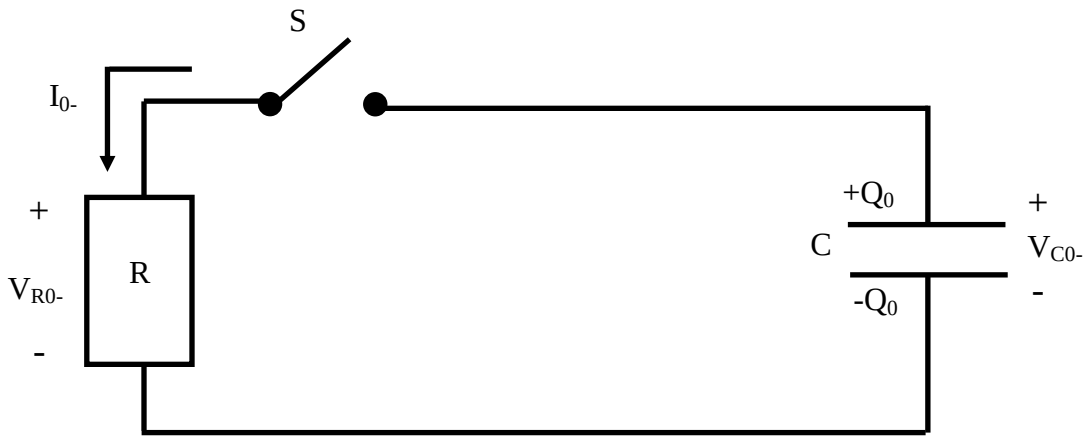
RC Circuits II

II. Discharging A Capacitor

A. Before Switch Is Closed: t < 0 s

1. The Circuit



2. Current Flowing In Circuit – I_{o-}

Since we have an open circuit, we know that

3. Voltage Across The Resistor – V_{R0-}

Using Ohm's law, we have that

4, Charge On The Plates Of The Capacitor – Q_0

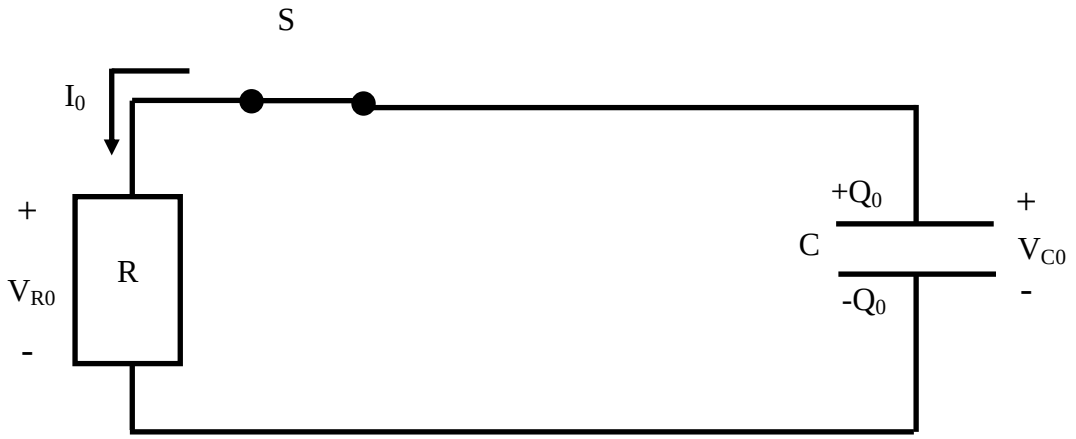
In our problem, we will assume that the capacitor's plates have already been charged to an amount Q_o

5. Voltage Across The Capacitor – V_{c0-}

Using the definition of capacitance, we have

B. Immediately After Closing The Switch: t = 0 s

1. The Circuit



2. Charge On The Plate's Of The Capacitor's – Q_0

3. Voltage Across The Capacitor – V_{C0}

4. Voltage Across The Resistor – V_{R0}

By definition of parallel circuits, we have

5. Current Flowing In The Circuit – I_0

Using Ohm's Law, we have

C. After Switch Has Been Closed For A Long Time: $t \to \infty$ s

1. As current flows through the circuit, the charge on the plates of the capacitor will decrease until the capacitor plates are neutral.

2. Voltage Across Capacitor - $V_{C\infty}$

3. Voltage Across Resistor - $V_{R\infty}$

By definition of parallel circuits, we have

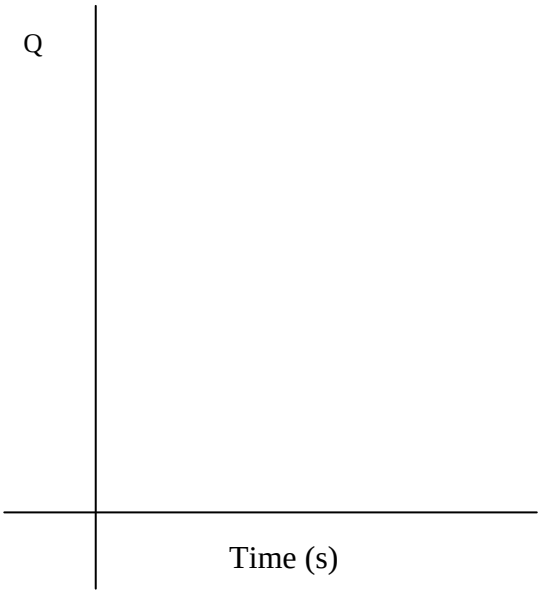
4. Current In the Circuit - $V_{C\infty}$

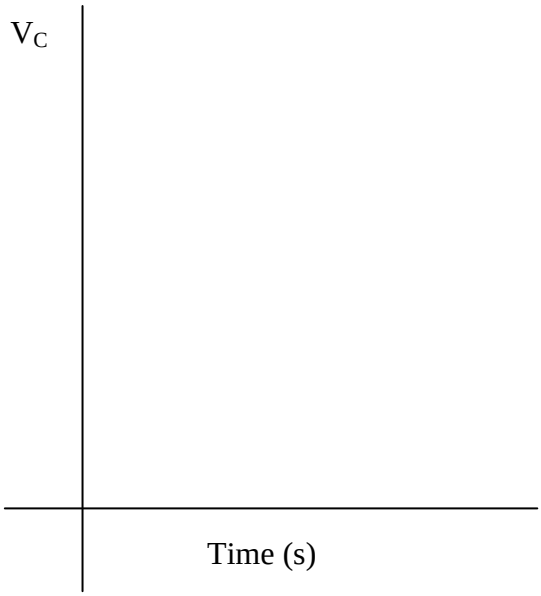
By Ohm's Law, we have

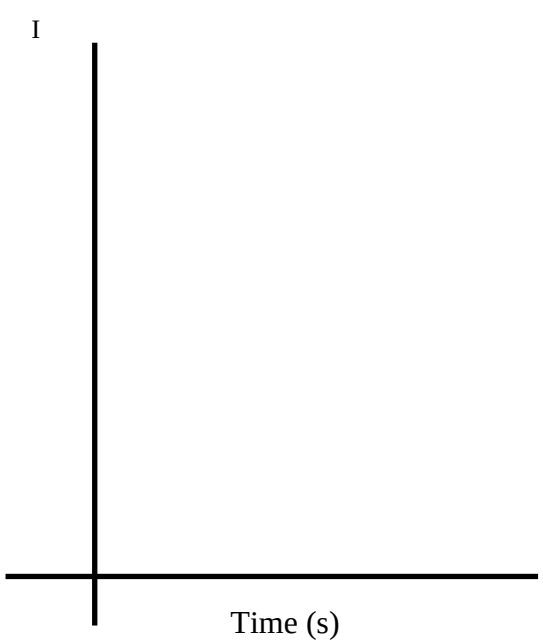
D. Graphical Results For A Discharging Capacitor

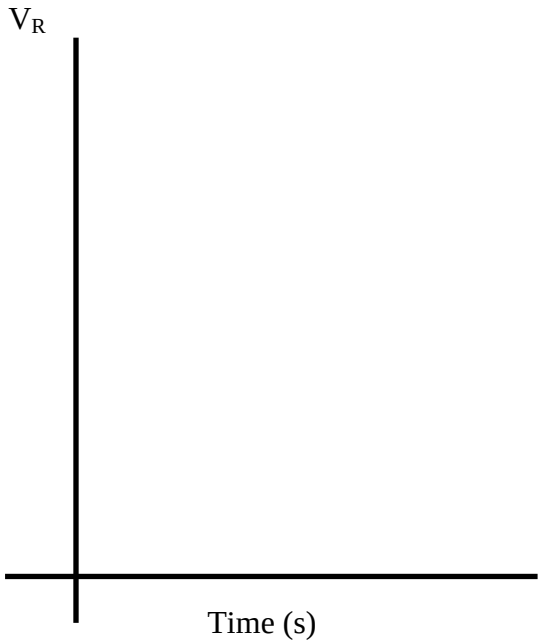
1. We plot our three points for each graph that we found in parts A, B, and C.

2. On each graph, we can connect our points from parts B and C by realizing that the graphs must be continuos and that they are limited by the values found in part C.









$$I(t) = I_0 e^{-\left(\frac{t}{\tau}\right)} = \frac{\varepsilon}{R} e^{-\left(\frac{t}{\tau}\right)}$$

$$V_R(t) = V_{R0} e^{-\left(\frac{t}{\tau}\right)} = \frac{Q_0}{C} e^{-\left(\frac{t}{\tau}\right)}$$

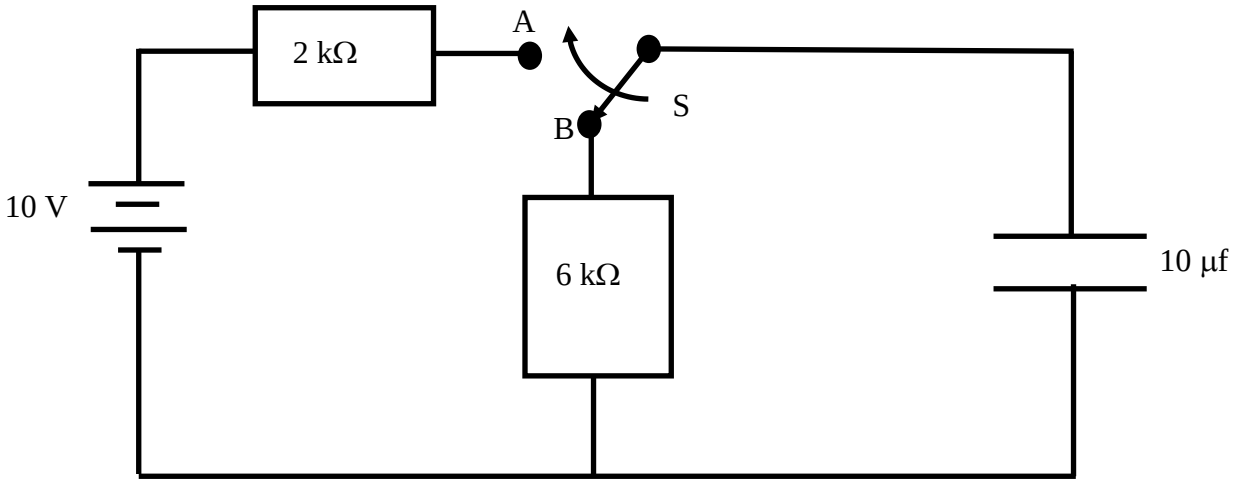
$$Q(t) = Q_0 e^{-\left(\frac{t}{\tau}\right)}$$

$$V_C(t) = V_{C0} e^{-\left(\frac{t}{\tau}\right)}$$

$$\tau = RC$$

Capacitor Problem

You are given the following RC circuit



A. What is the time constant when the switch is set to position A ("charging")?

B. What is the initial current through the 2 kΩ resistor when we begin charging the capacitor?

C. What is the maximum voltage across the capacitor after charging?

D. What is the maximum charge on the plate of the capacitor?

E. What is the voltage 15 ms after the capacitor begins to charge?

F. What is the time constant for the switch in position B ("discharging")?

G. If the capacitor is initially charged to 4 Volts, what is its voltage 20 ms after the switch is thrown to position B?