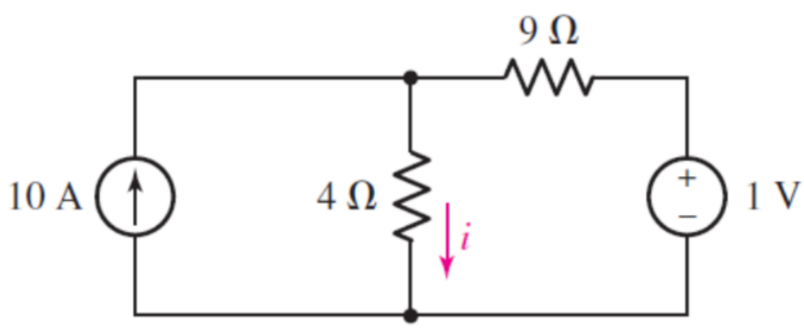
Q1.

(a) Employ superposition to determine the current labelled *i* in the circuit shown below.
(b) Express the contribution the 1 V source makes to the total current *i* in terms of a percentage.
(c) Changing only the value of the 10 A source, adjust the circuit shown below so that the two sources contribute equally to the current *i*.



(a) We replace the voltage source with a short circuit and designate the downward current through the 4 Ω resistor as i'.

Then, i' = (10)(9)/(13) = 6.923 A

Next, we replace the current source in the original circuit with an open circuit and designate the downward current through the 4 Ω resistor as i".
Then, i" = 1/13 = 0.07692 A

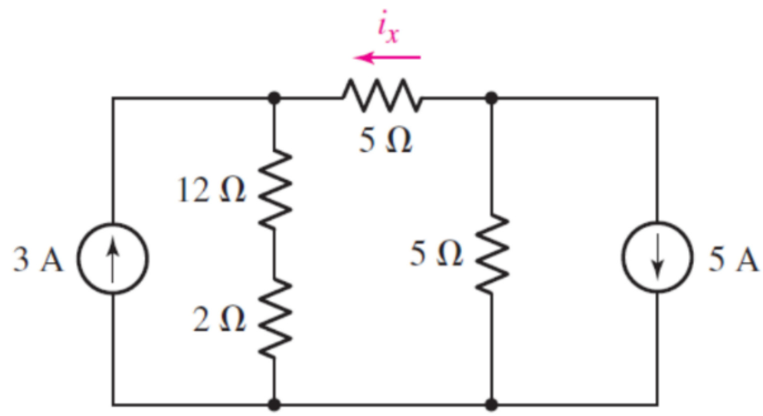
Adding, i = i' + i" = $\boxed{7.000\text{ A}}$

(b) The 1 V source contributes (100)(0.07692)/7.000 = $\boxed{1.1\%\text{ of the total current.}}$

(c) $I_x(9)/13 = 0.07692$. Thus, $\boxed{I_x = 111.1\text{ mA}}$

Q2.

(a) Employ superposition to obtain the individual contributions each of the two sources in Fig. shown below, makes to the current labelled i_x.
(b) Adjusting only the value of the rightmost current source, alter the circuit so that the two sources contribute equally to i_x.



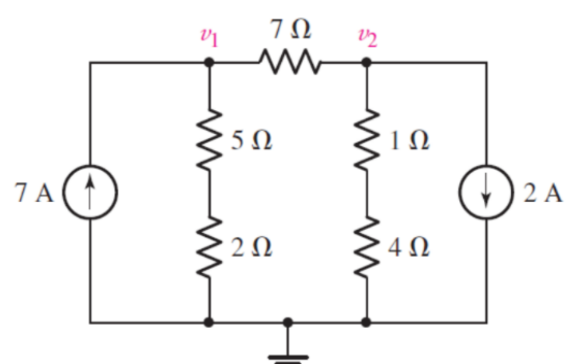
(a) Replacing the 5 A source with an open circuit, $i_x\big|_{3\text{ A only}} = -3\dfrac{14}{14+10} = \boxed{-1.75\text{ A}}$.

Replacing the 3 A source with an open circuit, $i_x\big|_{5\text{ A only}} = -5\dfrac{5}{19} = \boxed{-1.316\text{ A}}$.

(b) -I(5/19) = -1.75. Thus, $\boxed{\text{I} = 6.65\text{ A.}}$

Q3.

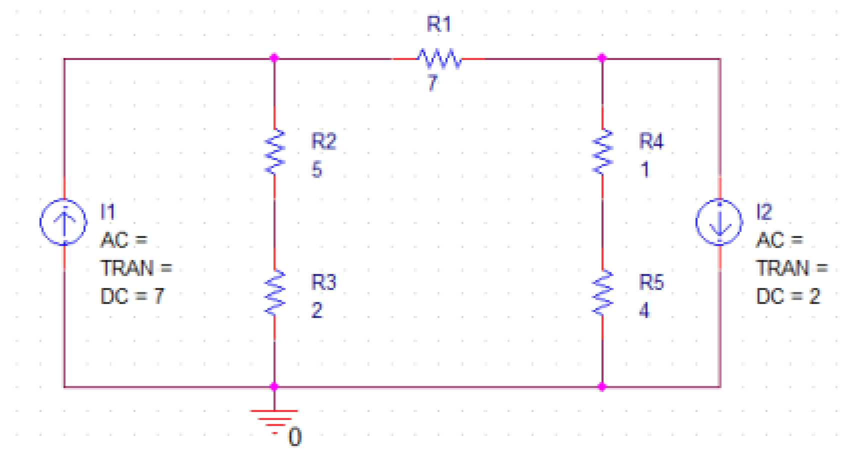
(a) Determine the individual contributions of each of the two current sources shown in Fig. shown below to the nodal voltage labelled v_2.
(b) Instead of performing two separate ltspice simulations, verify your answer by using a single dc sweep.

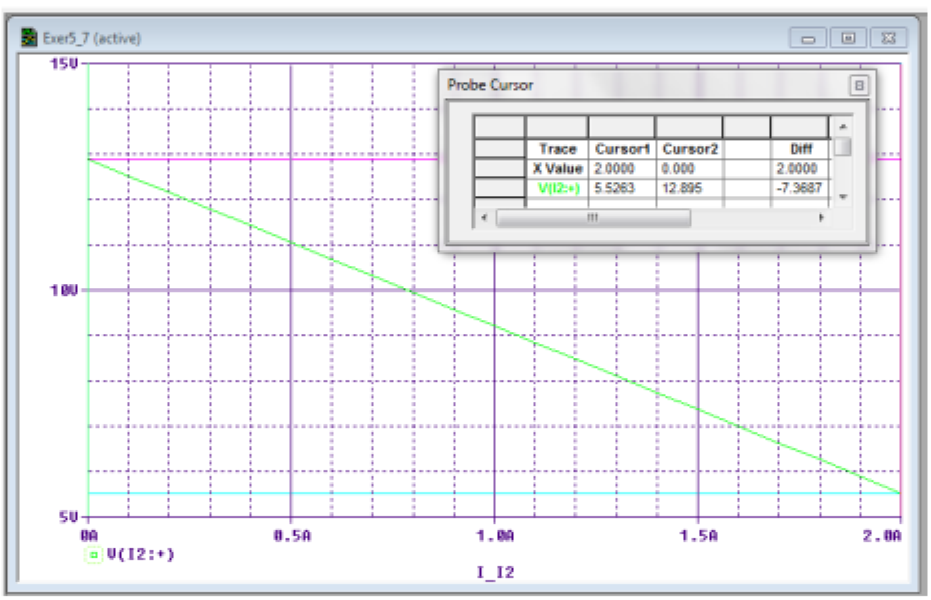


(a) $$v_2\big|_{7\text{ A}} = (5)\left[7\frac{7}{19}\right] = \boxed{12.89\text{ V}}$$

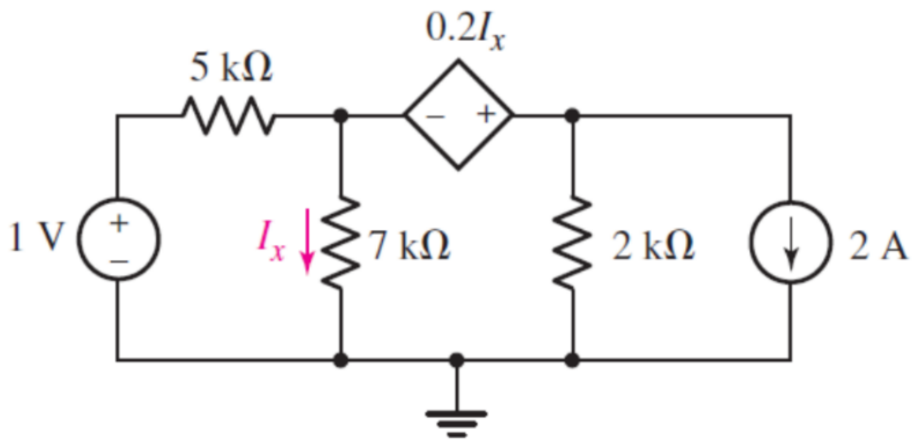
$$v_2\big|_{2\text{ A}} = (5)\left[-2\frac{14}{19}\right] = \boxed{-7.368\text{ V}}$$

(b) We see from the simulation output that the 7 A source alone contributes 12.89 V. The output with both sources on is 5.526 V, which agrees within rounding error to our hand calculations (5.522 V).





Q4. Employ superposition principles to obtain a value for the current I_x as labelled in Fig. shown below



We select the bottom node as the reference, then identify v_1 with the lefthand terminal of the dependent source and v_2 with the righthand terminal.

Via superposition, we first consider the contribution of the 1 V source:

$$\frac{v_1' - 1}{5000} + \frac{v_1'}{7000} + \frac{v_2'}{2000} = 0 \quad \text{and}$$

$$\left(1 + \frac{0.2}{7000}\right) v_1' - v_2' = 0$$

Solving, $v_1' = 0.237$ V

Next, we consider the contribution of the 2 A source:

$$\frac{v_1''}{5000} + \frac{v_1''}{7000} + \frac{v_2''}{2000} = -2 \quad \text{and}$$

$$\left(1 + \frac{0.2}{7000}\right) v_1'' - v_2'' = 0$$

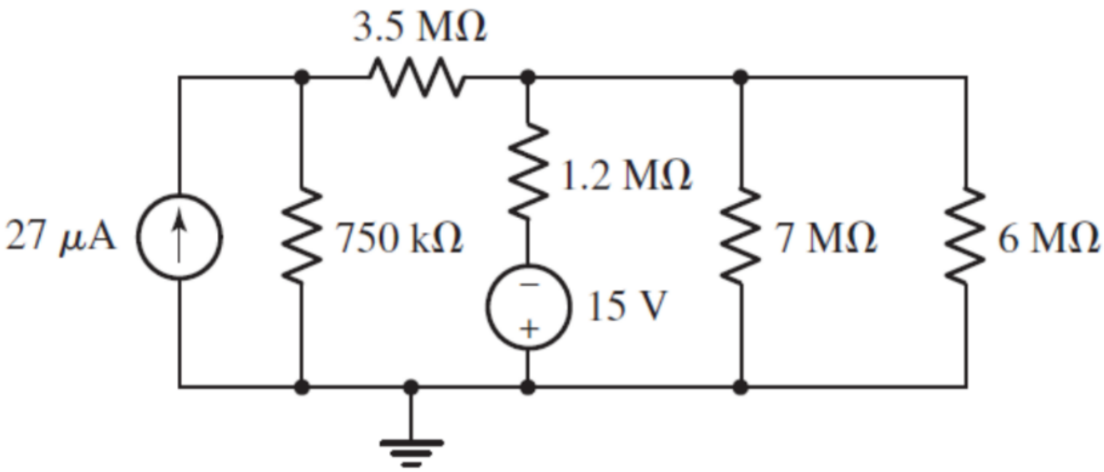
Solving, $v_1'' = -2373$ V. Adding our two components, $v_1 = -2373$ V.

Thus, $i_x = v_1/7000 = \boxed{339\text{ mA}}$

Q5.

(a) Using repeated source transformations, reduce the circuit of Fig. shown below to a voltage source in series with a resistor, both of which are in series with the 6 MΩ resistor.

(b) Calculate the power dissipated by the 6 MΩ resistor using your simplified circuit.



Perform the following steps in order:

Combine the 27 μA and 750 kΩ to obtain 20.25 V in series with 750 kΩ in series with 3.5 MΩ.

Convert this series combination to a 4.25 MΩ resistor in parallel with a 4.765 μA source, arrow up.

Convert the 15 V/ 1.2 MΩ series combination into a 12.5 μA source (arrow down) in parallel with 1.2 MΩ. This appears in parallel with the current source from above as well as the 7 MΩ and 6 MΩ.

Combine: 4.25 MΩ || 1.2 MΩ || 7 MΩ = 0.8254 MΩ. This, along with the -12.5 μA + 4.765 μA yield a -7.735 μA source (arrow up) in parallel with 825.4 kΩ in parallel with 6 MΩ.

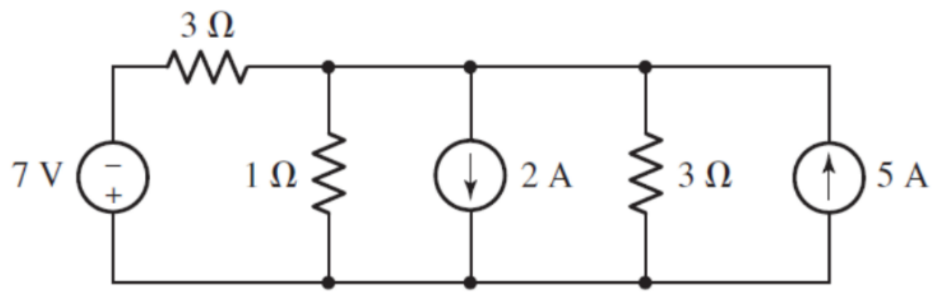
Convert the current source and 825.4 kΩ resistor into a -6.284 V source in series with 825.4 kΩ and 6 MΩ.

Then, $P_{6M\Omega} = \left[\dfrac{-6.384}{6\times10^{6} + 825.4\times10_{3}}\right]\left(6\times10^{6}\right) = \boxed{5.249\ \mu\text{W}}$

Q6.

(*a*) Using as many source transformations and element combination techniques as required, simplify the circuit shown below so that it contains only the 7 V source, a single resistor, and one other voltage source.

(*b*) Verify that the 7 V source delivers the same amount of power in both circuits.



(a) We combine the 1 Ω and 3 Ω resistors to obtain 0.75 Ω. The 2 A and 5 A current sources can be combined to yield a 3 A source.

These two elements can be source-transformed to a (9/4) V voltage source ("+" sign up) in series with a 0.75 Ω resistor in series with the 7 V source and the far-left 3 Ω resistor.

(b) In the original circuit, we define the top node of the current sources as v_1 and the bottom node is our reference node.

Then nodal analysis yields $(v_1 + 7)/3 + v_1/1 + v_1/3 = 5 - 2$

Solving, $v_1 = 2/5$ V and so the clockwise current flowing through the 7 V source is

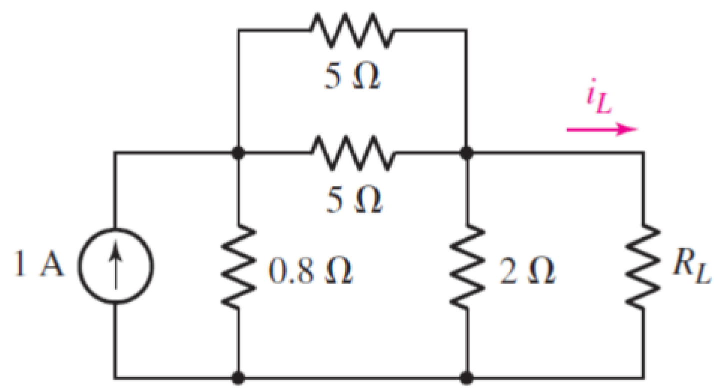
$i = (-7 - v_1)/3 = -37/15$. Hence, $\boxed{P_{7V} = 17.27 \text{ W}}$

Analyzing our transformed circuit, the clockwise current flowing through the 7 V source is $(-7 - 9/4)/3.75 = -37/15$ A.

Again, $\boxed{P_{7V} = 17.27 \text{ W}}$.

Q7.

(a) Obtain the Norton equivalent of the network connected to R_L in Fig. shown below
(b) Obtain the Thévenin equivalent of the same network.
(c) Use either to calculate i_L for R_L = 0 Ω, 1 Ω, 4.923 Ω, and 8.107 Ω.



(a) We remove R_L and replace it with a short. The downward current through the short is then

$i_{sc} = 0.8/(2.5 + 0.8) = \boxed{242.4 \text{ mA}}$

Returning to the original network, open circuit the current source, remove R_L. Looking into the open terminals we find $R_N = 2 \parallel (2.5 + 0.8) = \boxed{1.245\ \Omega}$

(b) $R_{TH} = R_N = \boxed{1.245\ \Omega}$

$V_{th} = (i_{sc})(R_N) = \boxed{301.8 \text{ mV}}$

(c)

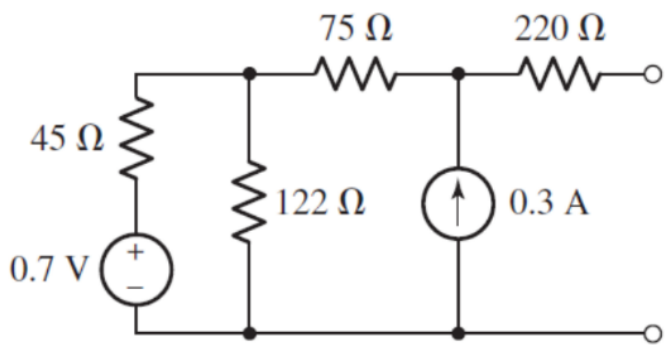
RL (Ω)	i_L(mA)
0	242.4
1	134.4
4.923	48.93
8.107	32.27

Q8.

(a) Employ Thevenin's theorem to obtain a simple two-component equivalent of the circuit shown in Fig. shown below.

(b) Use your equivalent circuit to determine the power delivered to a 100 Ω resistor connected to the open terminals.

(c) Verify your solution by analyzing the original circuit with the same 100 Ω resistor connected across the open terminals.



(a) Define three clockwise mesh currents i_1, i_2 and i_3, respectively in the three meshes, beginning on the left. Short the opn terminals together. Then, create a supermesh:

$$-0.7 + 45i_1 + 122i_1 - 122i_2 = 0 \quad [1]$$

$$-122i_1 + (122 + 75)i_2 + 220i_3 = 0 \qquad [2]$$

$$i_3 - i_2 = 0.3 \qquad [3]$$

Solving, $i_{sc} = i_3 = 100.3$ mA

Short the voltage source, open circuit the current source, and look into the open terminals:

$R_{th} = 220 + 75 + 45||122 = \boxed{328\ \Omega}$

Thus, $V_{th} = R_{th}(i_{sc}) = \boxed{32.8\text{ V}}$

(b) $P_{100\Omega} = (100)[V_{th}/(100 + R_{th})]^2 = \boxed{587.3\text{ mW}}$

(c) Only the second mesh equations needs to be modified:

$$-122i_1 + (122 + 75)i_2 + 220i_3 + 100i_3 = 0 \qquad [2']$$

Solving, $i_3 = 76.83$ mA and so $P_{100\Omega} = (100)(i_3)^2 = \boxed{590\text{ mW}}$