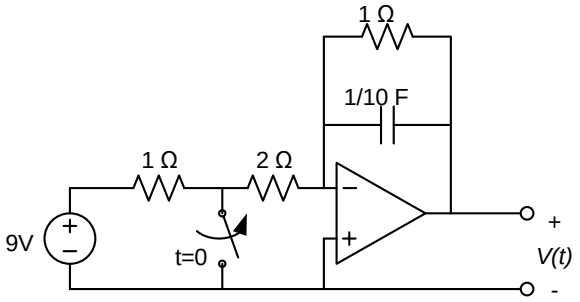
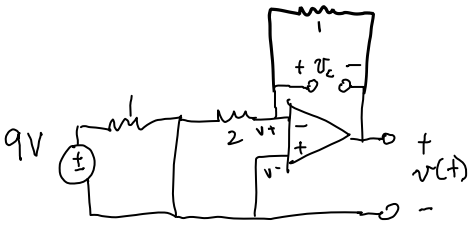
Concept: First order circuits and opamps
Find: $v(t)$ for **all** time in the following circuit:



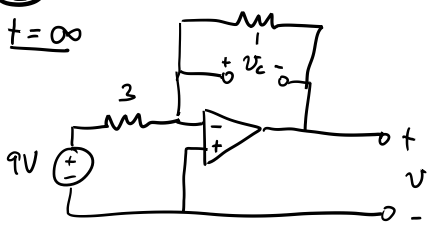
(1) $t<0$



neg feedback so $v^+ = v^-$
$v^+ = 0$ by inspection so $v^- = 0$
KCL @ v^-: $\frac{0-0}{2} + \frac{0-v}{1} = 0 \Rightarrow v = 0$

$v_c = v^+ - v = 0 - 0 = 0$
so $\boxed{V_0 = 0}$

(2) $t = \infty$



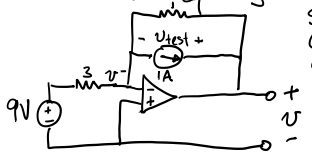
neg feedback so $v^- = v^+ = 0$
KCL @ v^-: $\frac{0-9}{3} + \frac{0-v}{1} = 0 \Rightarrow v = -3$

$v_c = v^- - v = 0 - -3 = 3$
so $\boxed{V_\infty = 3}$

(3) $0<t<\infty$

Goal: Find R_{eq} seen by cap. But no indep sources, so must find R_{eq} using test voltage or current source.

So to find R_{eq} as seen by C, replace C by I_{test} source and find voltage across it, then $R_{eq} = \frac{v_{test}}{i_{test}}$



KCL @ v^-: $\frac{0-9}{3} + 1 + \frac{0-v}{1} = 0 \Rightarrow v = -2$

$v_{test} = v^- - v = 0 - -2 = 2V$

$R_{eq} = \frac{v_{test}}{i_{test}} = \frac{2}{1} = 2\Omega$

$\tau = RC = 2\left(\frac{1}{10}\right) = \frac{1}{5}$ s

$\boxed{\tau = \frac{1}{5}\text{ s}}$

(4) Sub into PnC equation

$v_c(t) = V_\infty + (V_0 - V_\infty)e^{-t/\tau}$
$= 3 + (0-3)e^{-5t}$
$= 3(1-e^{-5t})$

$\boxed{v_c(t) = \begin{cases} 0V, & t<0 \\ 3(1-e^{-5t}), & t \geq 0 \end{cases}}$

(5) Find the variable you are asked to find

$v(t) = v^-(t) - v_c(t)$
$= 0 - v_c(t)$

$\boxed{v(t) = \begin{cases} 0\,V, & t<0 \\ -3(1-e^{-5t})\,V, & t \geq 0 \end{cases}}$