COM234 ELECTRONICS

Superposition

Thevenin’s and Norton’s Theorems

SUPERPOSITION

The idea of superposition rests on the linearity property.

The superposition principle states that the voltage across (or current through) an element in a linear circuit is the algebraic sum of the voltages across (or currents through) that element due to each independent source acting alone.

However, to apply the superposition principle, we must keep two things in mind:

1. We consider one independent source at a time while all other independent sources are turned off. This implies that we replace every voltage source by 0 V (or a short circuit), and every current source by 0 A (or an open circuit).

2. Dependent sources are left intact because they are controlled by circuit variables. With these in mind, we apply the superposition principle in three steps:

SUPERPOSITION

Steps to Apply Super position Principle:

1. Turn off all independent sources except one source. Find the output (voltage or current) due to that active source using nodal or mesh analysis.

2. Repeat step 1 for each of the other independent sources.

3. Find the total contribution by adding algebraically all the contributions due to the independent sources.

Analyzing a circuit using superposition has one major disadvantage: it may very likely involve more work. Keep in mind that superposition is based on linearity.

Example 1: Use the superposition theorem to find v in the circuit.

Solution:

Since there are two sources, let

$$v = v_1 + v_2$$

where v_1 and v_2 are the contributions due to the 6V voltage source and the 3A current source, respectively. To obtain v_1, we set the current source to zero, as shown in **Fig (a)**. Applying **KVL** to the loop in **Fig.(a)** gives

$$12i_1 - 6 = 0 \Rightarrow i_1 = 0.5\ A$$

Thus:

$$v_1 = 4i_1 = 2\ V$$

To get v_2, we set the voltage source to zero, as in **Fig. (b)**. Using current division,

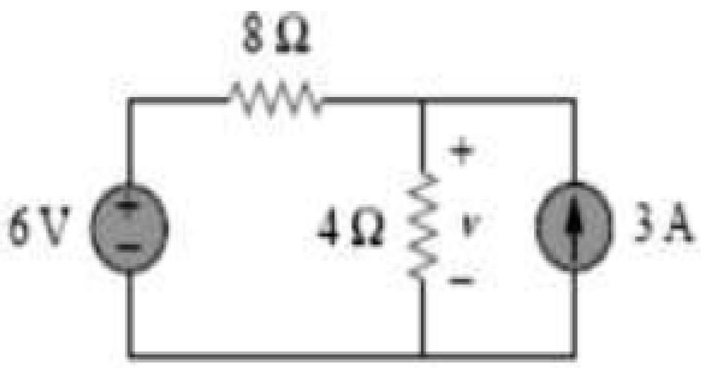
$$i_3 = \frac{8}{4+8} 3A = 2A$$

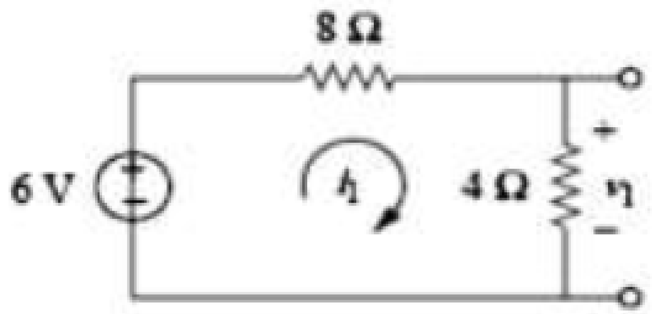
Hence,

$$v_2 = 4i_3 = 8\ V$$

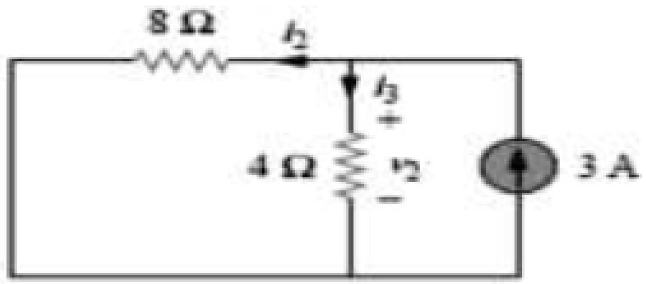
And we find

$$v = v_1 + v_2 = 2 + 8 = 10\ V$$





(a)

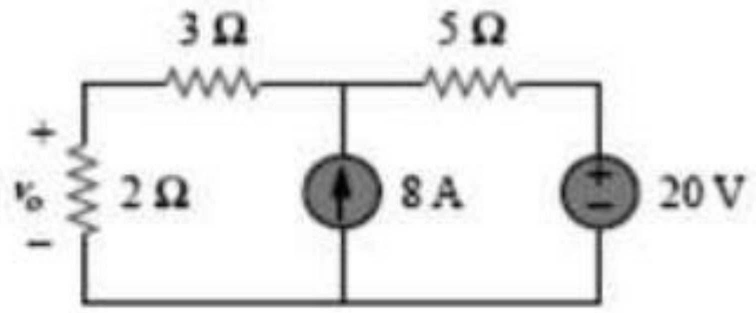


(b)

Practice 1:

Using the superposition theorem, find $\mathbf{v_o}$ in the circuit in Figure below.

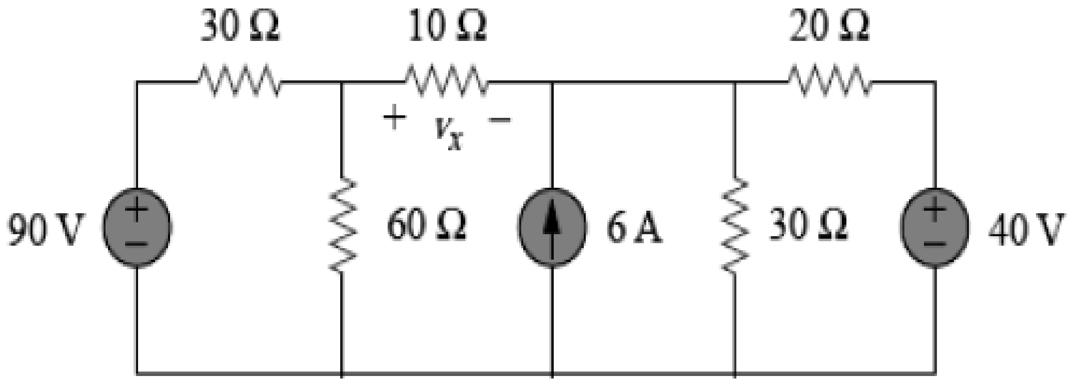
Answer:12 V



Practice 2:

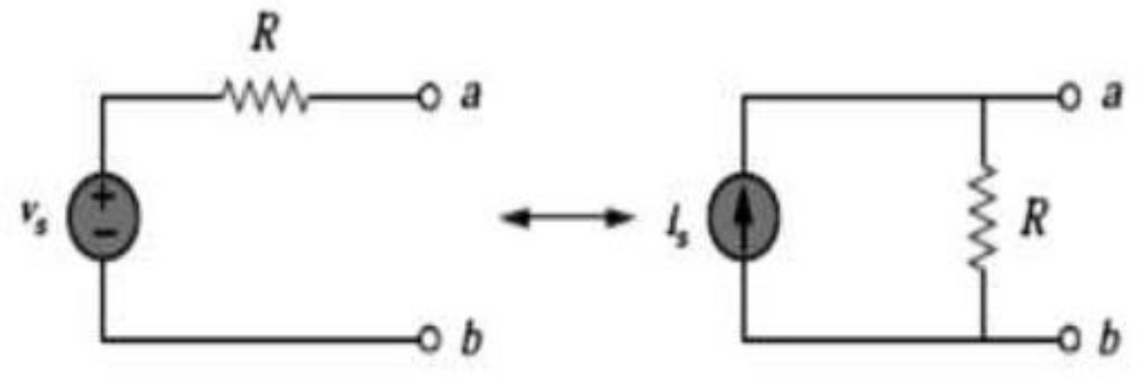
Use superposition to obtain v_x in the circuit of Figure below..

Answer: 0.75 A



SOURCE TRANSFORMATION

We have noticed that series-parallel combination. Source transformation is another tool for simplifying circuits. We can substitute a voltage source in series with a resistor for a current source in parallel with a resistor, or vice versa, as shown in **Fig.** below. Either substitution is known as a ***source transformation***.



Key Point: *A source transformation is the process of replacing a voltage source vs in series with a resistor R by a current source is in parallel with a resistor R, or vice versa.*

SOURCE TRANSFORMATION

We need to find relationship between v_s and i_s that guarantees the two configurations in Fig below are equivalent with respect to nodes a, b.

Suppose R_L , is connected between nodes a, b in Fig. Using Ohm Law, the Current in R_L is.

$$i_L = \frac{v_s}{(R+R_L)}$$

R and R_L in series

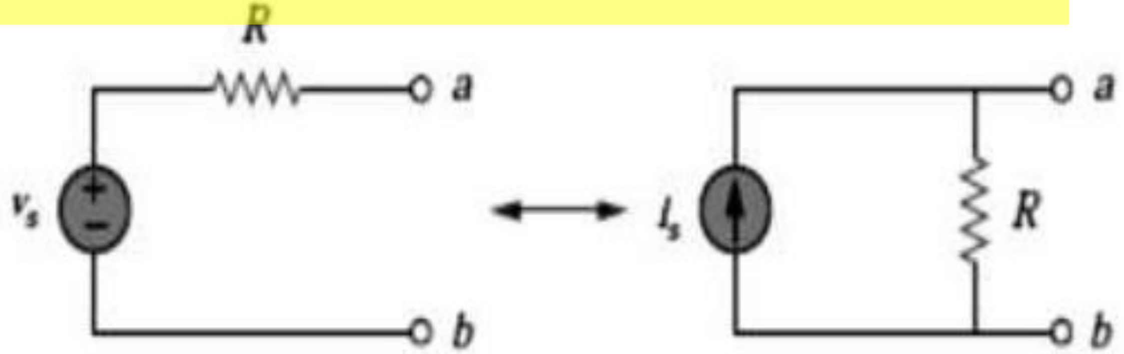
If it is to be replaced by a current source then load current must be $\frac{V}{(R+R_L)}$

Now suppose the same resistor $\mathbf{R_L}$, is connected between nodes **a**, **b** in **Fig. (b)**. Using current division, the current in $\mathbf{R_L}$, is

$$i_L = i_s \frac{R}{(R+R_L)}$$

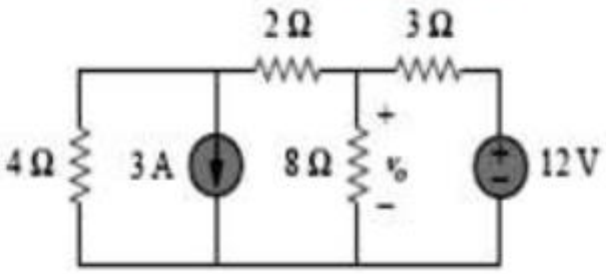
If the two circuits in Fig are equivalent, these resistor and currents must be the same. Equating the right hand sides of equations and simplifying

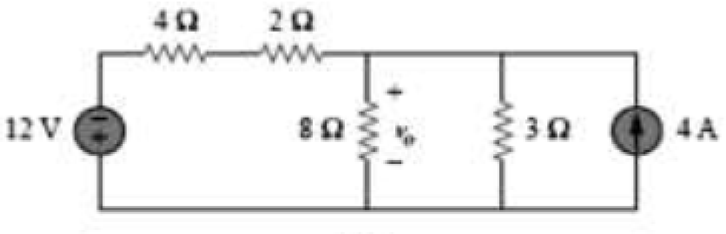
$$i_s = \frac{v_s}{R} \quad or \quad v_s = i_s R$$



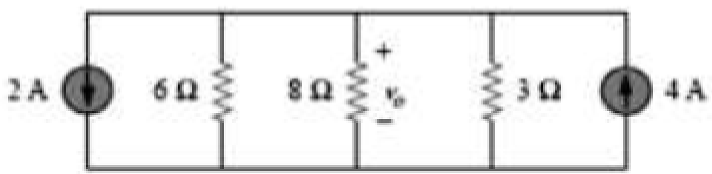
EXAMPLE: Use source transformation to find v_o in the circuit in Fig

Solution: We first transform the current and voltage sources to obtain the circuit in **Fig. (a)**. Combining the 4Ω and 2Ω resistors in series and transforming the 12V voltage source gives us **Fig. (b)**. We now combine the 3Ω and 6Ω resistors in parallel to get 2Ω. We also combine the 2A and 4A current sources to get a 2A source. Thus, by repeatedly applying source transformations, we obtain the circuit in **Fig. (c)**.





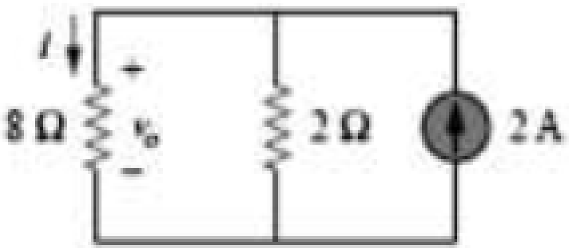
(a)



(b)

Alternatively, since the 8Ω and 2Ω resistors in **Fig. (c)** are in parallel, they have the same voltage v_o across them. Hence,

$$v_o = (8||2)(2\text{ A}) = ((8\times 2)/10)*2 = 3.2\text{ V}$$

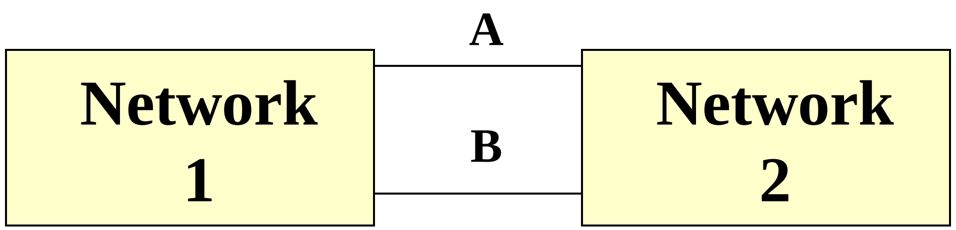


(c)

THEVENIN AND NORTON

THEVENIN’S THEOREM

Consider the following:

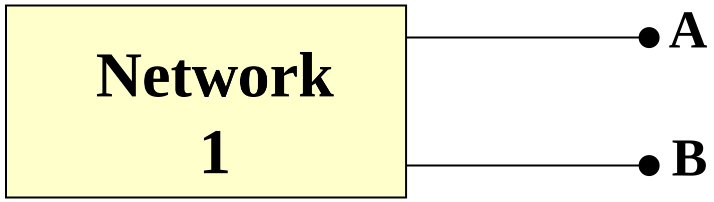


For purposes of discussion, at this point, we consider that both networks are composed of resistors and independent voltage and current sources

THEVENIN & NORTON

THEVENIN'S THEOREM:

Suppose Network 2 is detached from Network 1 and we focus temporarily only on Network 1.



Network 1 can be as complicated in structure as one can imagine. Maybe 45 meshes, 387 resistors, 91 voltage sources and 39 current sources.