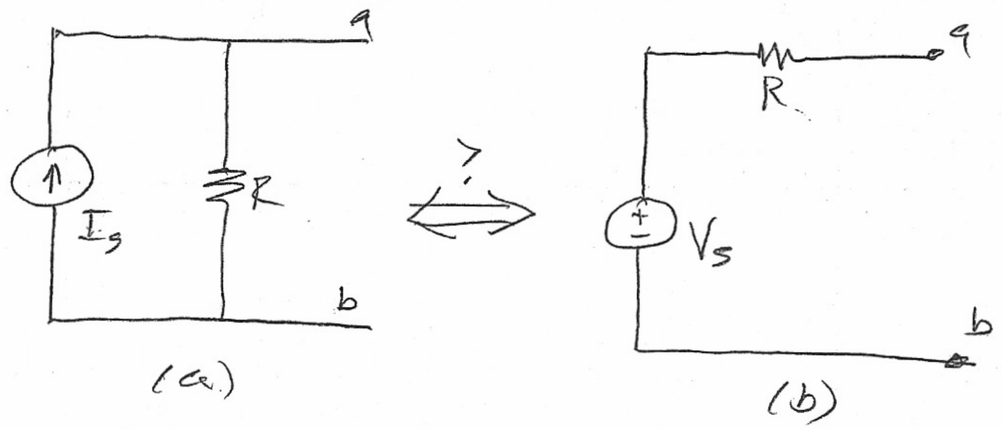
Lecture 6
wlg

ECE 301
Source Transformation

Source Transformations

Suppose we are give a current source shunted by resistance R and we want to determine if we can transform this to a voltage source in series with a resistor. Also we want to know if the transformation is reverseable. That is,



For the circuits to be equivalent for each case

(a) the open-circuit voltage must be the same

(b) the short circuit current must be the same.

For the circuit in (a) the open circuit voltage

$$V_{os_1} = I_s R \quad (1)$$

The short circuit current is

$$I_{ss_1} = I_s \quad (2)$$

For the circuit on the right the open circuit voltage is

$$V_{os_2} = V_s \quad (3)$$

the short circuit current is

$$I_{ss_2} = \frac{V_s}{R} \quad (4)$$

So (1) and (3) must agree. Thus

$$\boxed{I_s R = V_s}$$

and (2) and (4) must agree

$$I_{ss_1} = I_{ss_2}$$

$$\boxed{I_s = \frac{V_s}{R}}$$

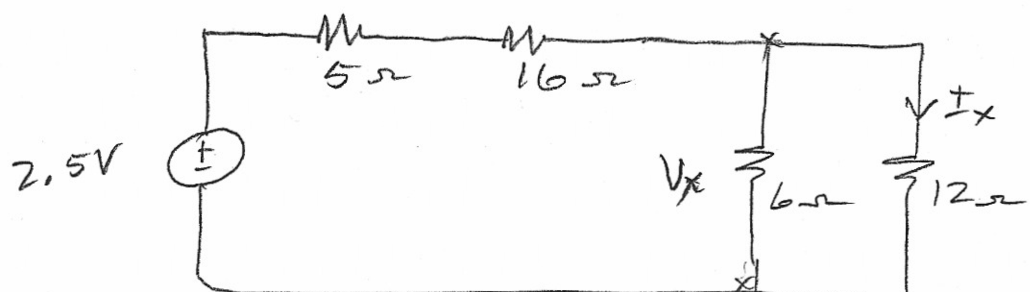
How do we use this.

Example (very simple case)
Give the following circuit.
Transform the current source and resistor to a voltage source in series with a resistor.

Then find I_x as indicated.

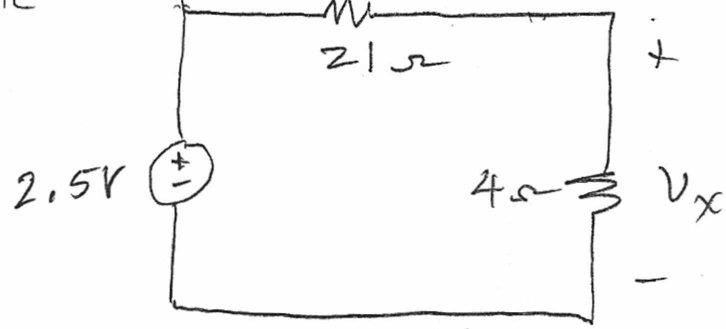
(a)

$V_s = 0.5 \times 5 = 2.5V$



(b)

OR



(c)

By voltage division,

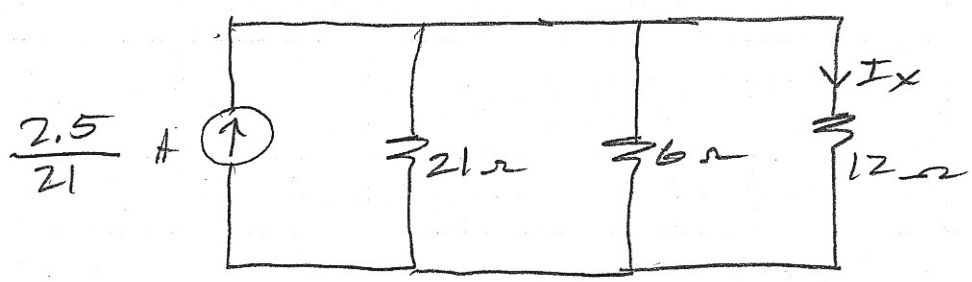
$$V_x = \frac{2.5 \times 4}{21+4} = 0.4\,V$$

then

$$I_x = \frac{V_x}{12} = \frac{0.4}{12}$$

$$I_x = 0.0333\ A$$

You can also transform the circuit in (b) to the following:



$$\frac{1}{R_{eq}} = \frac{1}{21} + \frac{1}{6} + \frac{1}{12} = .0476 + .1667 + .0833$$

$$\frac{1}{R_{eq}} = 0.2948\ S$$

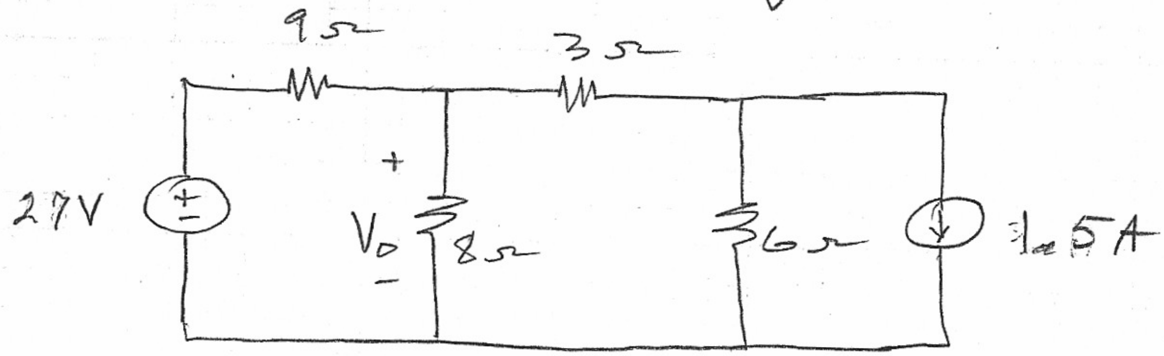
$$I_x = \left(\frac{2.5}{21}\right) \times \frac{R_{eq}}{12} = \left(\frac{2.5}{21}\right) \times \frac{1}{12 \times 0.2948}$$

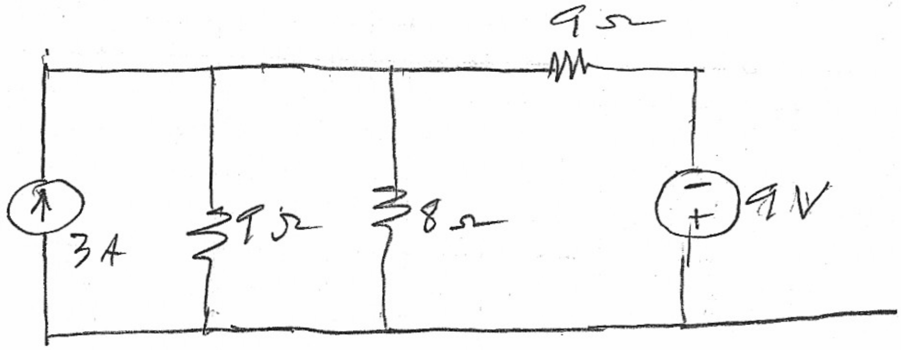
$I_x = .033\ A$ (rounding)

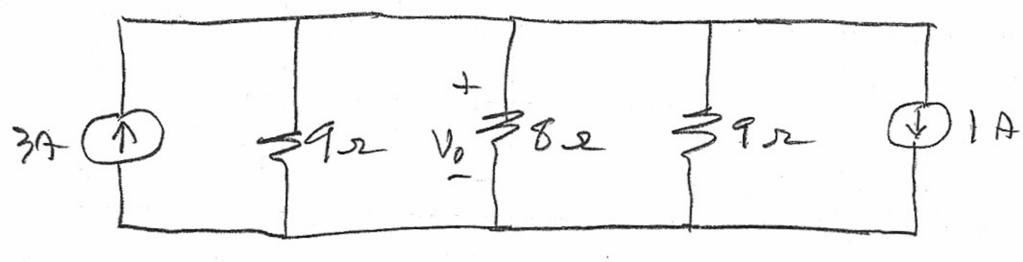
(Not the easiest way)

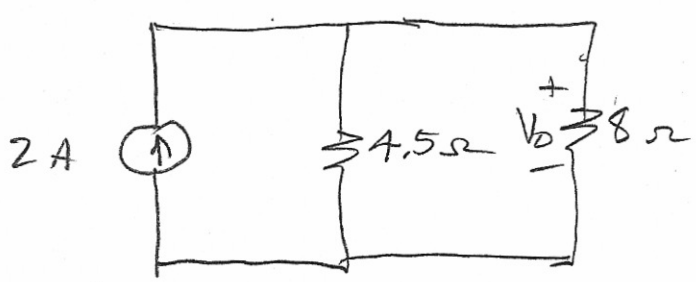
Example 2

Use source transformation to find V_o in the following circuit.





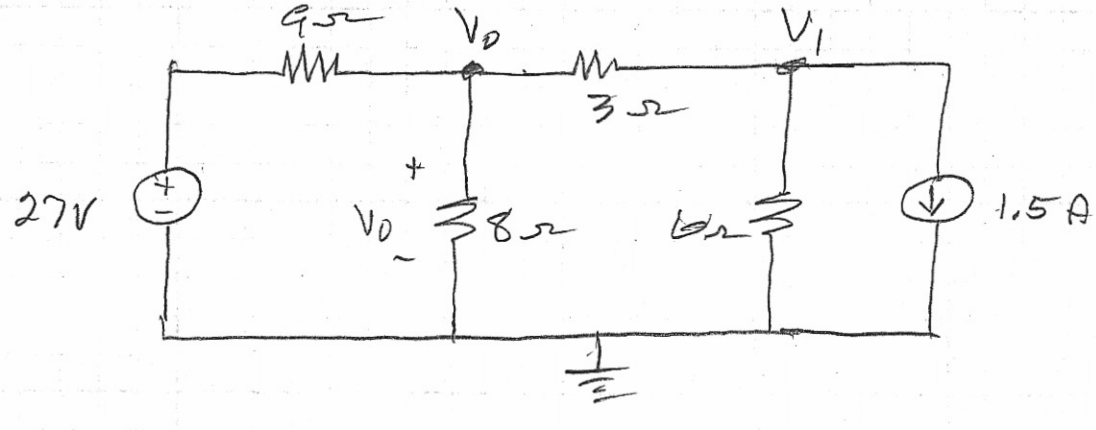




$$V_o = \left(\frac{2 \times 4.5}{4.5+8}\right) 8 = 5.76\,V$$

Verify by nodal analysis

Example 2 by Nodal Analysis



At V_o

$$\frac{V_o - 27}{9} + \frac{V_o}{8} + \frac{V_o - V_1}{3} = 0$$

$$0.111V_o - 3 + 0.125V_o + .333V_o - .333V_1 = 0$$

$$0.569V_o - .333V_1 = 3 \qquad (1)$$

At V_1

$$\frac{V_1 - V_o}{3} + \frac{V_1}{6} = -1.5$$

$$2V_1 - 2V_o + V_1 = -9$$

$$-2V_o + 3V_1 = -9 \qquad (2)$$

Solving (1) and (2)

$V_o = 5.76\ V$, $V_1 = 0.844\ V$

OK