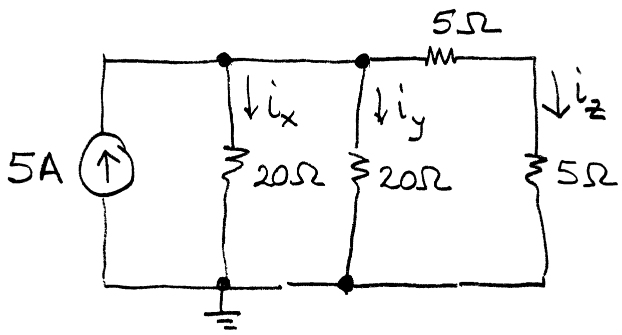
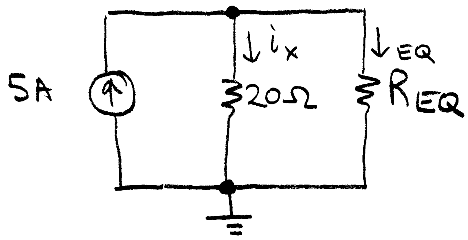
Example 2-18

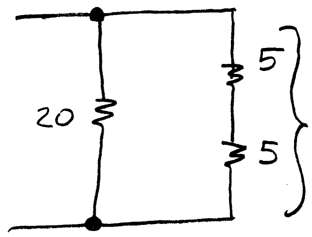
Find the current i_x.



Reduce this circuit to

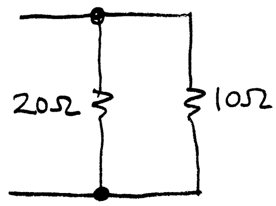


The problem now is to calculate R_{EQ} for



These two are in series and can simply be added together.

$$R'_{EQ} = 5+5 = 10\Omega$$



This is now a parallel circuit. The equivalent resistance is given by

$$\frac{1}{R_{EQ}} = \frac{1}{R_1} + \frac{1}{R_2}$$

or

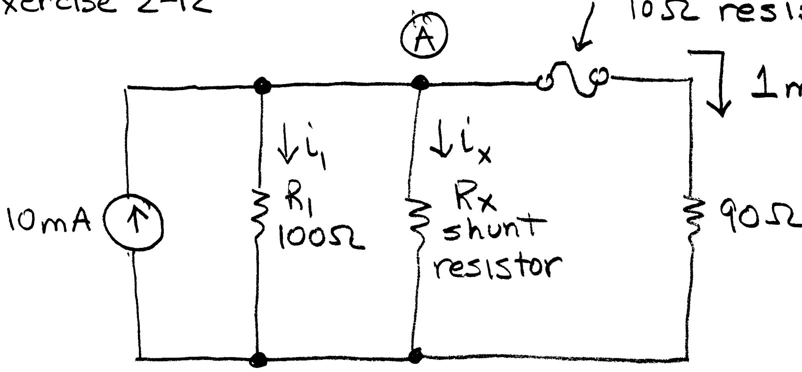
$$R_{EQ} = \frac{R_1 R_2}{R_1 + R_2} = \frac{(20)(10)}{20+10}$$

$$R_{EQ} = 6\tfrac{2}{3}\Omega$$

Now use a current divider to find i_x

$$i_x = \frac{R_{EQ}}{20+R_{EQ}} \cdot 5A = \frac{6.67}{20+6.67}(5A) = 1.25 \text{ Amperes.}$$

Exercise 2-12



② You protect the device with a 1.5mA fuse which looks like a 10Ω resistor.

① This is an expensive device you want to protect. It cannot receive more than 1mA.

③ Calculate R_x so that only 1mA goes to the device.

This is a current division problem.

The fuse plus 90Ω resistor are in series and can be replaced by a $R_{EQ} = R_1 + R_2 = 10 + 90 = 100\Omega$

Since there is a 1mA current through R_{EQ} the voltage across R_{EQ} is $v_A = i R_{EQ} = (1\times10^{-3})(100) = 0.1$ volts.

The same 0.1 volts appears across R_1 and R_x. The current thru R_1 is then

$$i_1 = \frac{v_A}{R_1} = \frac{0.1 \text{ volts}}{100} = 1\text{mA}$$

Applying KCL @ A gives

$$\sum_{+in} i = 0 \qquad +10\text{mA} - 1\text{mA} - i_x - 1\text{mA} = 0$$

$$i_x = 8\text{mA}$$

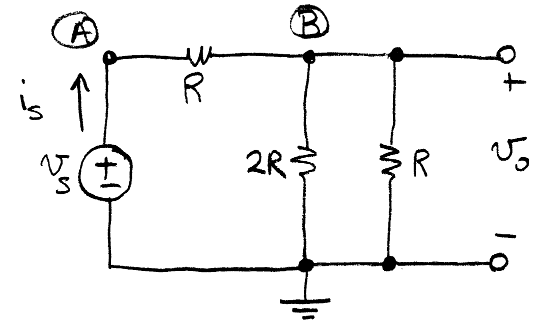
This allows us to solve for R_x

$$R_x = \frac{v}{i} = \frac{0.1 \text{ volts}}{8\times10^{-3}\text{ amps}} = 12.5 \text{ ohms.}$$

2-6 Circuit Reduction

Example 2-20

Use series and parallel equivalence to find the output voltage and the input current in the circuit shown below.



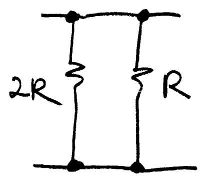
Solution approach

a. combine parallel resistors R and 2R

b. calculate v_o using voltage divider

c. combine all resistances to determine input current i_s

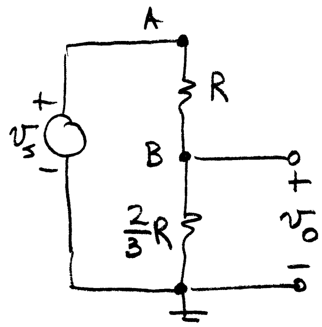
a.



From (2-22)

$$R_{EQ} = 2R \parallel R = \frac{(2R)(R)}{2R+R} = \frac{2R^2}{3R} = \frac{2}{3}R$$

b.

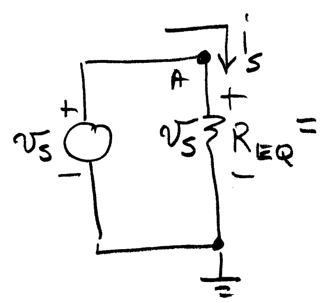


From (2-31) $v_K = \frac{R_K}{R_{EQ}} v_{TOTAL}$

$$v_o = \frac{\frac{2}{3}R}{R+\frac{2}{3}R} v_s = \frac{\frac{2}{3}R}{\frac{5}{3}R} v_s = \frac{2}{5} v_s$$

resistors in series add

c.



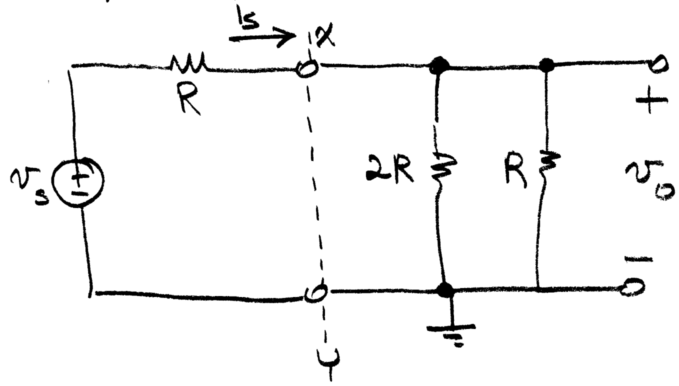
$$R_{EQ} = R + \frac{2}{3}R = \frac{5}{3}R$$

Using Ohm's Law

$$i_s = \frac{v_s}{R_{EQ}} = \frac{v_s}{\frac{5}{3}R} = \frac{3}{5}\frac{v_s}{R}$$

Example 2-21

Use source transformations to find the output voltage v_o and the input current i_s in the circuit shown below.



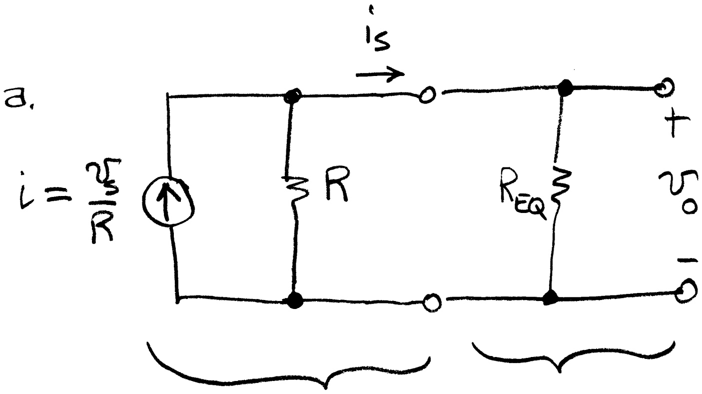
a. apply a source transformation to v_s - R left of x-y

b. combine the two parallel resistors

c. use current division to find i_s

d. calculate v_o

a.



a.

b. $R_{EQ} = \frac{(2R)(R)}{2R+R} = \frac{2R^2}{3R} = \frac{2}{3}R.$

c. Using current divider

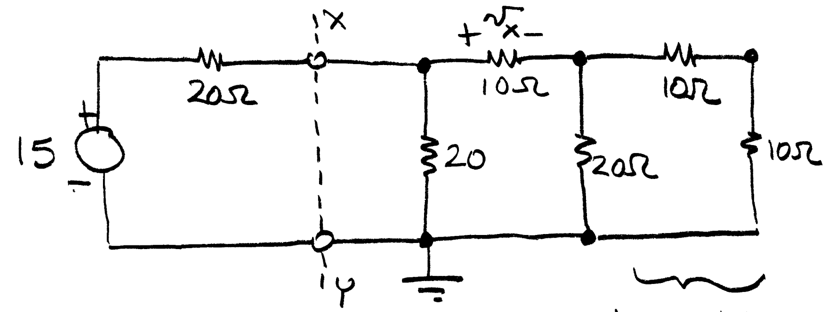
$$i_s = \frac{R}{R+R_{EQ}}\, i = \frac{R}{R+\frac{2}{3}R}\,\frac{v_s}{R} = \frac{3}{5}\,\frac{v_s}{R}$$

d. calculate v_o using Ohm's Law

$$v_o = i_s R_{EQ} = \left(\frac{3}{5}\,\frac{v_s}{R}\right)\left(\frac{2}{3}R\right) = \frac{2}{5}v_s$$

Example 2-22

Find v_x in the circuit below.

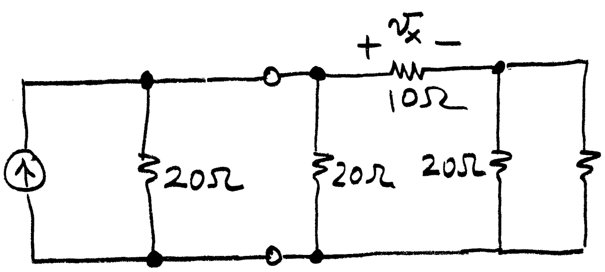


b, combine resistors

a. do source transformation

$i = \frac{15}{20}$

$i = \frac{3}{4}$ A.



$R_{EQ} = 10 + 10 = 20\Omega$

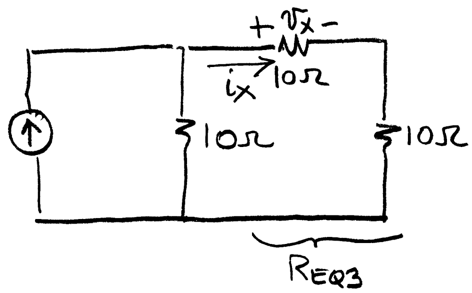
c. combine resistors

$R_{EQ1} = \frac{(20)(20)}{20+20} = 10$

d. combine resistors

$R_{EQ2} = \frac{(20)(20)}{20+20} = 10$

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



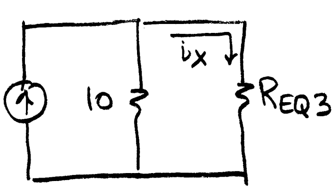
e. several ways to finish

e.1 use source transformation and voltage divider, OR

e.2 combine two 10Ω resistors in series and use a current divider followed by Ohm's Law

e.2 $R_{EQ3} = 10 + 10 = 20\Omega$

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



using current divider $i_x = \frac{10}{10 + R_{EQ3}} i$

$i_x = \frac{10}{10+20}\left(\frac{3}{4}\right) = \frac{1}{3} \cdot \frac{3}{4} = \frac{1}{4}$

using Ohm's Law $v_x = i_x(10\Omega) = \frac{1}{4}(10) = 2.5$ Volts