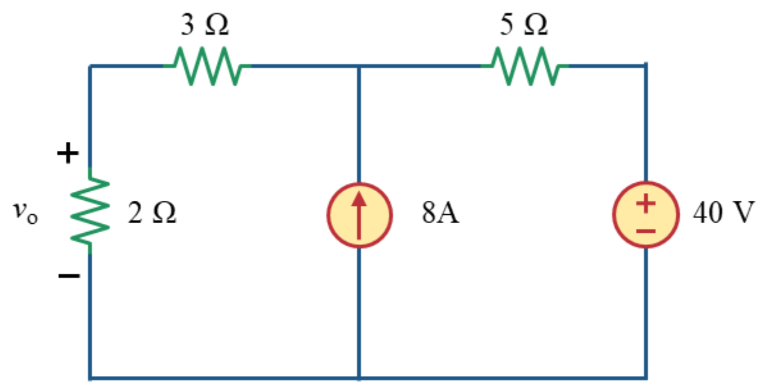
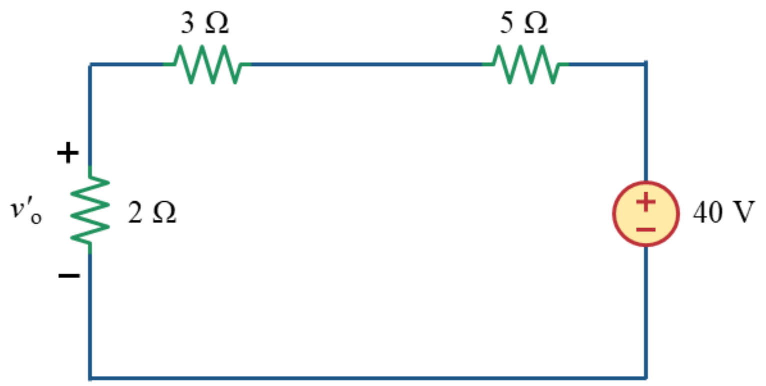
Solution to Problem 1



If v_0' and v_0'' are the contributions from the 40 V voltage source and 8 A current source respectively, then

$$v_0 = v_0' + v_0''$$

First, Considering the contribution of the 40 V voltage source (replacing the current source (8 A) by an open circuit)

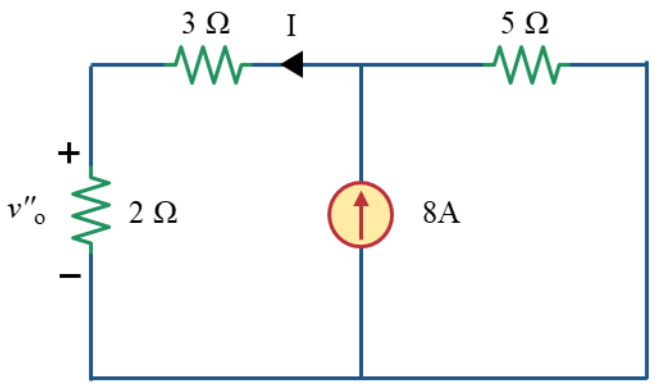


Using voltage divider rule,

$$v_0' = 40 \times \frac{2}{2+3+5}$$

$$\boxed{v_0' = 8\ \mathrm{V}}$$

Considering the contribution of the 8 A current source (replacing the voltage source (40 V) by a short circuit)



Applying current divider rule,

$$I = 8 \times \frac{(3+2) \,||\, 5}{3+2}$$

$$I = 4 \text{ A}$$

Now,

$$v_0'' = I \times 2$$

$$v_0'' = 4 \times 2$$

$$\boxed{v_0'' = 8 \text{ V}}$$

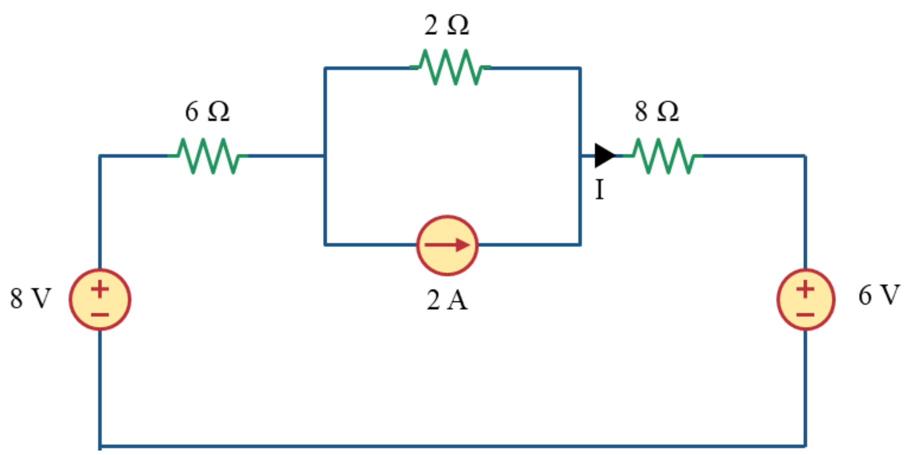
Finally,

$$v_0 = v_0' + v_0''$$

$$v_0 = 8 + 8$$

$$\boxed{v_0 = 16 \text{ V}}$$

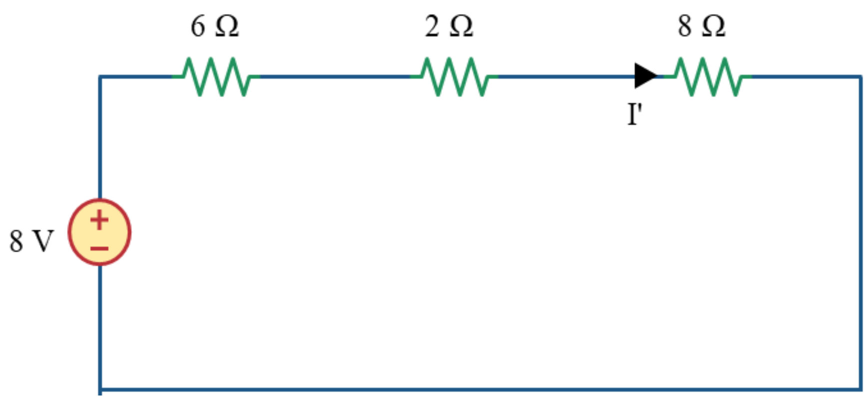
Solution to Problem 2



If I′, I″ and I‴ are the contributions from the 8 V voltage source, 2 A current source and 6 V voltage source respectively, then

$$I = I' + I'' + I'''$$

First, Considering the contribution of the 8 V voltage source (replacing the current source (2 A) by an open circuit and voltage source (6 V) by a short circuit)

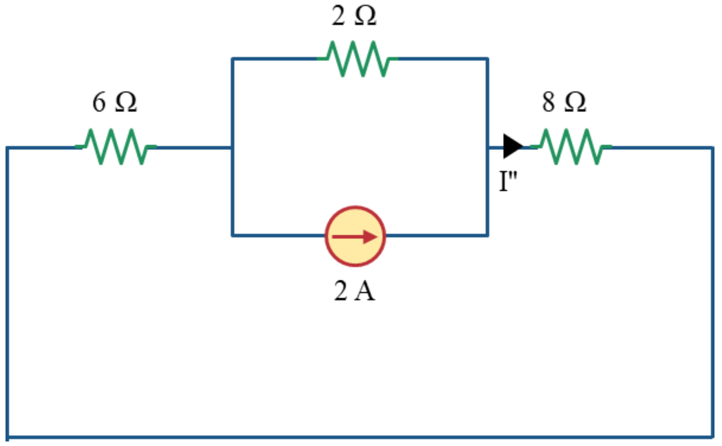


Applying KVL in the circuit,

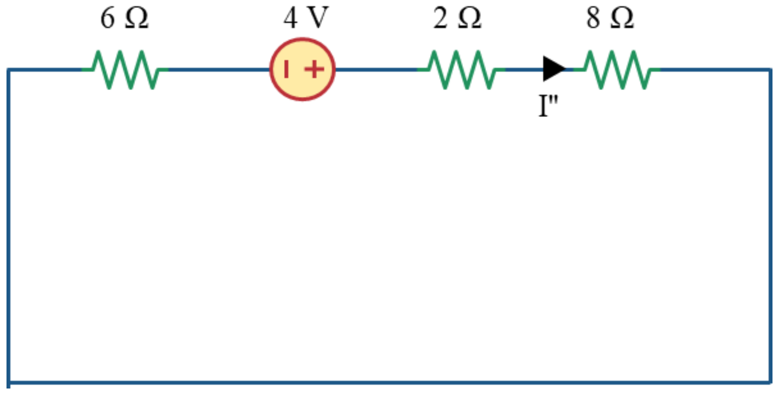
$$-8 + 6I' + 2I' + 8I' = 0$$

$$\boxed{I' = 0.5\ A}$$

Considering the contribution of the 2A current source (replacing the voltage sources (8 V & 6 V) by a short circuits)



Converting the current source into voltage source to simply the circuit,

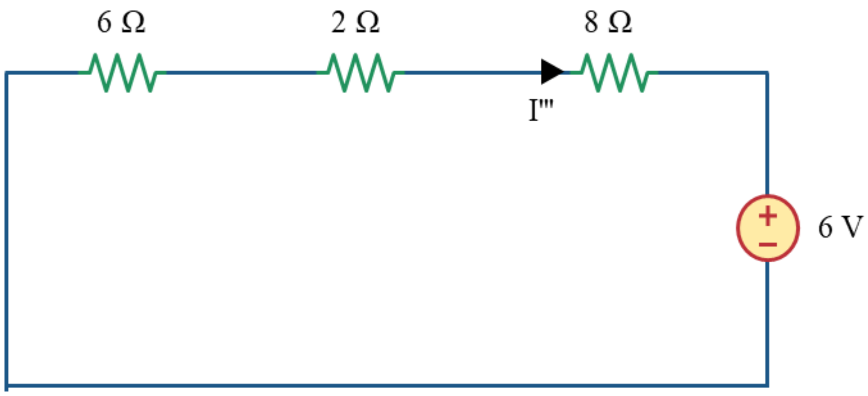


Applying KVL in the circuit,

$$-4 + 2I'' + 8I'' + 6I'' = 0$$

$$\boxed{I'' = 0.25\ A}$$

Considering the contribution of the 6 V voltage source (replacing the current source (2 A) by an open circuit and voltage source (8 V) by a short circuit)



Applying KVL in the circuit,

$$6 + 6I''' + 2I''' + 8I''' = 0$$

$$\boxed{I''' = -0.375\ A}$$

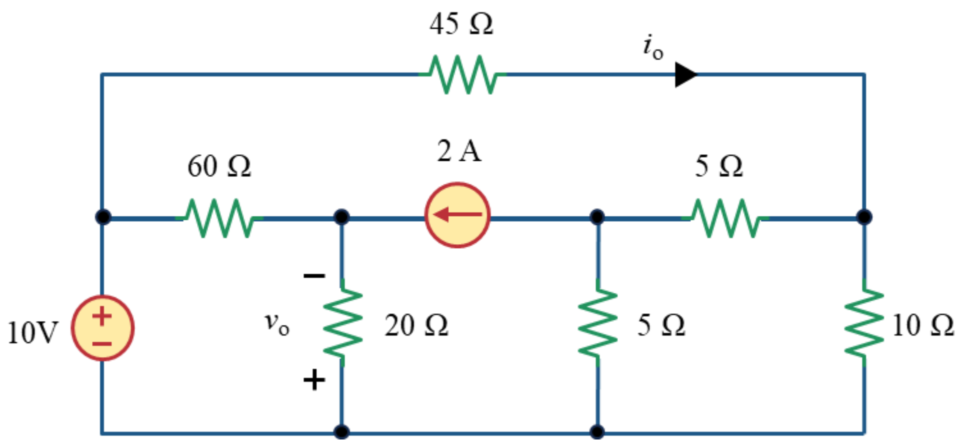
Finally,

$$I = I' + I'' + I'''$$

$$I = 0.5 + 0.25 - 0.375$$

$$\boxed{I = 0.375\ A}$$

Solution to Problem 4

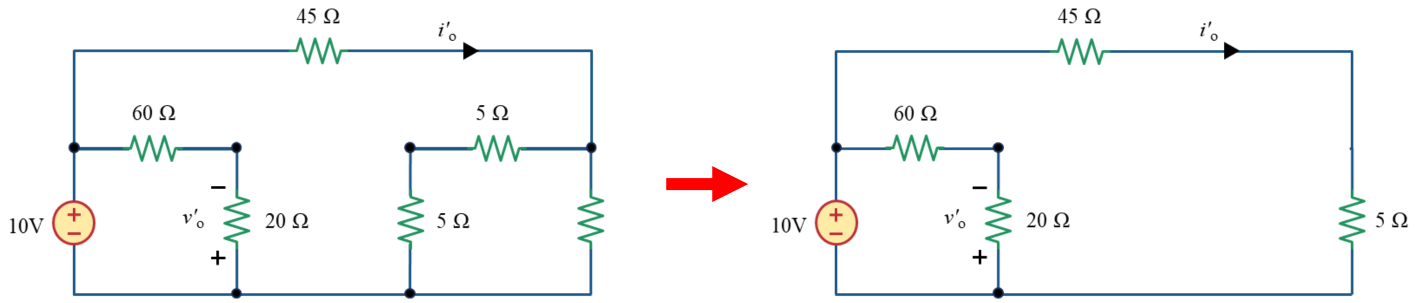


If v_0' (and i'_0) and v_0'' (and i''_0) are the contributions from the 10 V voltage source and 2 A current source respectively, then

$$v_0 = v_0' + v_0''$$

$$i_0 = i_0' + i_0''$$

Considering the contribution of the 10 V voltage source (replacing the current source (2 A) by an open circuit). The resistors in the right portion have been replaced by equaivalent resistance, $(5 + 5)||10 = 5\Omega$



As, 10 V is across the (45 + 5) = 50 Ω, the current i'_0 through it will be,

$$\boxed{i'_0 = \frac{10}{50} = 0.2 \text{ A}}$$

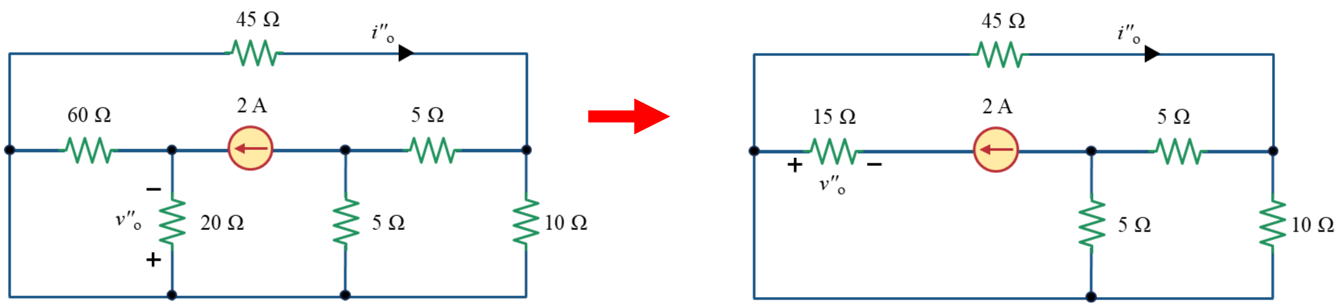
As, 10 V is across the (60 + 20) = 80 Ω, the voltage v_0' across 20 Ω will be, (Using voltage divider rule)

$$\boxed{v_0' = 10 \times \frac{-20}{80} = -2.5\ V}$$

The – (minus) sign is due to given polarity of v_0

Now, considering the contribution of the 2 A current source (replacing the voltage source (10 V) by a short circuit). Let's find out v_0'' first

We can see that; the 2 A current is divided into the 20 Ω and 60 Ω resistors. Infact, if we look closely, the voltage v_0'' is not only across 20 Ω, but also across 60 Ω. So, if we find the equivalent resistance (20||60 = 15 Ω) of these resistors then we can find the v_0'' by multiplying the current with the equivalent resistance. In that case, the circuit will be,

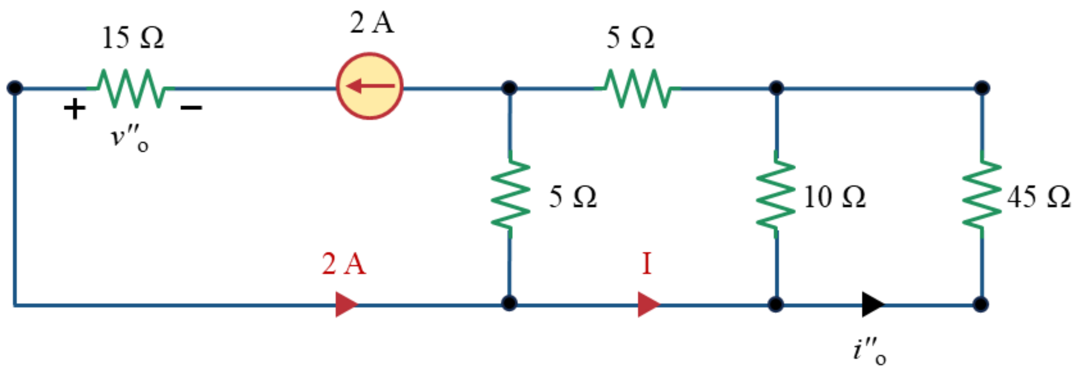


$$\boxed{v_0'' = -2 \times 15 = -30\text{ V}}$$

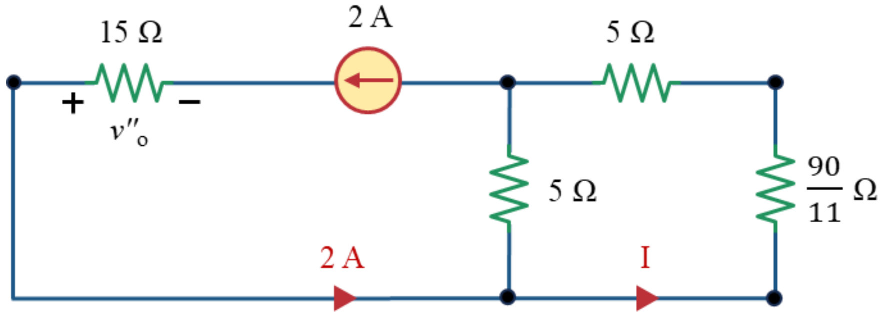
The – (minus) sign is due to given polarity of v_0

Let's find out i_0''

If we look closely we can see that the 45 Ω is parallel with 10 Ω. We can rearrange the circuit as follows,



To find out the i_0'', we first have to calculate I. To calculate we need to have equivalent resistance of the parallel 45 Ω and 10 Ω ($45 \,||\, 10 = \frac{90}{11}$ Ω). So, the circuit becomes



The equivalent resistance on the right portion:

$$R_{eq} = \left(\left(\frac{90}{11} + 5\right) || \, 5\right) = \frac{29}{8}$$

Using current divider rule,

$$\mathrm{I} = 2 \times \left(\frac{\frac{29}{8}}{\frac{90}{11} + 5}\right) = 0.55\ \mathrm{A}$$

Now,

$$i''_0 = I \times \frac{\frac{90}{11}}{45}$$

$$i''_0 = 0.55 \times \frac{\frac{90}{11}}{45}$$

$$\boxed{i''_0 = 0.1\ \mathrm{A}}$$

Finally,

$$v_0 = v_0' + v_0''$$

$$v_0 = -2.5 - 30$$

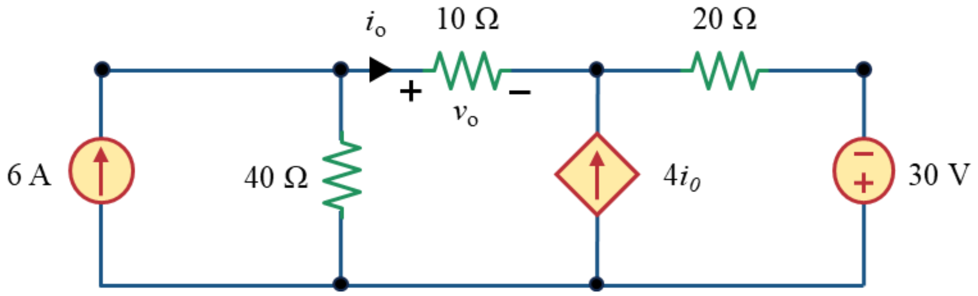
$$\boxed{v_0 = -32.5\ \mathrm{V}}$$

$$i_0 = i_0' + i_0''$$

$$i_0 = 0.2 + 0.1$$

$$\boxed{i_0 = 0.3\ A}$$

Solution to Problem 5



If v_0' (and i'_0) and v_0'' (and i''_0) are the contributions from the 6 A current source and 30 V voltage source respectively, then

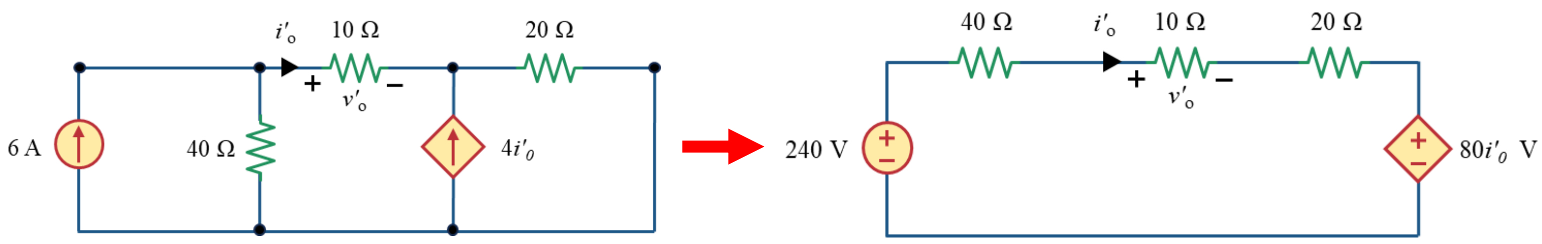
$$v_0 = v_0' + v_0''$$

$$i_0 = i_0' + i_0''$$

Now, considering the contribution of the 6 A current source (replacing the voltage source (30 V) by a short circuit).

If we look closely, we can apply source transformation for 6 A current source and $4i'_0$ dependent current source and convert them into voltage sources with resistance in series. This will simplyfy the circuit

Could have used Nodal Analysis



Applying KVL in the circuit,

$$-240 + 40\, i_0' + 10i_0' + 20i_0' + 80i_0' = 0$$

$$\boxed{i_0' = 1.6 \text{ A}}$$

Now,

$$v_0' = 10i_0'$$

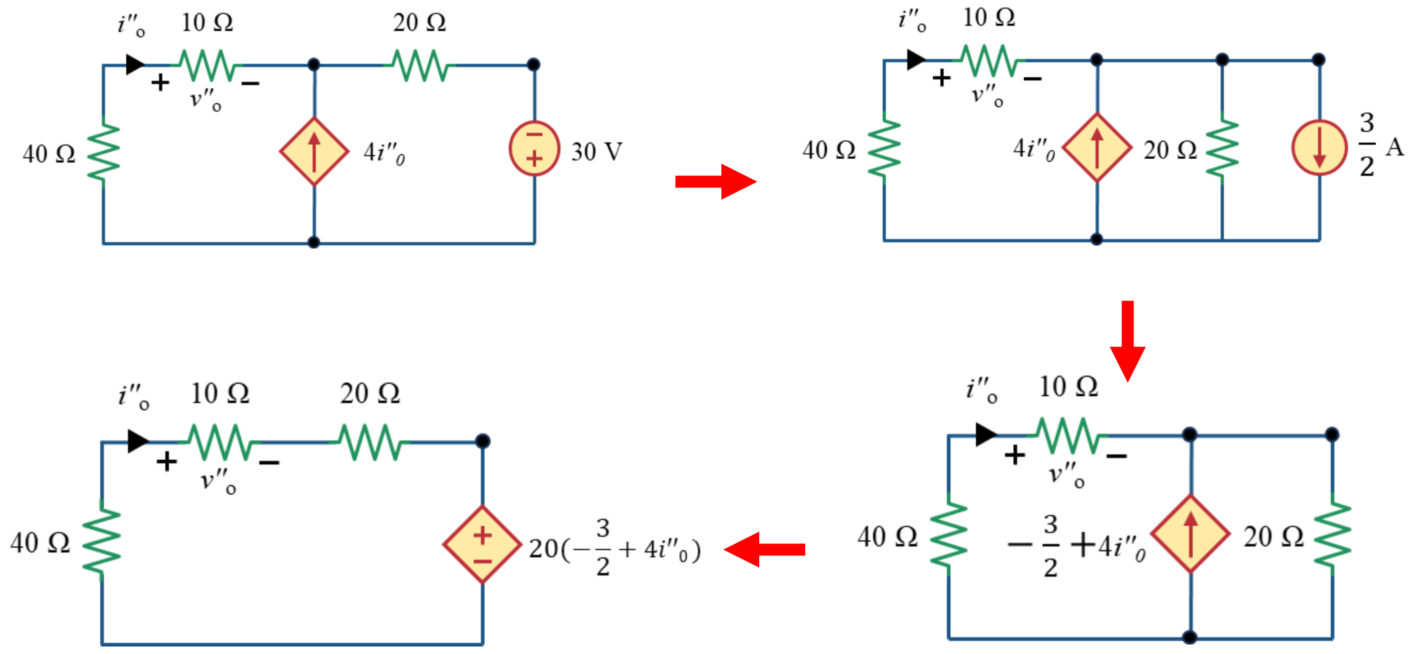
$$v_0' = 10 \times 1.6$$

$$\boxed{v_0' = 16 \text{ V}}$$

Now, considering the contribution of the 30 V voltage source (replacing the current source (6 A) by an open circuit).

Now, if we do a series of source transformations as in the figures below, the circuit will become simple.

Could have used Mesh Analysis



Applying KVL in the circuit,

$$40i_0'' + 10i''_0 + 20i''_0 + 20\left(-\frac{3}{2} + 4i_0''\right) = 0$$

$$40i_0'' + 10i''_0 + 20i''_0 - \frac{40}{3} + 80i_0'' = 0$$

$$\boxed{i_0'' = 0.2\ \mathrm{A}}$$

Now,

$$v_0'' = 10i_0''$$

$$v_0'' = 10 \times 0.2$$

$$\boxed{v_0'' = 2\ \mathrm{V}}$$

Finally,

$$v_0 = v_0' + v_0''$$

$$v_0 = 16 + 2$$

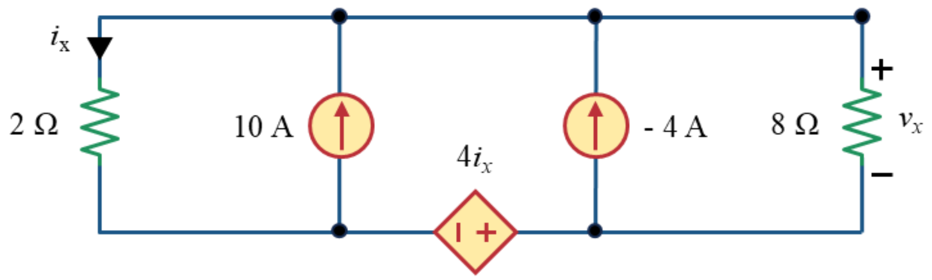
$$\boxed{v_0 = 18\ \mathrm{V}}$$

$$i_0 = i_0' + i_0''$$

$$i_0 = 1.6 + 0.2$$

$$\boxed{i_0 = 1.8\ A}$$

Solution to Problem 6

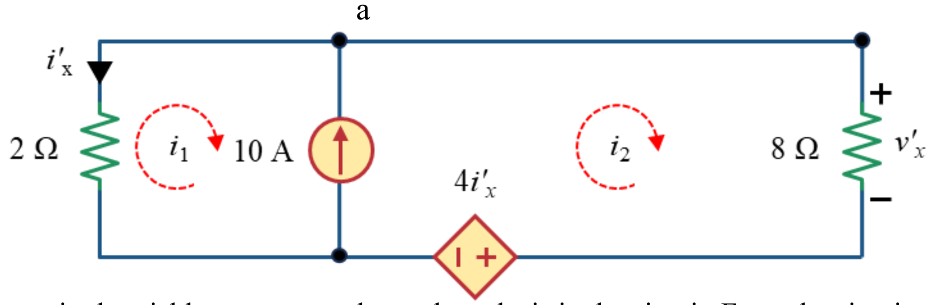


If v_0' (and i'_0) and v_0'' (and i''_0) are the contributions from the 10 A current source and - 4 A current source respectively, then

$$v_x = v_x' + v_x''$$

$$i_x = i_x' + i_x''$$

Now, considering the contribution of the 10 A current source (replacing the current source (- 4 A) by an open circuit)



To find the required variables we can apply mesh analysis in the circuit. From the circuit,

$$i_x' = -i_1$$

$$v_x' = 8i_2$$

We can see that there is supermesh. Applying KVL in supermesh,

$$2i_1 + 8i_2 + 4i_x' = 0$$

$$2i_1 + 8i_2 + 4(-i_1) = 0$$

$$-2i_1 + 8i_2 = 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

Applying KCL in node a,

$$i_1 - i_2 = -10 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(ii)}$$

Solving (i) and (ii),

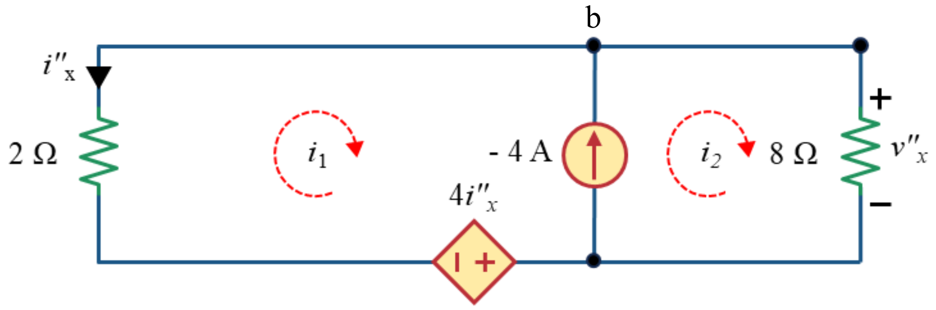
$$i_1 = -\frac{40}{3}$$

$$i_2 = -\frac{10}{3}$$

Now,

$$\boxed{\begin{aligned} i_x' &= -\left(-\frac{40}{3}\right) = \frac{40}{3}\ A \\ v_x' &= -\frac{10}{3} \times 8 = -\frac{80}{3}\ V \end{aligned}}$$

Considering the contribution of the - 4 A current source (replacing the current source (10 A) by an open circuit)



To fine the required variables we can apply mesh analysis in the circuit. From the circuit,

$$i_x'' = -i_1$$

$$v_x'' = 8i_2$$

We can see that there is supermesh. Applying KVL in supermesh,

$$2i_1 + 8i_2 + 4i_x'' = 0$$

$$2i_1 + 8i_2 + 4(-i_1) = 0$$

$$-2i_1 + 8i_2 = 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

Applying KCL in node b,

$$i_1 - i_2 = 4 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(ii)}$$

Solving (i) and (ii),

$$i_1 = \frac{16}{3}$$

$$i_2 = \frac{4}{3}$$

Now,

$$\boxed{\begin{aligned} i_x'' &= -\left(\frac{16}{3}\right) = \frac{-16}{3}\ A \\ v''_x &= \frac{4}{3} \times 8 = \frac{32}{3}\ V \end{aligned}}$$

Finally,

$$v_0 = v_0' + v_0''$$

$$v_0 = -\frac{80}{3} + \frac{32}{3}$$

$$\boxed{v_0 = -16\text{ V}}$$

$$i_0 = i_0' + i_0''$$

$$i_0 = \frac{40}{3} + \frac{32}{3}$$

$$\boxed{i_0 = 24\ A}$$