Name: ______________________________

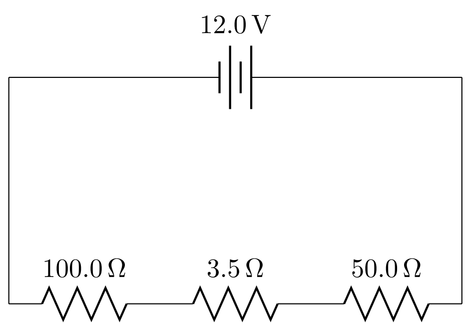
Answer the questions in the spaces provided on the question sheets. If you run out of room for an answer, continue on the back of the page.

1. If electrons are flowing towards the right of a segment of a wire, then the current is flowing towards
   - ◯ the right.
   - $\surd$ **the left.**
   - ◯ –neither left nor right.

2. What is the charge on a wire that has a cross-section area of 0.00004m^3 with electrons drifting along with a drift velocity $v_d = 0.0156\text{m/s}$ and the density of the charges in the wire is $5.3 \times 10^{24}/\text{m}^3$. The charge of the electrons is, -1.602×10^{-19} C. What is the current?

Solution:

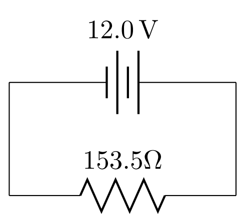
$$I = \left(5.3 \times 10^{24}/\text{m}^3\right)(-1.602 \times 10^{-19}\text{C})(0.0156\text{m/s})(0.00004\text{m}^2) = -5.30 \times 10^{-1}\text{A}$$



3. What is the equivalent resistance and current in the circuit shown above?

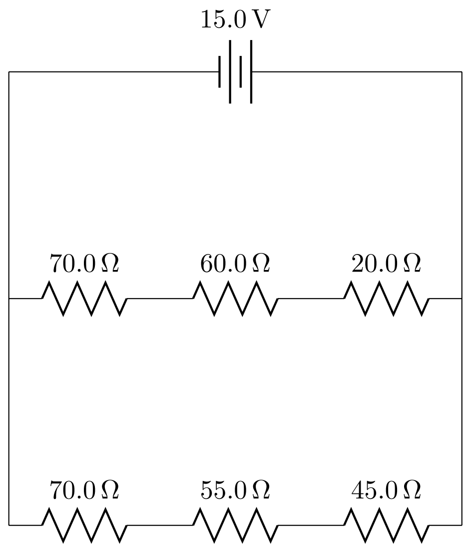
Solution: Since the resistors are in series, the equivalent resistance is the sum of the resistors:

$$R_{eq} = 3.5\Omega + 100.0\Omega + 50.0\Omega = 153.5\Omega$$



The current in the circuit is the same as the current in the equivalent circuit since their is only one loop:

$$I = \frac{V}{R_{eq}} = \frac{12.0\text{V}}{153.5\Omega} = 0.08\text{A}$$



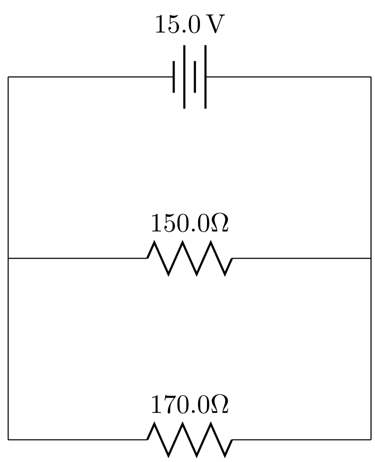
4. Find the equivalent resistor in the above circuit and the current in each branch of the circuit. *Hint: first treat each branch individually in series and find the equivalent resistor for each branch, then treat the parallel problem.*

Solution: First find the equivalent circuit in each branch in series. The top branch gives

$$R_{eqT} = 60.0\Omega + 70.0\Omega + 20.0\Omega = 150.0\Omega$$

and the bottom branch gives,

$$R_{eqB} = 55.0\Omega + 70.0\Omega + 45.0\Omega = 170.0\Omega$$



The current passing through the top equivalent resistor is:

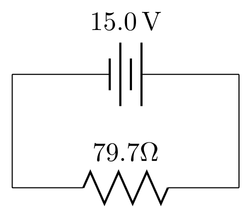
$$I_T = \frac{V}{R_{eqT}} = \frac{15.0\text{V}}{150.0\Omega} = 0.10\text{A}$$

and through the bottom resistor:

$$I_B = \frac{V}{R_{eqB}} = \frac{15.0\text{V}}{170.0\Omega} = 0.09\text{A}$$

Now that we have reduced this to the simplest possible parallel circuit, we find the final equivalent resistor for parallel resistors:

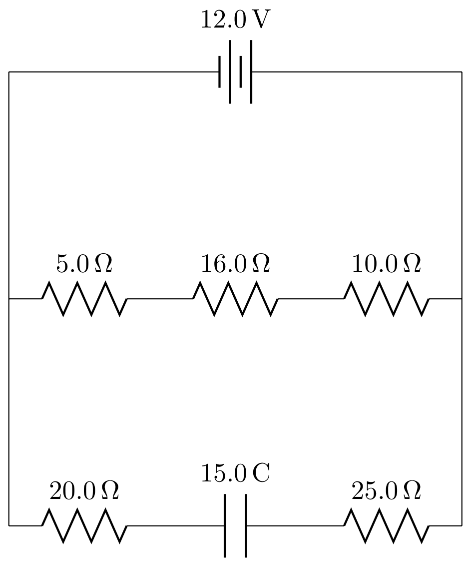
$$\frac{1}{R_{eq}} = \frac{1}{R_T} + \frac{1}{R_B} = \frac{1}{150.0\Omega} + \frac{1}{170.0\Omega}$$
$$R_{eq} = 79.7\Omega$$



So now we can solve for the current **that passes through the battery branch**:

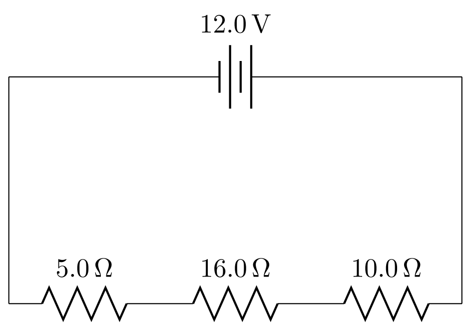
$$I = \frac{V}{R_{eq}} = \frac{15.0\text{V}}{79.7\Omega} = 0.19\text{A}$$

We see that $I = I_T + I_B$ as required by the **junction rule**.



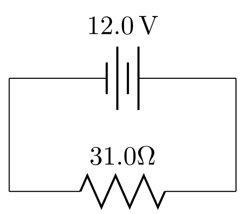
5. When a circuit with a capacitor in it is first turned on, current flows as if there were no capacitor. After a very long period of time, the capacitor becomes fully charged and no current flows through the branch that has a capacitor on it. Using this knowledge, find the equivalent resistor for the entire circuit at time $t = 0$ when the circuit is first activated and at a long long time later. Find the current in each branch in both cases.

Solution: Let's first take the case when the circuit has been open for a very long period of time:



Since the resistors are in series, the equivalent resistance is the sum of the resistors:

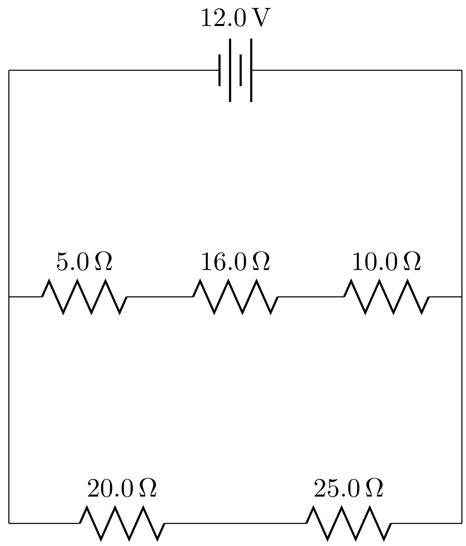
$$R_{eq} = 16.0\Omega + 5.0\Omega + 10.0\Omega = 31.0\Omega$$



The current in the circuit is the same as the current in the equivalent circuit since their is only one loop:

$$I = \frac{V}{R_{eq}} = \frac{12.0\text{V}}{31.0\Omega} = 0.39\text{A}$$

Second case: Now suppose that the circuit was just opened, in which case the capacitor acts as if it were just a wire (in only that initial instance of time is that true):

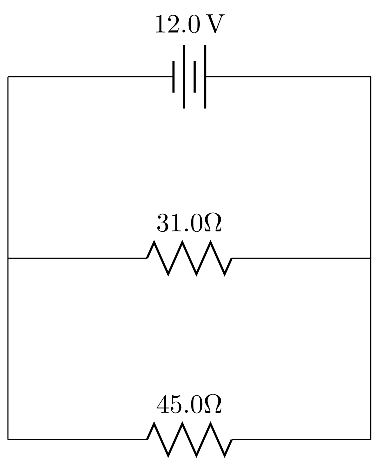


First find the equivalent circuit in each branch in series. The top branch gives

$$R_{eqT} = 16.0\Omega + 5.0\Omega + 10.0\Omega = 31.0\Omega$$

and the bottom branch gives,

$$R_{eqB} = 20.0\Omega + 25.0\Omega = 45.0\Omega$$



The current passing through the top equivalent resistor is:

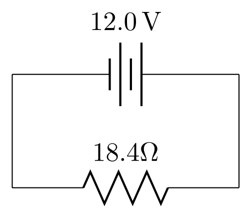
$$I_T = \frac{V}{R_{eqT}} = \frac{12.0\text{V}}{31.0\Omega} = 0.39\text{A}$$

and through the bottom resistor:

$$I_B = \frac{V}{R_{eqB}} = \frac{12.0\text{V}}{45.0\Omega} = 0.27\text{A}$$

Now that we have reduced this to the simplest possible parallel circuit, we find the final equivalent resistor for parallel resistors:

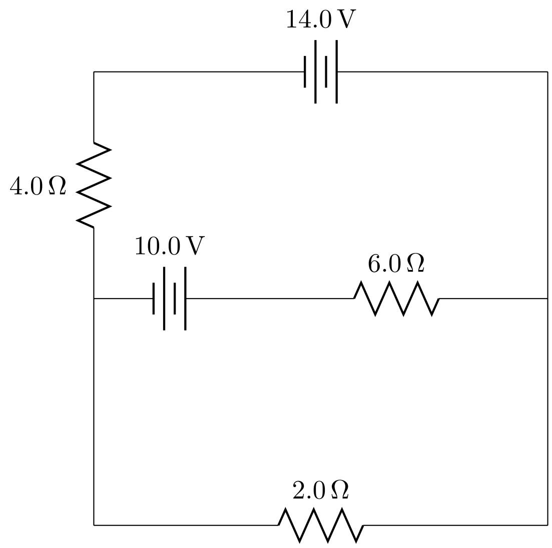
$$\frac{1}{R_{eq}} = \frac{1}{R_T} + \frac{1}{R_B} = \frac{1}{31.0\Omega} + \frac{1}{45.0\Omega}$$
$$R_{eq} = 18.4\Omega$$



So now we can solve for the current **that passes through the battery branch**:

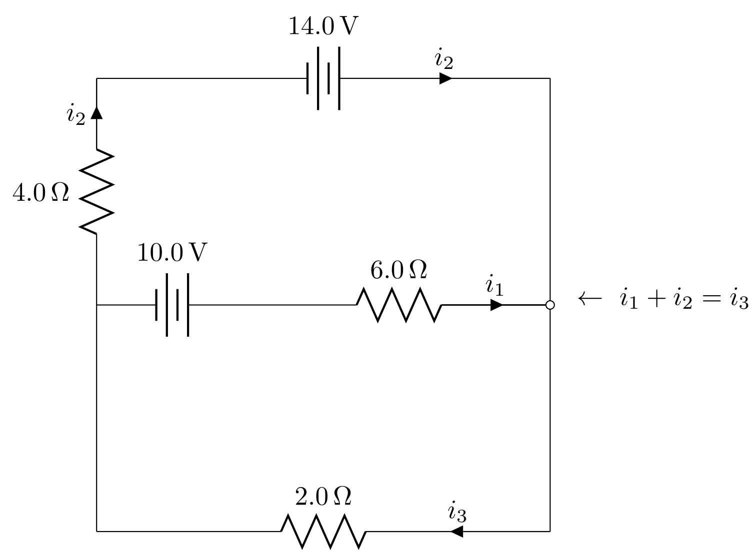
$$I = \frac{V}{R_{eq}} = \frac{12.0\text{V}}{18.4\Omega} = 0.65\text{A}$$

We see that $I = I_T + I_B$ as required by the **junction rule**.



6. Using the loop and junction rules, find the current in each branch of the above circuit. Label each branch and give its current.

Solution:



Our first equation is acquired from applying the junction rule at the node indicated in the figure, which gives us that $i_1 + i_2 = i_3$. We require two more equations to have three total independent equations to solve for the three unknown variables. Having two loops, we apply the loop rule for each:

$$0 = 14.0\text{V} + i_1 6.0\Omega - 10.0\text{V} - i_2 4.0\Omega \quad \rightarrow \quad i_2 = 1.0\text{A} + i_1 1.5$$

$$0 = 10.0\text{V} - i_1 6.0\Omega - i_3 2.0\Omega \quad \rightarrow \quad i_3 = 5.0\text{A} - 3.0 i_1$$

Our first equation from the junction rule becomes:

$$i_1 + 1.0\text{A} + i_1 1.5 = 5.0\text{A} - 3.0 i_1$$

Or,

$$i_1 = 0.7\text{A}$$

Then,

$$i_3 = 2.8\text{A}$$

$$i_2 = 2.1\text{A}$$

As a final check, we see that this conforms to the requirement that $i_1 + i_2 = i_3$.