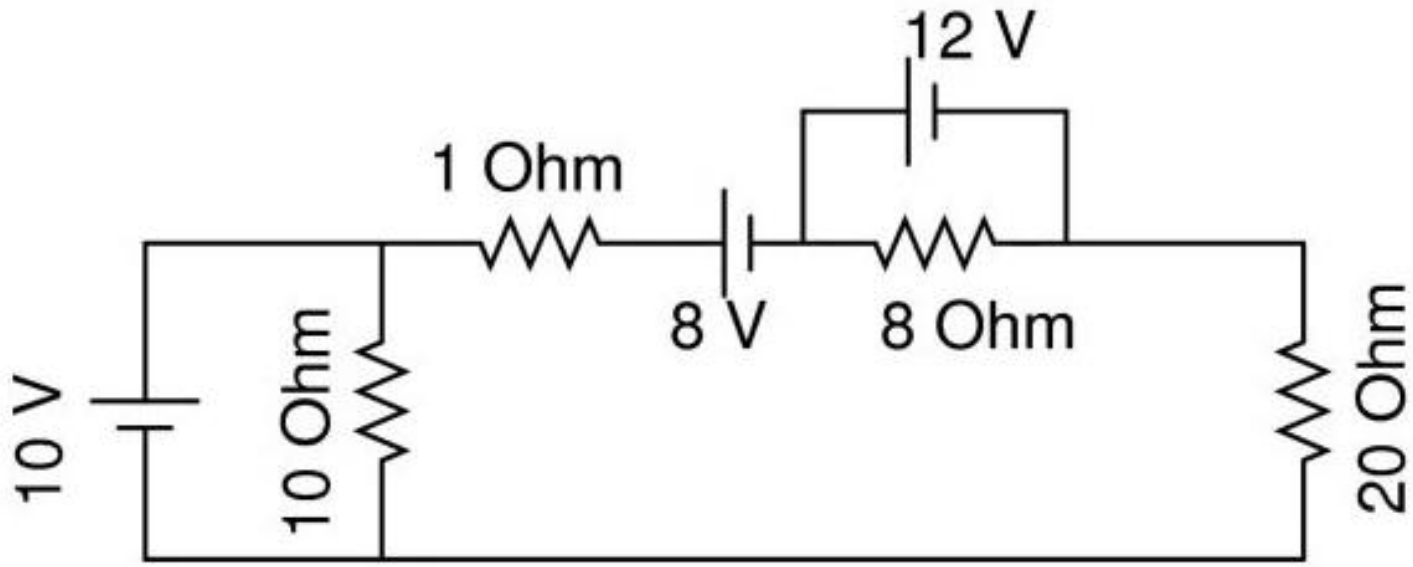
SOURCE 2



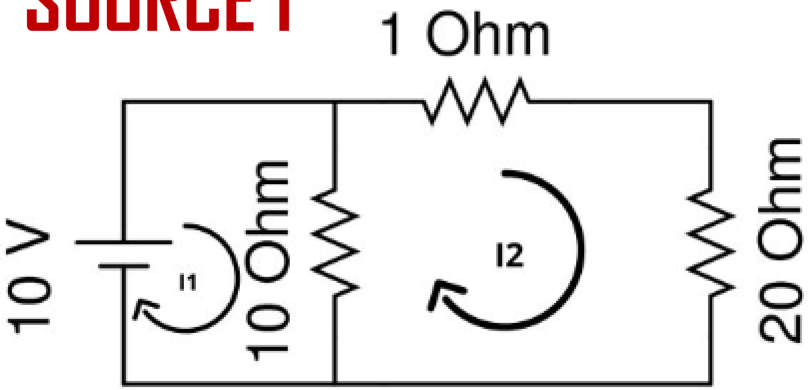
$$I_2 = 1.6\ A$$

$$I_1 + I_2 = 2\ A$$

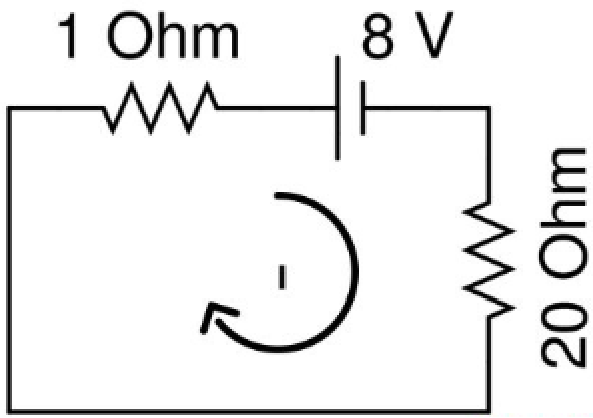
Calculate the current in 20 ohm resistance using superposition theorem.



SOURCE 1



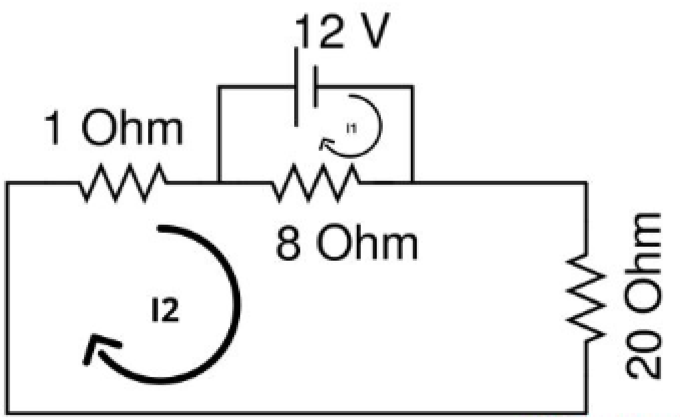
$$I'_{20\Omega} = 0.4761A(\downarrow)$$



$$I''_{20\Omega} = -0.3809A(\downarrow)$$

SOURCE 2

SOURCE 3



$$I'''_{20\Omega} = -0.5714(\downarrow)$$

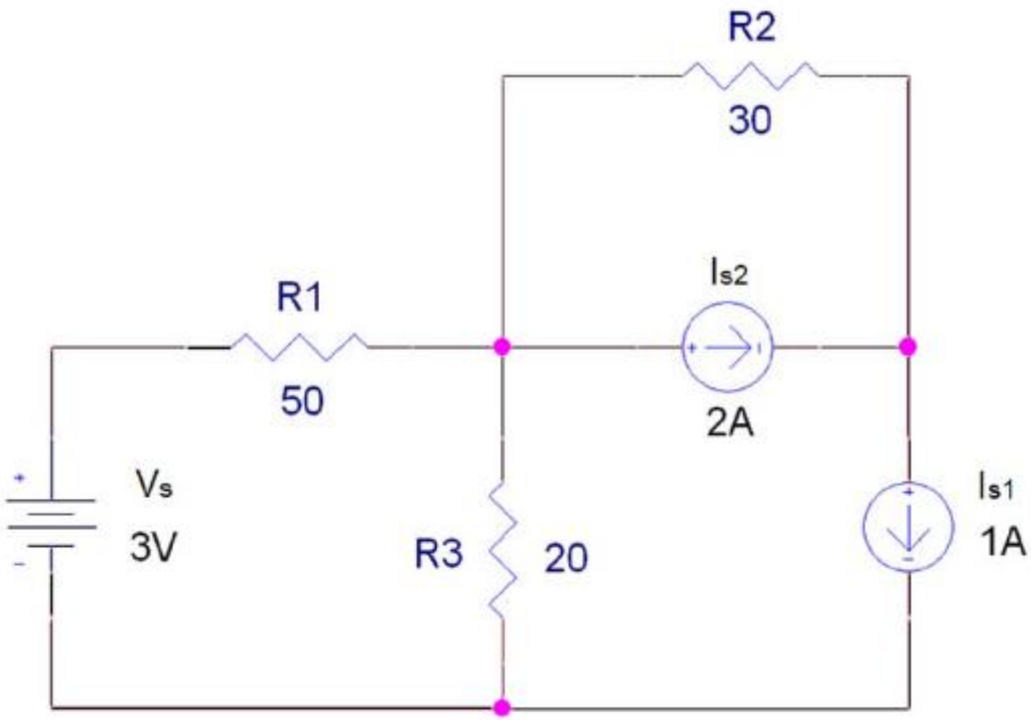
$$I_{20\Omega} = I'_{20\Omega} + I''_{20\Omega} + I'''_{20\Omega}$$

$$I_{20\Omega} = 0.4761 + (-0.3809) + (-0.5714)$$

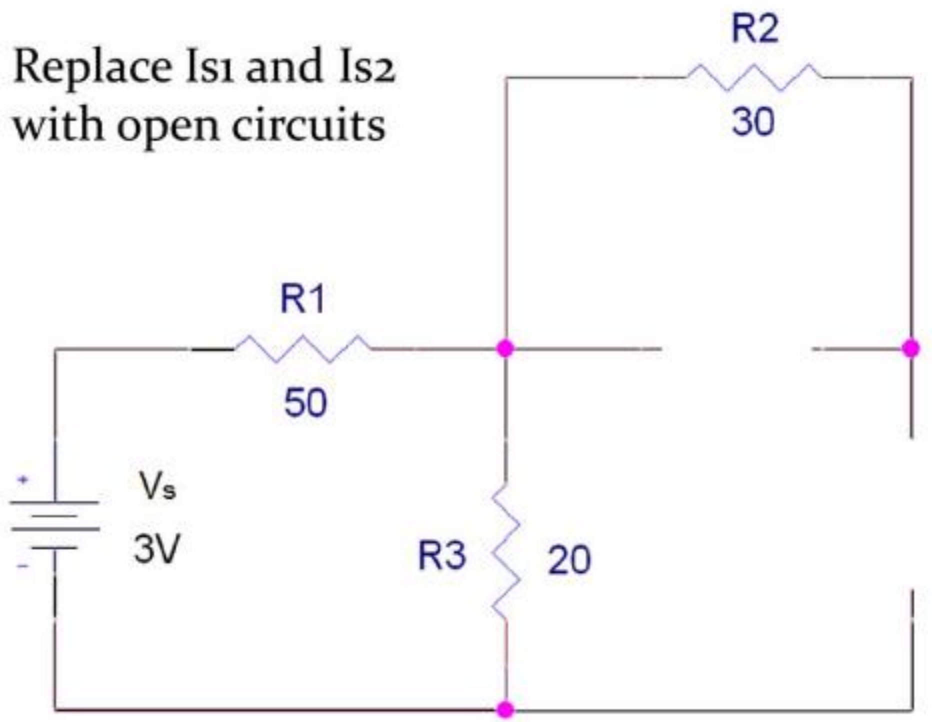
$$I_{20\Omega} = -0.4762A\ (\downarrow)$$

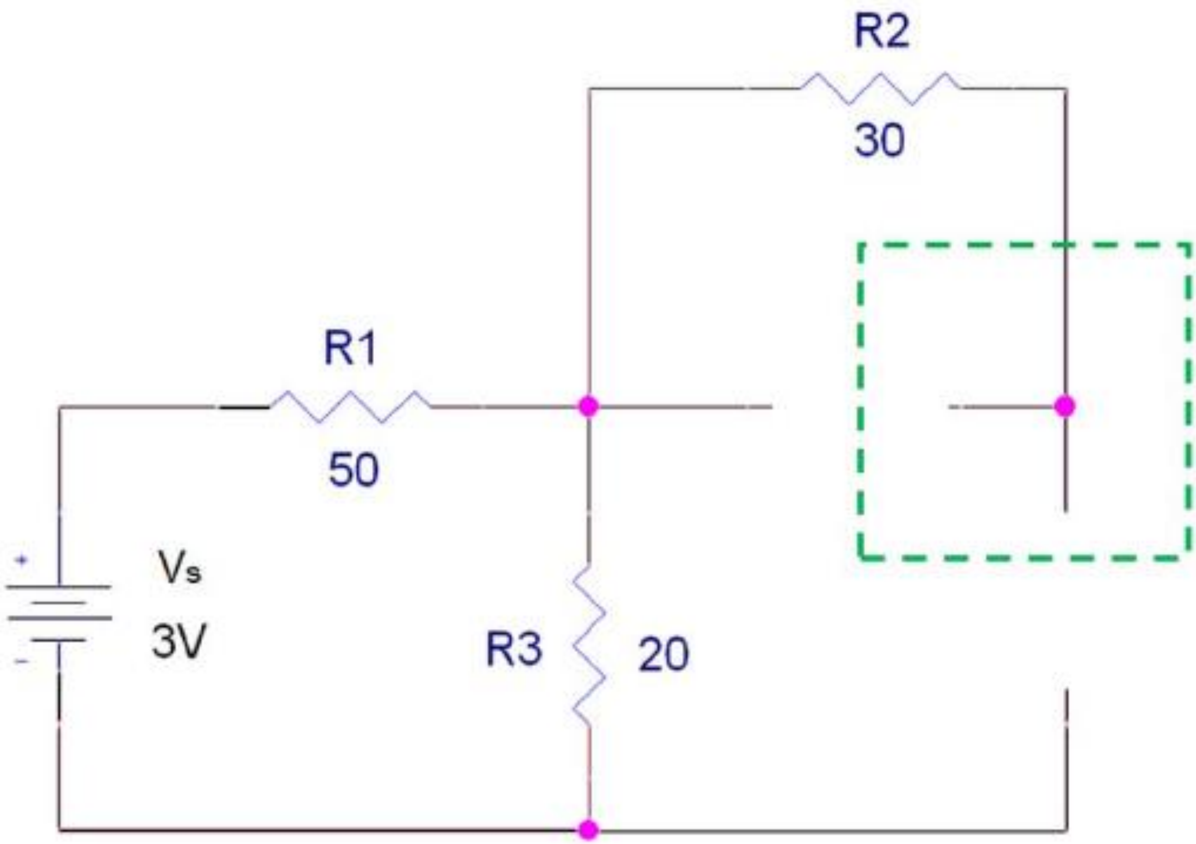
$$I_{20\Omega} = 0.4762A\ (\uparrow)$$

Problem 2



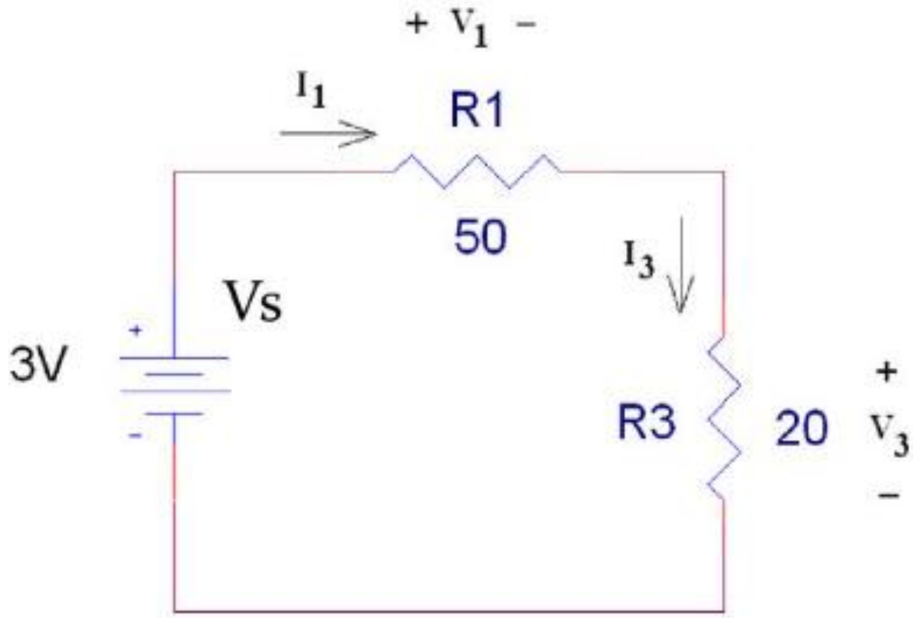
Replace Is1 and Is2 with open circuits





Since R2 is not connected to the rest of the circuit on both ends of the resistor, it can be deleted from the new circuit.

Redraw circuit without R2 in it.



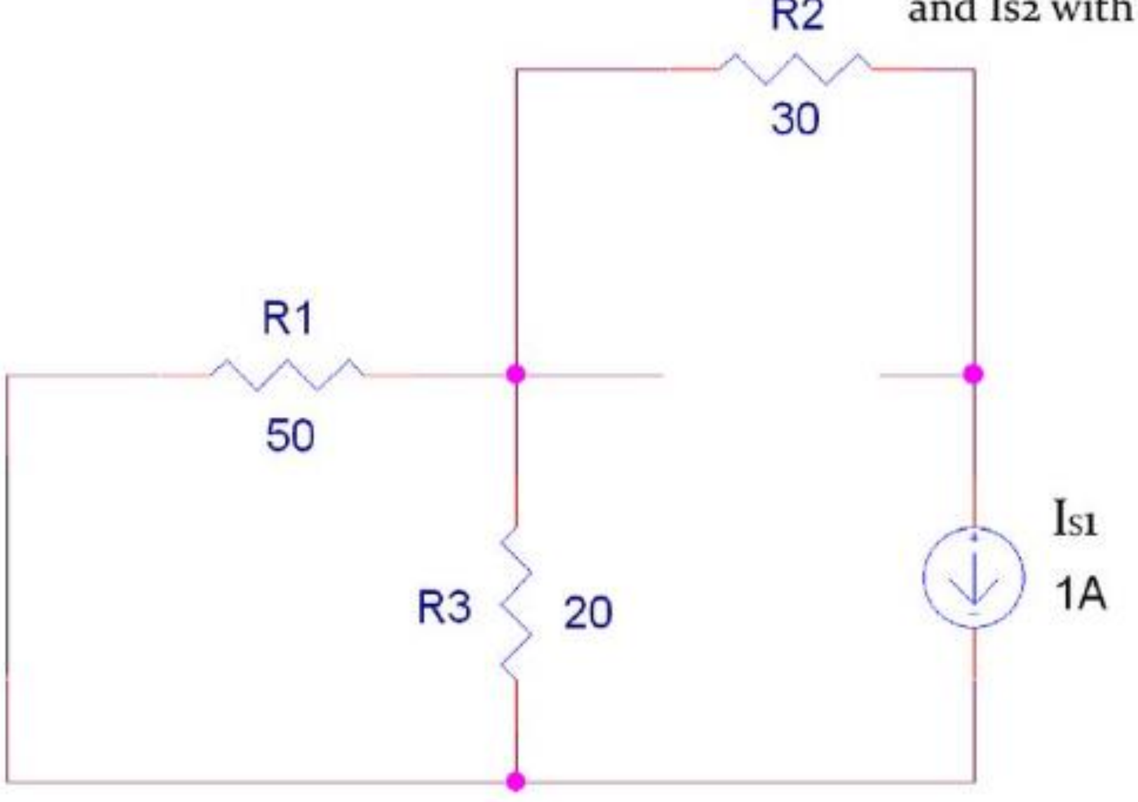
$$I_1 = I_3$$
$$R_{eq} = R_1 + R_3 = 70\Omega$$
$$I_1 = V_S / R_{eq} = 42.9mA$$

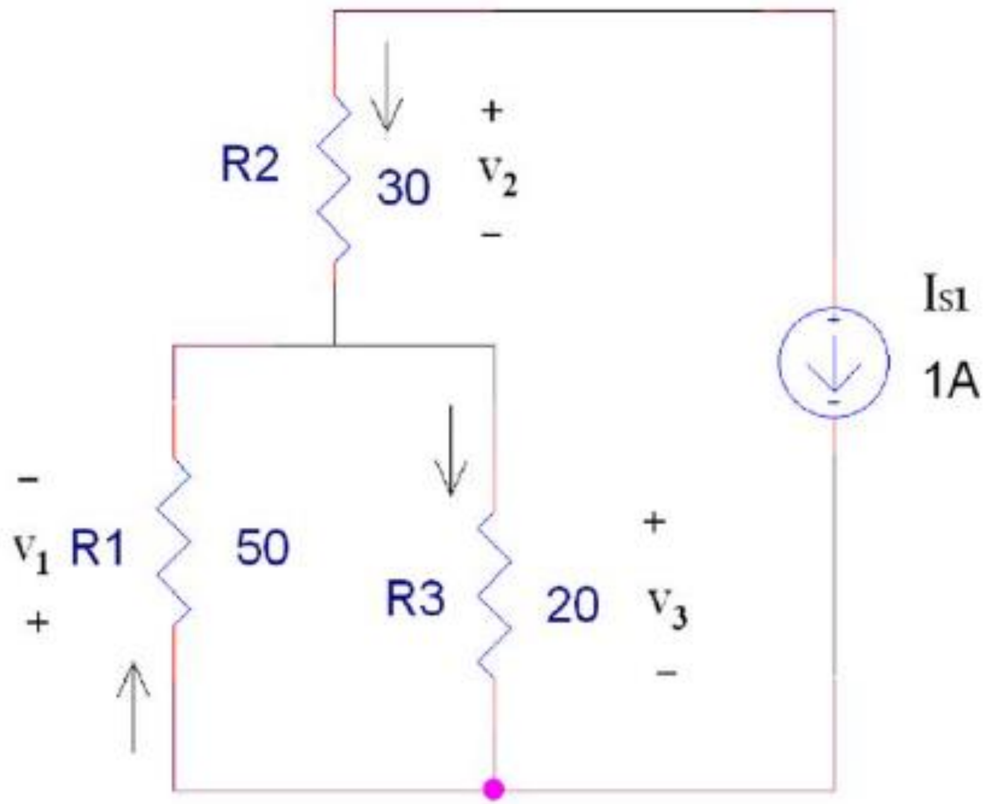
$$V_1 = (R_1 / R_{eq})V_S = I_1 R_1$$
$$V_1 = 2.14V$$

$$V_3 = (R_3 / R_{eq})V_S = I_3 R_3$$
$$V_3 = 0.857V$$

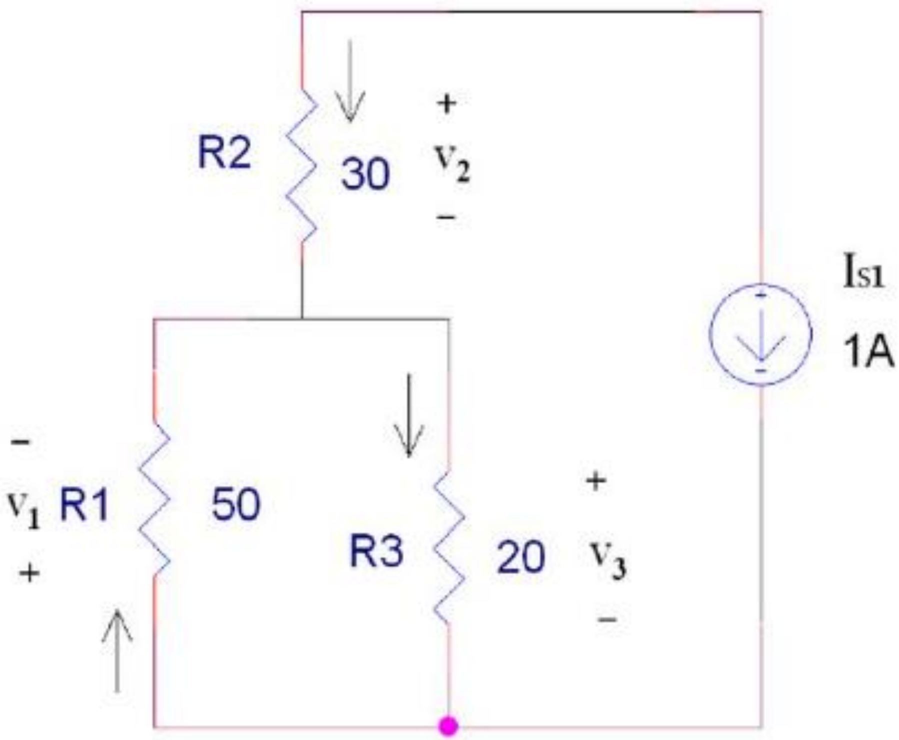
Replace V_S with a Short Circuit and Is2 with an Open Circuit

Redraw circuit.





Note: The polarity of the voltage and the direction of the current through R1 has to follow what was used in the first solution.



$$I_2 = -I_{S1} = -1A$$

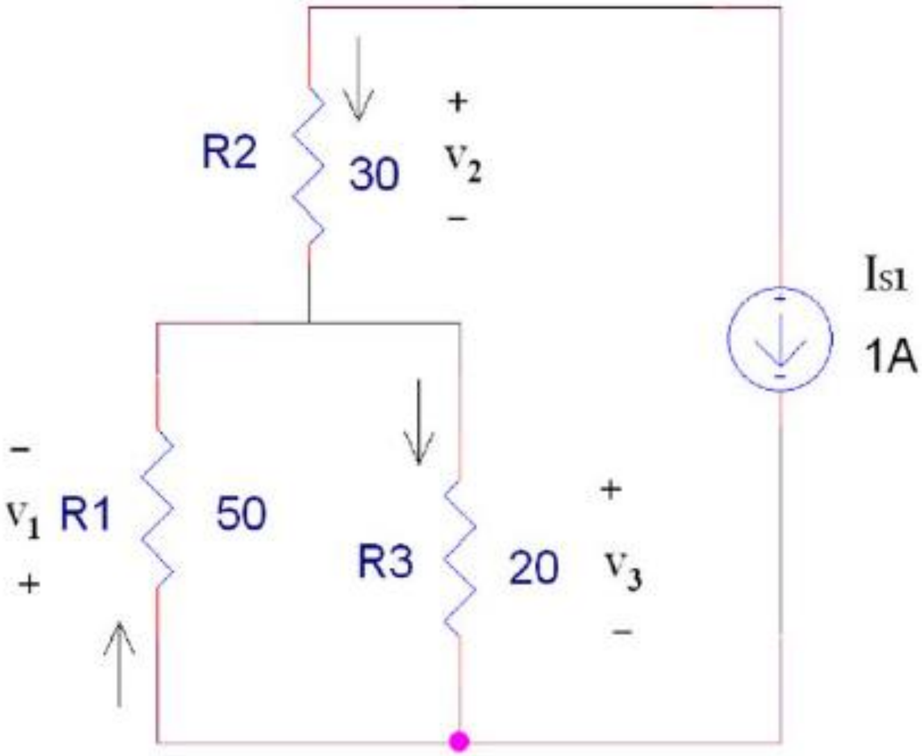
$$V_1 = -V_3$$

$$I_1 + I_2 = I_3$$

$$R_{eq} = R_2 + R_1 \| R_3$$

$$R_{eq} = 30\Omega + \frac{50\Omega(20\Omega}{50\Omega + 20\Omega}$$

$$R_{eq} = 44.3\Omega$$



$$V_2 + V_3 = R_{eq} I_2 = -44.3V$$

$$V_3 = \left[\left(R_1 \| R_3\right) / R_{eq}\right]\left(-44.3V\right)$$

$$V_3 = -14.3V$$

$$V_1 = 14.3V$$

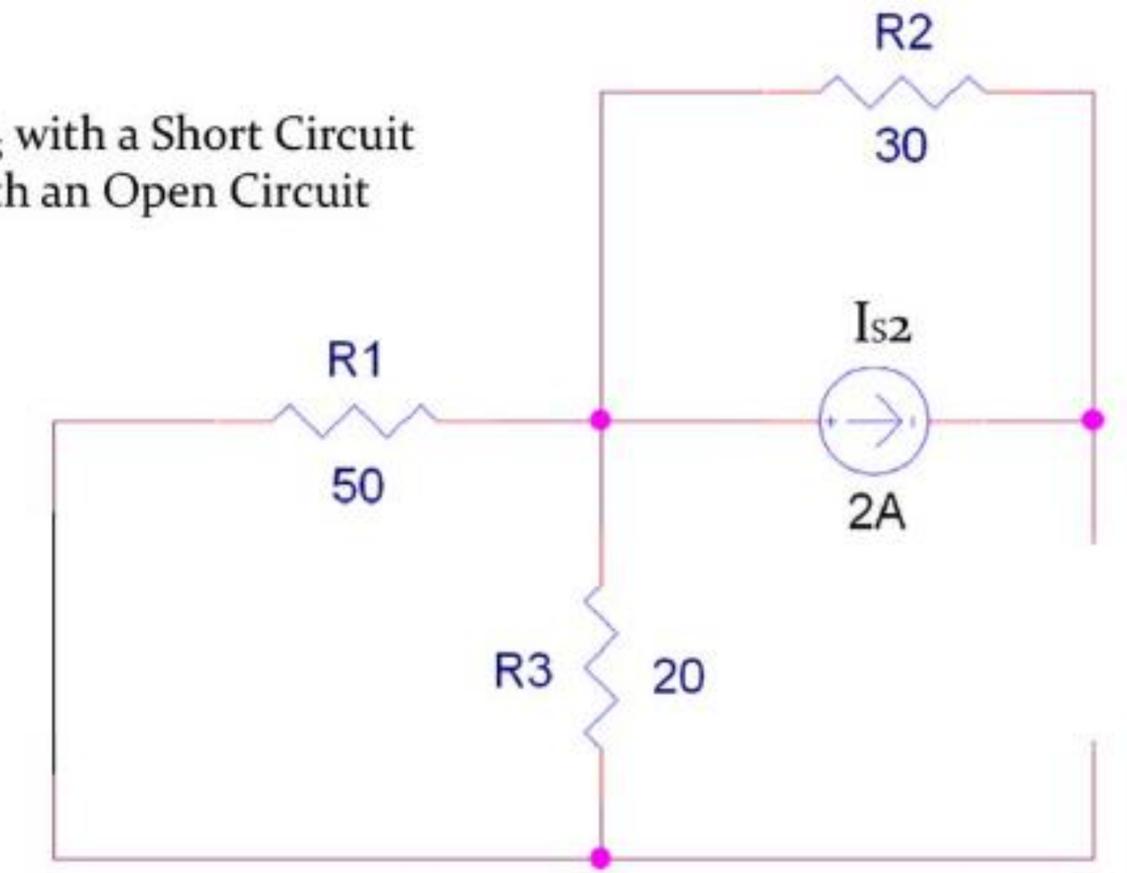
$$V_2 = -30V$$

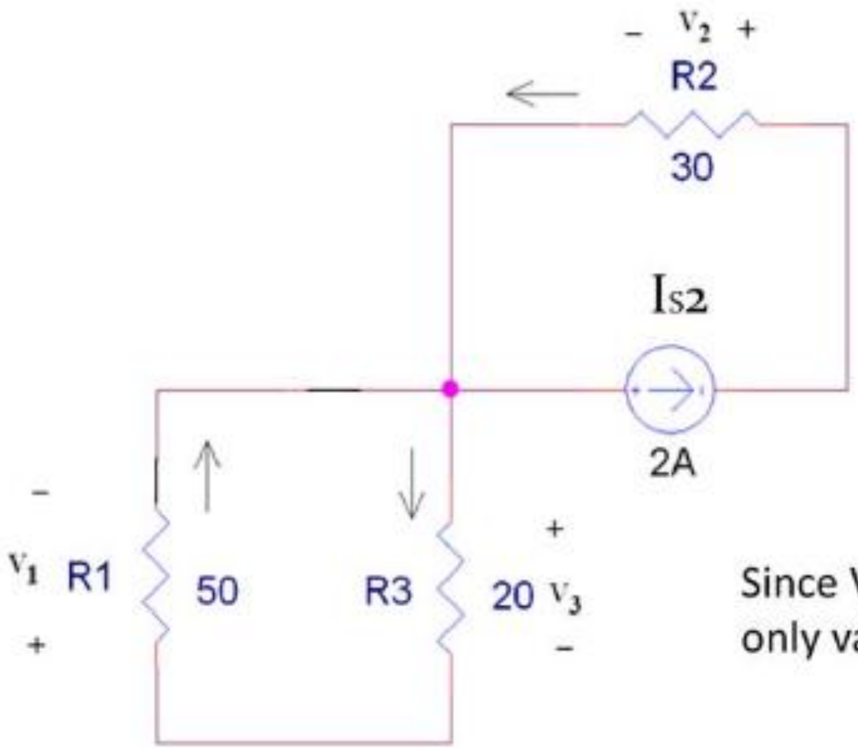
$$I_3 = -14.3V / 20\Omega$$

$$I_3 = -0.714A$$

$$I_1 = V_1 / R_1 = +0.286A$$

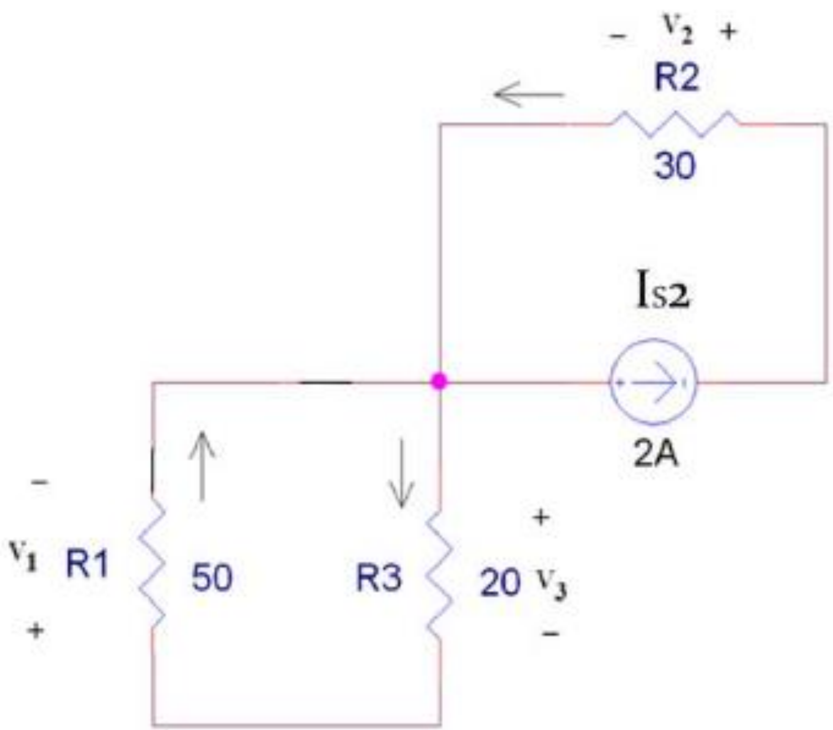
Replace V_S with a Short Circuit and I_{S1} with an Open Circuit





R2 and I2 are not in parallel with R1 and R3.

Since V1 = -V3, but I1 must equal I3, the only valid solution is when I1 = I3 = 0A.



$$I_1 + I_2 = I_3 + I_{S2}$$
$$I_2 = I_{S2} = 2A$$
$$I_1 = I_3$$

$$V_2 = I_2 R_2 = 2A(30\Omega) = 60V$$

$$0 = V_1 + V_3 = I_1 R_1 + I_3 R_3$$
$$I_1 R_1 = -I_3 R_3$$
$$I_1 = I_3 = 0A$$
$$V_1 = 0V$$
$$V_3 = 0V$$

Currents and voltages in original circuit with all sources turned on.

	Vs on	Is1 on	Is2 on	Total
I_1	+42.9mA	+0.286A	0A	+0.329A
I_2	0	-1A	2A	+1A
I_3	+42.9mA	-0.714A	0A	-0.671A
V_1	+2.14V	+14.3V	0V	16.4V
V_2	0V	-30V	+ 60V	+30.0V
V_3	0.857V	-14.3V	0V	-13.4V

Use source transformation to reduce the circuit between terminals *a* and *b* shown in Figure to a single voltage source in series with a single resistor.