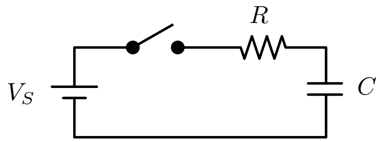
Physics 11 - Quiz 12 3/18/2020

A circuit is built of a battery, a switch, a resistor and a capacitor as shown: $R = 1.5\text{k}\Omega$, $C = 20\mu\text{F}$ and $V_S = 10\text{V}$.



The voltage on the capacitor is 2.0 V before the switch is closed. At time $t = 0$ switch is closed, this connects the positive terminal of the battery to the resistor. When does the voltage on the capacitor reach 7 volts?

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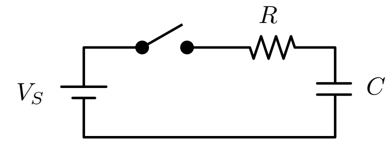

The voltage on the capacitor is 2.0 V before the switch is closed. At time $t = 0$ switch is closed, this connects the positive terminal of the battery to the resistor. When does the voltage on the capacitor reach 7 volts?

Solution: We can compute the constant

$$
\begin{aligned}
RC &= (1.5 \times 10^3 \Omega)(20 \times 10^{-6}\mathrm{F}) \\
&= 30 \times 10^{-3} \Omega \cdot \mathrm{F} \\
&= 30 \times 10^{-3} \frac{\mathrm{V}}{\mathrm{A}} \cdot \frac{\mathrm{C}}{\mathrm{V}} \\
&= 30 \times 10^{-3} \frac{\mathrm{C}}{\mathrm{A}} \\
&= 30 \times 10^{-3} \frac{\mathrm{C}}{\mathrm{C/s}} \\
&= 30 \times 10^{-3} \mathrm{s} \\
&= 30\mathrm{ms}
\end{aligned}
$$

Now we can use the theorem for the an RC circuit.

$$
\begin{aligned}
V_C(t) - V_S &= (V_C(0) - V_S)\, e^{-t/RC} \\
(7\mathrm{V}) - (10\mathrm{V}) &= ((2\mathrm{V}) - (10\mathrm{V}))\, e^{-t/RC} \\
-3\mathrm{V} &= -8\mathrm{V} e^{-t/RC} \\
\frac{3}{8} &= e^{-t/RC} \\
\ln\left(\frac{3}{8}\right) &= -t/RC \\
t &= -RC \ln\left(\frac{3}{8}\right) \\
t &= -(30\mathrm{ms}) \ln\left(\frac{3}{8}\right) \\
t &= 29.42\mathrm{ms}
\end{aligned}
$$