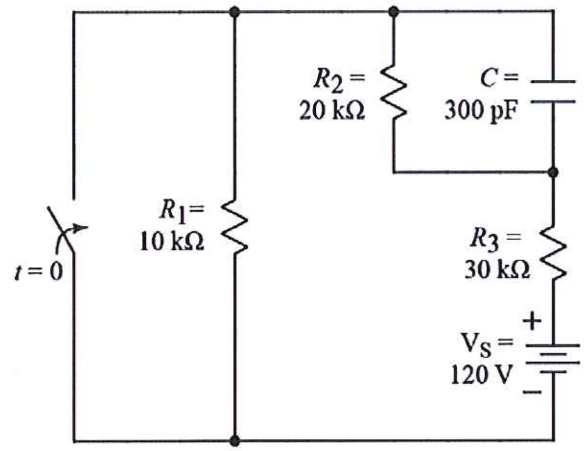
Ex:

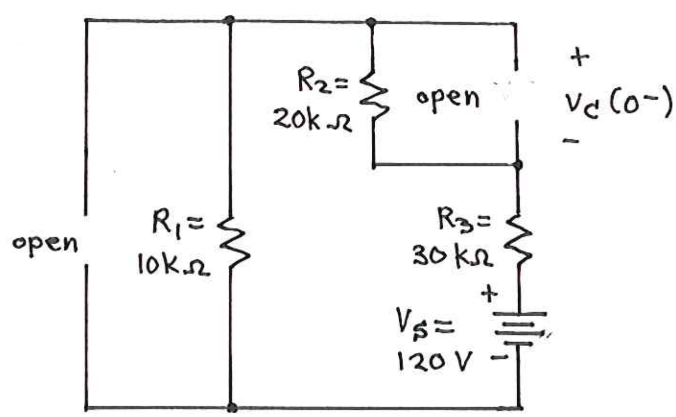


The switch has been open for a long time and is closed at $t = 0$.

Write the full numerical expression for $v_C(t)$ for $t > 0$.

sol'n: Time $t = 0^-$ yields the initial value of v_C. The circuit has reached equilibrium, and the C acts like an open circuit because it has ceased charging.

$t = 0^-$ model:



v_C is the same as the voltage across R_2.

A voltage divider formula gives the voltage across R_2.

$$V_C = V_{R2} = -120V \frac{R_2}{R_1 + R_2 + R_3}$$

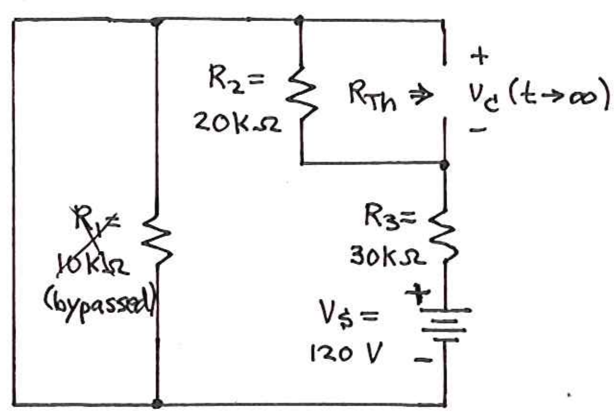
$$" = -120V \frac{20\,k\Omega}{10\,k\Omega + 20\,k\Omega + 30\,k\Omega}$$

$$" = -120V \frac{20k}{60k}$$

$$v_C(0^-) = -40V$$

Time $t \to \infty$ yields the final value of v_C. Again, the circuit reaches equilibrium and C acts like an open circuit.

The switch is closed, bypassing R_1

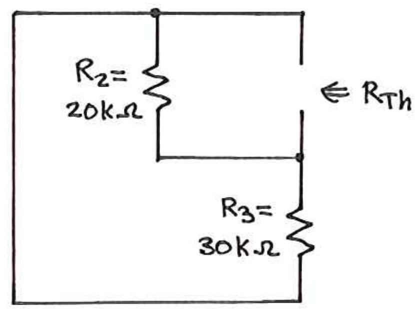


The voltage divider formula for v_C now excludes R_1.

$$V_C(t \to \infty) = -120V \cdot \frac{20\,k\Omega}{20\,k\Omega + 30\,k\Omega} = -48V$$

The time constant is $\tau = R_{Th} C$.

R_{Th} is the resistance seen looking into the terminals where C is connected, with V_s set to zero. and the switch closed.



$$R_{Th} = R_2 \| R_3 = 20k\Omega \| 30k\Omega$$

or

$$'' = 10k\Omega \cdot 2\|3 = 10k\Omega \cdot \frac{2(3)}{2+3} = 12k\Omega$$

$$\tau = R_{Th} C = 12k\Omega(300pF) = 3.6\ \mu s$$

The values found above are placed in the general form of solution for RC problems:

$$v_C(t \geq 0) = v_C(t \to \infty) + [v_C(0^-) - v_C(t \to \infty)]e^{-t/\tau}$$

or

$$v_C(t \geq 0) = -48V + [-40V - -48V]e^{-t/3.6\mu s}$$

or

$$\boxed{v_C(t \geq 0) = -48 + 8e^{-t/3.6\mu s}\ V}$$