SUPERPOSITION THEOREM

NETWORK THEOREMS

1. ***SUPERPOSITION THEOREM***

2. ***THEVENIN'S THEOREM***

3. ***NORTON'S THEOREM***

1. ***MAXIMUM POWER TRANSFER THEOREM***

SUPERPOSITION THEOREM

APPLICATIONS OF SUPERPOSITION THEOREM:

1. ***Analyze networks that have two or more sources that are not in series or parallel.***

2. ***Reveal the effect of each source on a particular quantity of interest.***

3. ***For sources of different types (such as dc and ac which affect the parameters of the network in a different manner), apply a separate analysis for each type, with the total result simply the algebraic sum of the results***

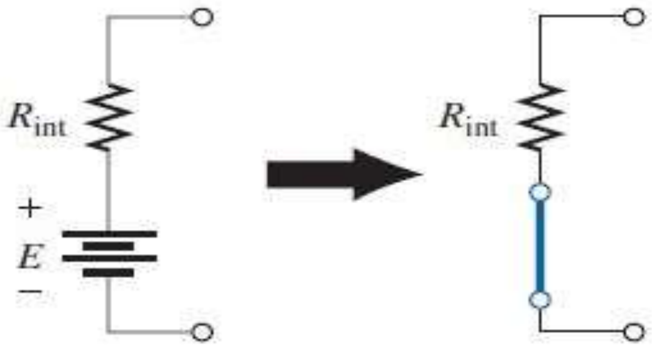
SUPERPOSITION THEOREM

STATEMENT OF SUPERPOSITION THEOREM: (4min 3 sec.)

The current through, or voltage across, any element of a network is equal to the algebraic sum of the currents or voltages produced independently by each source

Points to Remember:

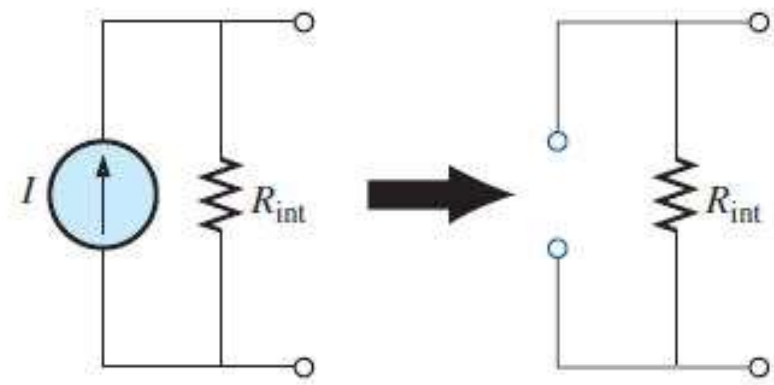
when removing a voltage source from a network schematic, replace it with a direct connection (short circuit) of zero ohms. Any internal resistance associated with the source must remain in the network



SUPERPOSITION THEOREM

Points to Remember:

when removing a current source from a network schematic, replace it by an open circuit of infinite ohms. Any internal resistance associated with the source must remain in the network.



Points to Remember:

Since the effect of each source will be determined independently, the number of networks to be analyzed will equal the number of sources.

SUPERPOSITION THEOREM

Points to Remember: For Current:

If a particular current of a network is to be determined-
the contribution to that current must be determined for *each source* currents in the same direction are added, and those having the opposite direction are subtracted the algebraic sum is being determined.

Points to Remember: For Voltage

if a particular voltage of a network is to be determined-
The contribution to that voltage must be determined for each source voltages with the same polarity are added, and those with the opposite polarity are subtracted; the algebraic sum is being determined

Superposition cannot be applied to power effects because the power is related to the square of the voltage across a resistor or the current through a resistor

SUPERPOSITION THEOREM

EXAMPLE 9.1 Using the superposition theorem, determine current *I*1 for the network in Fig. 9.2.

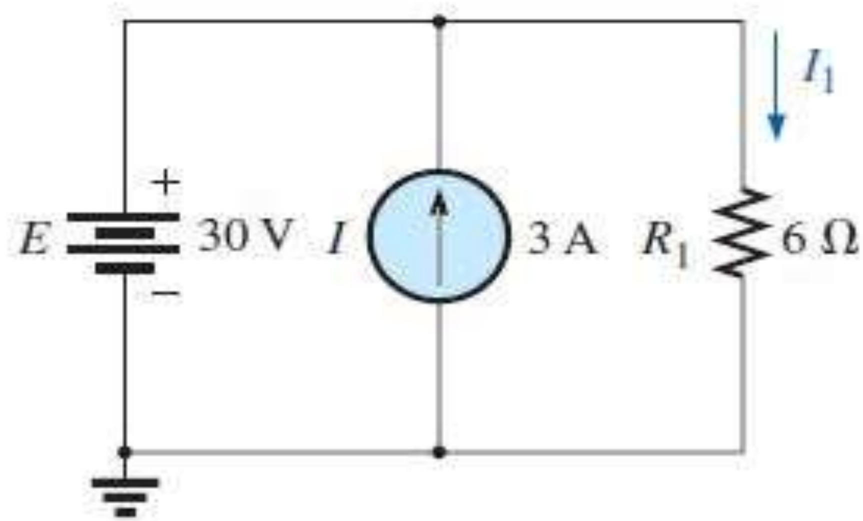


FIG. 9.2
Two-source network to be analyzed using the superposition theorem in Example 9.1.

SUPERPOSITION THEOREM

Solution: Since two sources are present, there are two networks to be analyzed.
First let us determine the effects of the voltage source by setting the current source to zero amperes as shown in Fig. 9.3

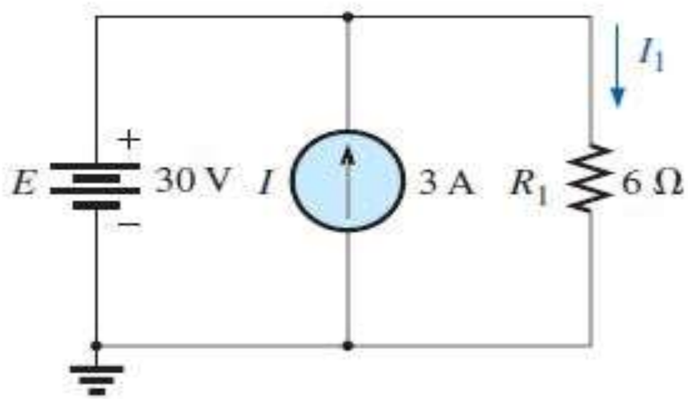


FIG. 9.2
Two-source network to be analyzed using the superposition theorem in Example 9.1.

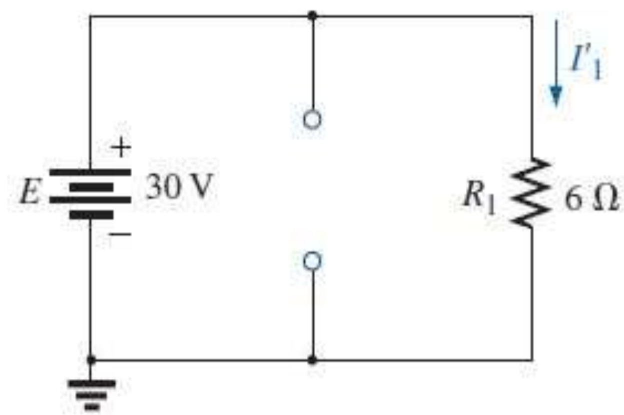


FIG. 9.3
Determining the effect of the 30 V supply on the current I_1 in Fig. 9.2.

SUPERPOSITION THEOREM

Solution: Note that the resulting current is defined as $I'1$ because it is the current through resistor $R1$ due to the voltage source only. Due to the open circuit, resistor $R1$ is in series with the voltage source E current $I'1$ is determined by

$$I'_1 = \frac{V_1}{R_1} = \frac{E}{R_1} = \frac{30\ \text{V}}{6\ \Omega} = 5\ \text{A}$$

Now for the contribution due to the current source. Setting the voltage source to zero volts results in the network in Fig. 9.4

application of the current divider rule as follows:

$$I''_1 = \frac{R_{sc}I}{R_{sc} + R_1} = \frac{(0\ \Omega)I}{0\ \Omega + 6\ \Omega} = 0\ \text{A}$$

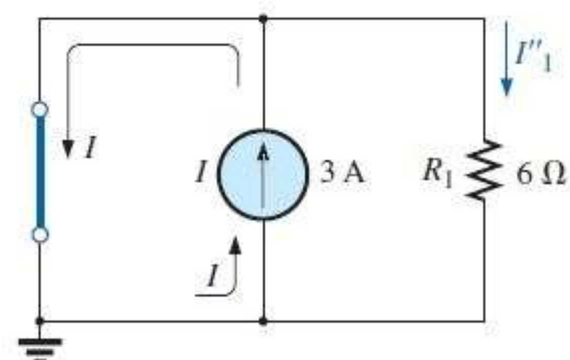


FIG. 9.4
Determining the effect of the 3 A current source on the current I_1 in Fig. 9.2.

SUPERPOSITION THEOREM

Since I'_1 and I''_1 have the same defined direction in Figs. 9.3 and 9.4, the total current is defined by

$$I_1 = I'_1 + I''_1 = 5\text{ A} + 0\text{ A} = 5\text{ A}$$

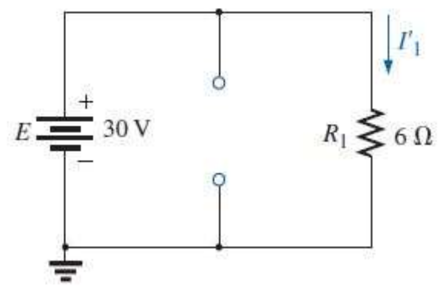


FIG. 9.3
Determining the effect of the 30 V supply on the current I_1 in Fig. 9.2.

the voltage source is in parallel with the current source and load resistor R_1, so the voltage across each must be 30 V. The result is that I_1 must be determined solely by

$$I_1 = \frac{V_1}{R_1} = \frac{E}{R_1} = \frac{30\text{ V}}{6\ \Omega} = 5\text{ A}$$

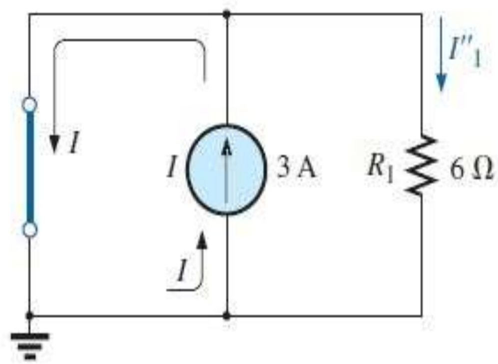


FIG. 9.4
Determining the effect of the 3 A current source on the current I_1 in Fig. 9.2.

SUPERPOSITION THEOREM

EXAMPLE 9.2 Using the superposition theorem, determine the current through the 12 Ω resistor in Fig. 9.5. Note that this is a two-source network of the type examined in the previous chapter when we applied branch-current analysis and mesh analysis.

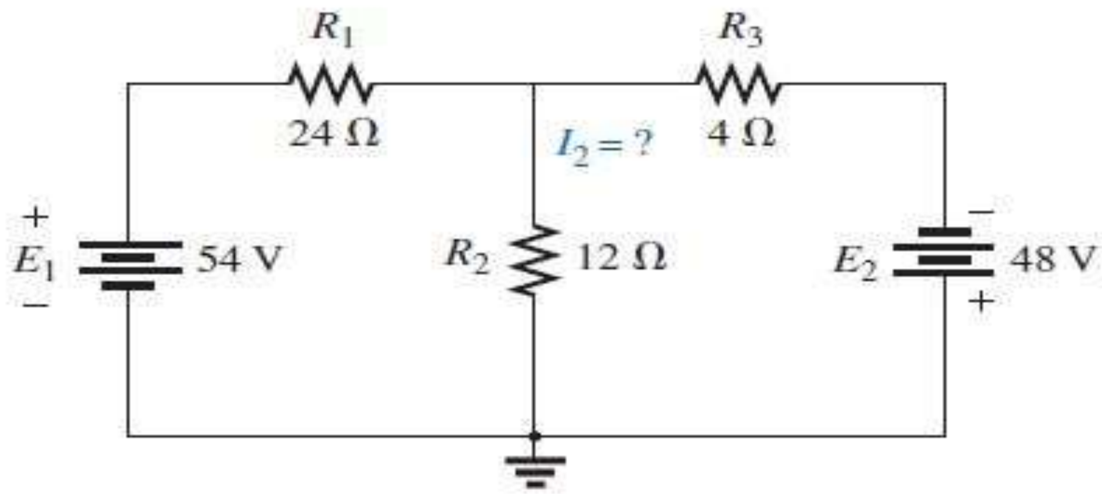


FIG. 9.5

Using the superposition theorem to determine the current through the 12 Ω resistor (Example 9.2).

SUPERPOSITION THEOREM

Solution: Considering the effects of the 54 V source requires replacing the 48 V source by a short-circuit equivalent as shown in Fig. 9.6. The result is that the 12 Ω and 4 Ω resistors are in parallel.

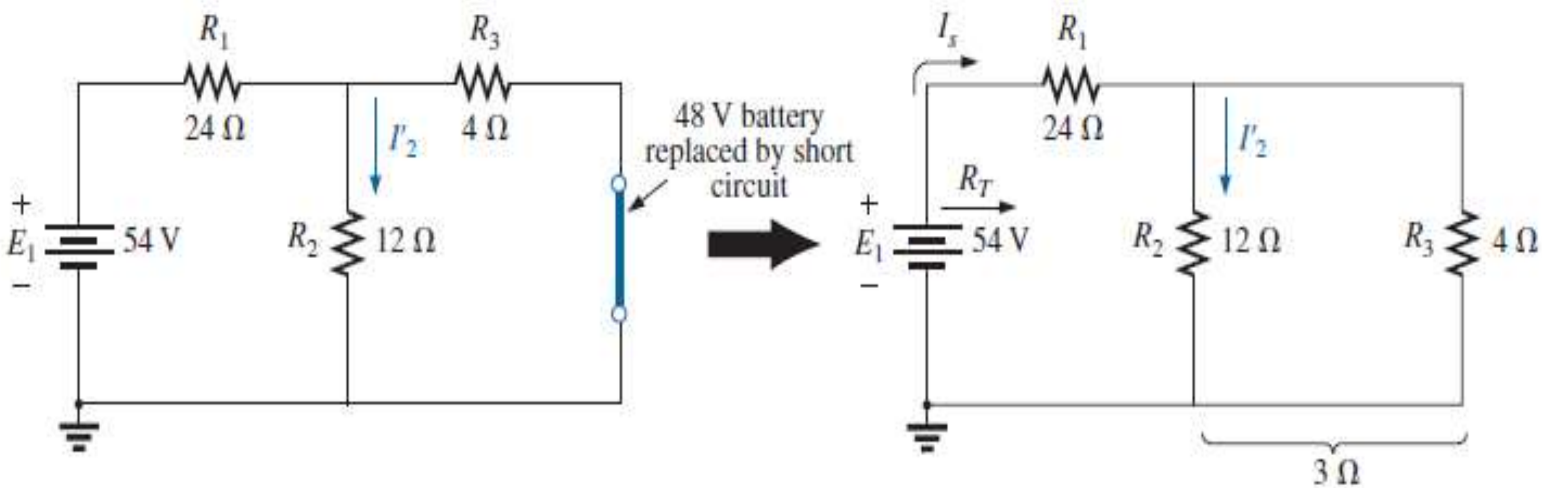


FIG. 9.6

Using the superposition theorem to determine the effect of the 54 V voltage source on current I_2 in Fig. 9.5.

SUPERPOSITION THEOREM

The total resistance seen by the source is therefore

$$R_T = R_1 + R_2 \| R_3 = 24\ \Omega + 12\ \Omega \| 4\ \Omega = 24\ \Omega + 3\ \Omega = 27\ \Omega$$

and the source current is $$I_s = \frac{E_1}{R_T} = \frac{54\ \text{V}}{27\ \Omega} = 2\ \text{A}$$

Using the current divider rule results in the contribution to I_2 due to the 54 V source:

$$I'_2 = \frac{R_3 I_s}{R_3 + R_2} = \frac{(4\ \Omega)(2\ \text{A})}{4\ \Omega + 12\ \Omega} = 0.5\ \text{A}$$

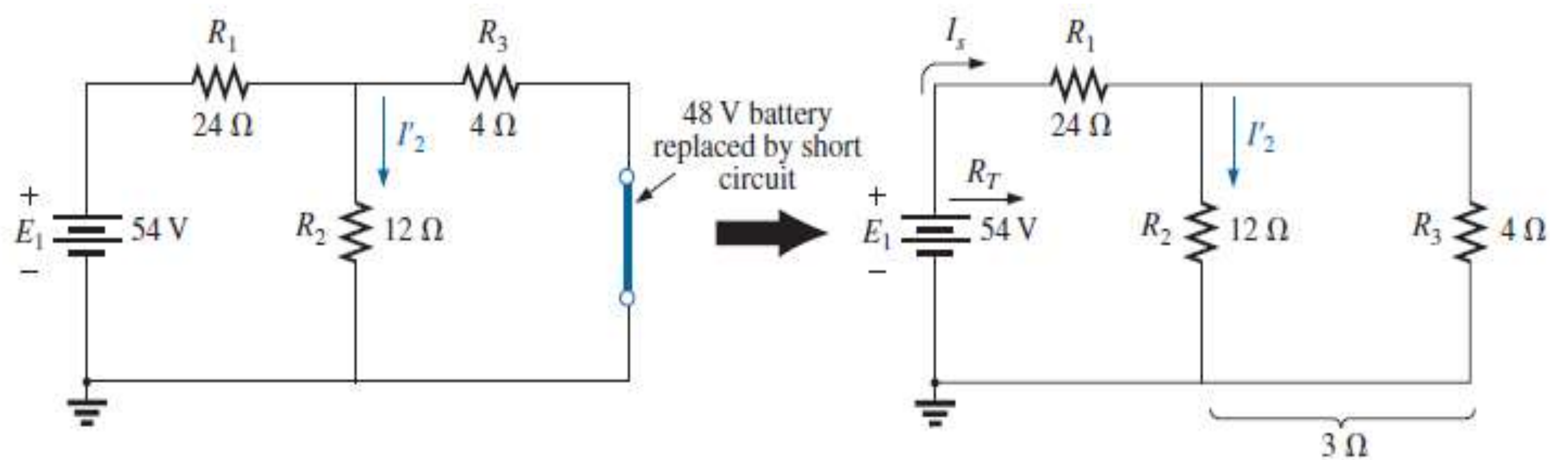


FIG. 9.6

Using the superposition theorem to determine the effect of the 54 V voltage source on current I_2 in Fig. 9.5.

SUPERPOSITION THEOREM

If we now replace the 54 V source by a short-circuit equivalent, the network in Fig. 9.7 results. The result is a parallel connection for the 12 _and 24 _ resistors.

Therefore, the total resistance seen by the 48 V source is

$$R_T = R_3 + R_2 \| R_1 = 4\,\Omega + 12\,\Omega \| 24\,\Omega = 4\,\Omega + 8\,\Omega = 12\,\Omega$$

and the source current is $$I_s = \frac{E_2}{R_T} = \frac{48\text{ V}}{12\,\Omega} = 4\text{ A}$$

Applying the current divider rule results in $$I''_2 = \frac{R_1(I_s)}{R_1 + R_2} = \frac{(24\,\Omega)(4\text{ A})}{24\,\Omega + 12\,\Omega} = 2.67\text{ A}$$

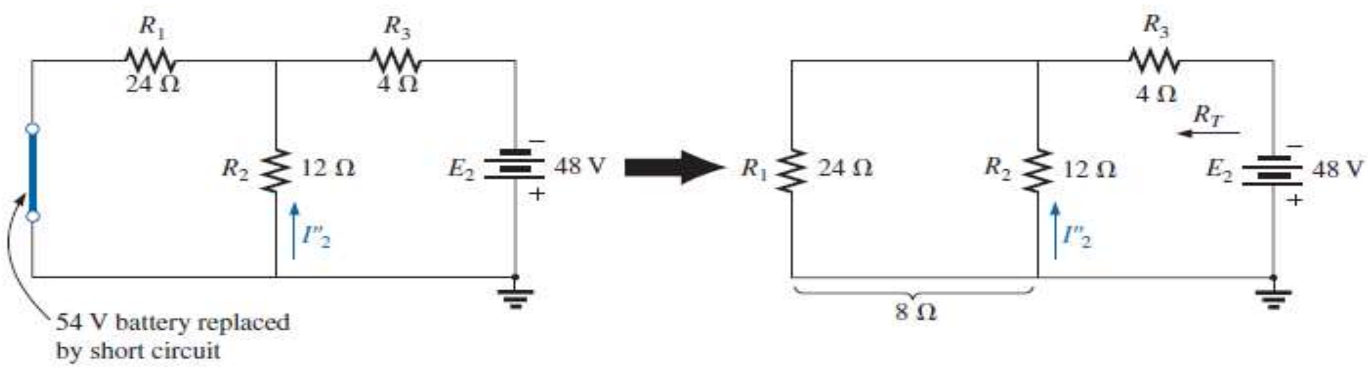


FIG. 9.7
Using the superposition theorem to determine the effect of the 48 V voltage source on current I_2 in Fig. 9.5.

SUPERPOSITION THEOREM

It is now important to realize that current *I*2 due to each source has a different direction, as shown in Fig. 9.8. The net current therefore is the difference of the two and the direction of the larger as follows:

$$I_2 = I''_2 - I'_2 = 2.67\text{ A} - 0.5\text{ A} = 2.17\text{ A}$$

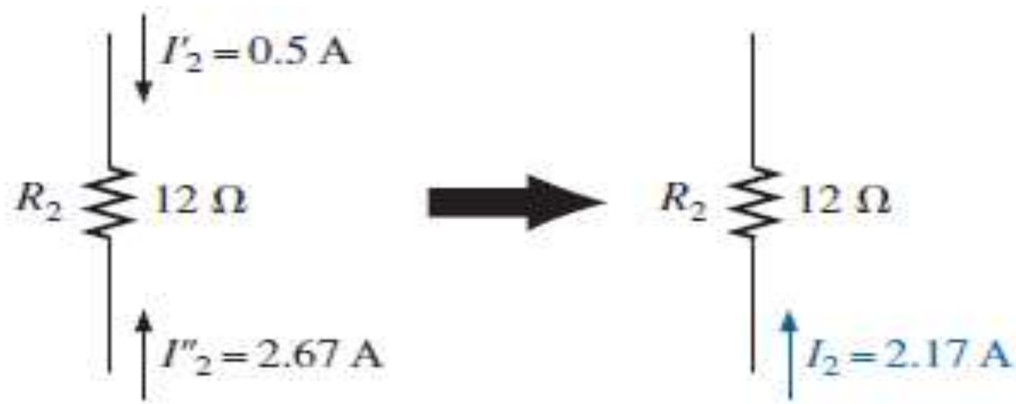


FIG. 9.8
Using the results of Figs. 9.6 and 9.7 to determine current I_2 for the network in Fig. 9.5.

SUPERPOSITION THEOREM

EXAMPLE 9.3

a. Using the superposition theorem, determine the current through resistor R2 for the network in Fig. 9.9.
b. Demonstrate that the superposition theorem is not applicable to power levels.

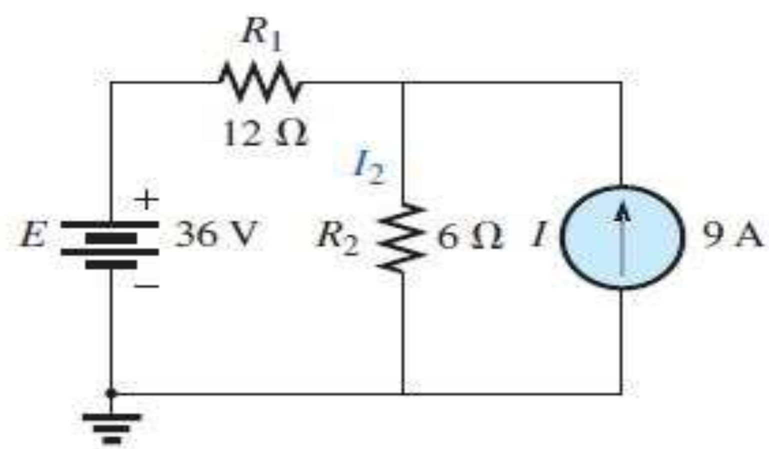


FIG. 9.9
Network to be analyzed in Example 9.3 using the superposition theorem.

SUPERPOSITION THEOREM

EXAMPLE 9.4 Using the principle of superposition, find the current I_2 through the 12 kΩ resistor in Fig. 9.15.

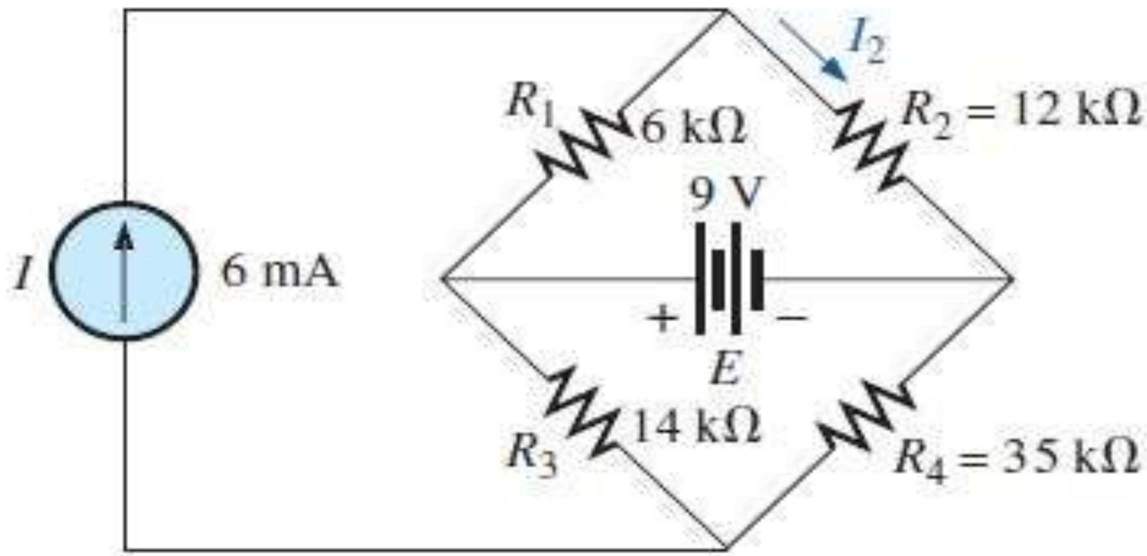


FIG. 9.15
Example 9.4.

SUPERPOSITION THEOREM

EXAMPLE 9.5 Find the current through the 2 Ωresistor of the network in Fig. 9.18

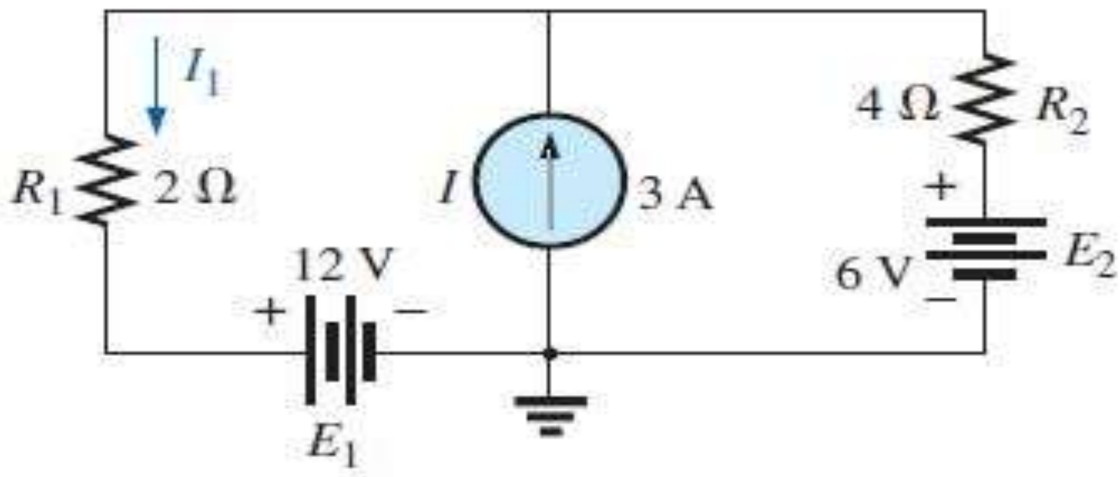


FIG. 9.18
Example 9.5.