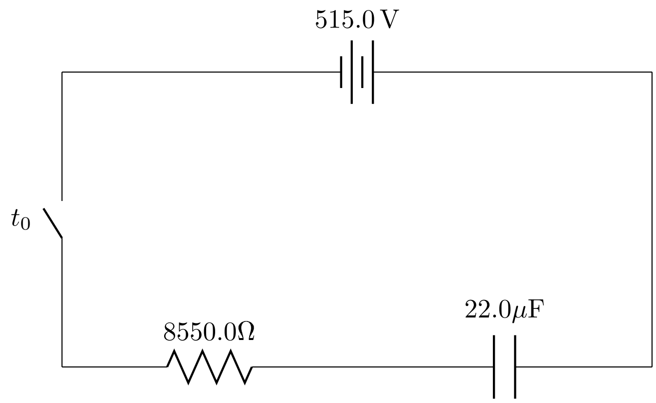
Name: ________________________________

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. Find the charge, as a function of time, on the capacitor for the above circuit when the switch is closed. What is the value for each at 5.0×10^{-5} seconds? What about 150.0×10^{-3} seconds? What about 1.0?

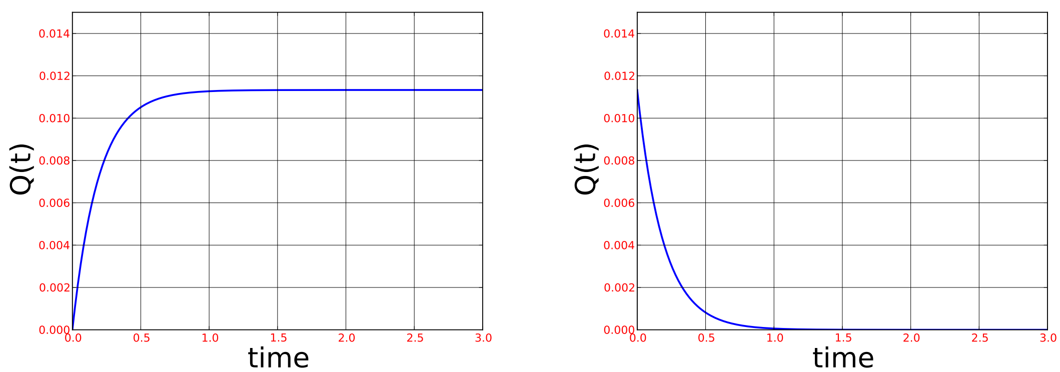


Figure 0.1: Charging a capacitor as a function of time (left) and discharging as a function of time (right).

Solution: The charge on the capacitor is given by,

$$Q(t) = C\mathcal{E}\left(1 - e^{-t/RC}\right) = 1.133 \times 10^{-2}\left(1 - e^{-t/\left(1.9 \times 10^{-1}\right)}\right)$$

at 5.0×10^{-5} seconds:

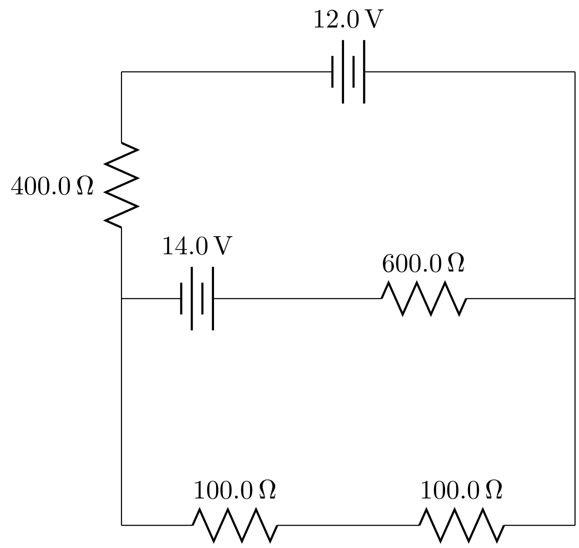
$$Q(3) = C\mathcal{E}\left(1 - e^{-5.0 \times 10^{-5}/RC}\right) = 3.011 \times 10^{-6}\mathrm{C}$$

At 150.0×10^{-3} seconds:

$$Q(3) = C\mathcal{E}\left(1 - e^{-150.0 \times 10^{-3}/RC}\right) = 6.226 \times 10^{-3}\mathrm{C}$$

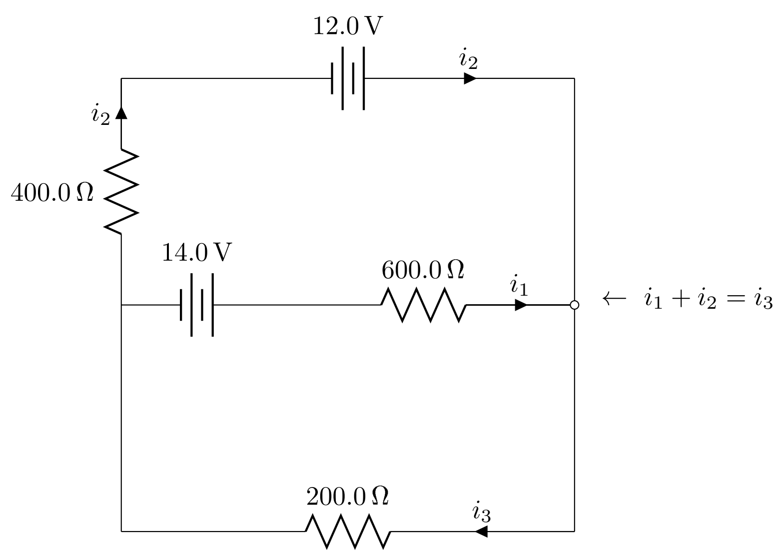
At 1.0 seconds:

$$\boxed{Q(3) = C\mathcal{E}\left(1 - e^{-1.0/RC}\right) = 1.127 \times 10^{-2}\mathrm{C}}$$



2. 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:

$$0 = 12.0\text{V} + i_1 600.0\Omega - 14.0\text{V} - i_2 400.0\Omega \quad \rightarrow \quad i_2 = -0.005\text{A} + i_1 1.500$$

$$0 = 14.0\text{V} - i_1 600.0\Omega - i_3 200.0\Omega \quad \rightarrow \quad i_3 = 0.070\text{A} - 3.000 i_1$$

Our first equation from the junction rule becomes:

$$i_1 + -0.005\text{A} + i_1 1.500 = 0.070\text{A} - 3.000 i_1$$

Or,

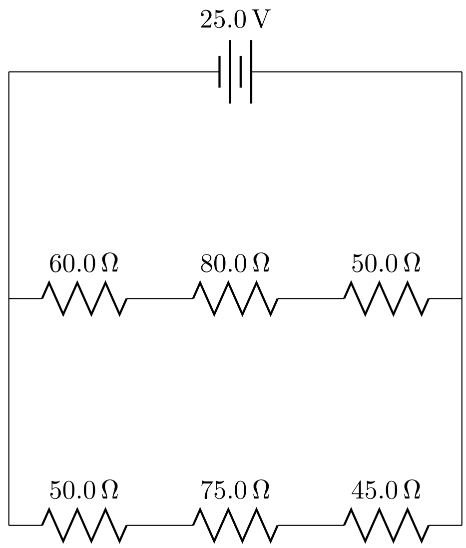
$$i_1 = 0.014\text{A}$$

Then,

$$i_3 = 0.029\text{A}$$

$$i_2 = 0.015\text{A}$$

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



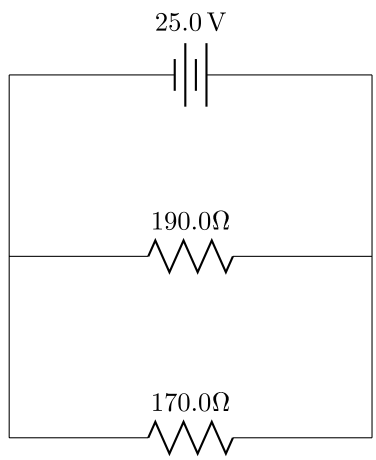
3. Find the equivalent resistor in the above circuit and the current in each branch of the circuit. *Hint: first treat each branch individually in series and find the equivalent resistor for each branch, then treat the parallel problem.*

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

$$R_{eqT} = 80.0\Omega + 60.0\Omega + 50.0\Omega = 190.0\Omega$$

and the bottom branch gives,

$$R_{eqB} = 75.0\Omega + 50.0\Omega + 45.0\Omega = 170.0\Omega$$



The current passing through the top equivalent resistor is:

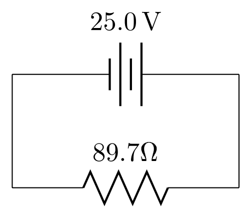
$$I_T = \frac{V}{R_{eqT}} = \frac{25.0\text{V}}{190.0\Omega} = 0.13\text{A}$$

and through the bottom resistor:

$$I_B = \frac{V}{R_{eqB}} = \frac{25.0\text{V}}{170.0\Omega} = 0.15\text{A}$$

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

$$\frac{1}{R_{eq}} = \frac{1}{R_T} + \frac{1}{R_B} = \frac{1}{190.0\Omega} + \frac{1}{170.0\Omega}$$
$$R_{eq} = 89.7\Omega$$



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

$$I = \frac{V}{R_{eq}} = \frac{25.0\text{V}}{89.7\Omega} = 0.28\text{A}$$

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