MU QUIZ #3 OLIN 408
3:30 TODAY

Two methods to solve transient problems

1. write equations in state variable

$L \rightarrow i$

$C \rightarrow v$

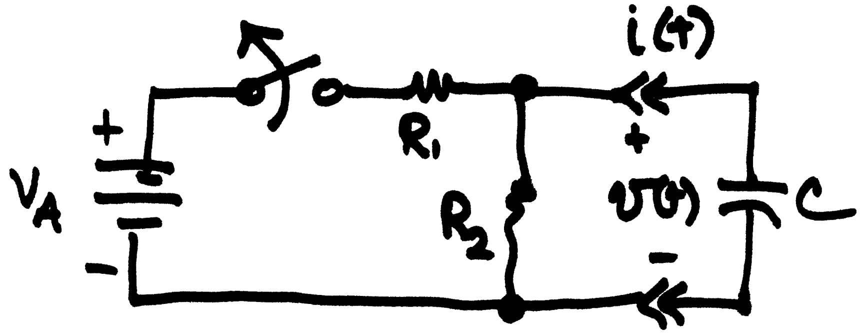
2. initial - final value theorem

$$(IV - FV)e^{-\frac{t}{T_c}} + FV$$

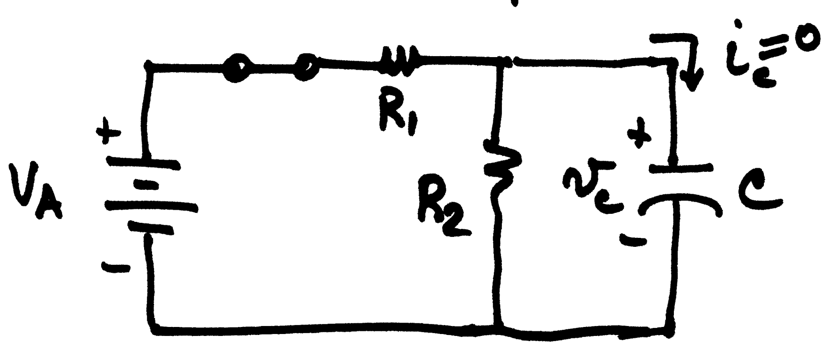
IV - initial value

FV - final value

T_c - time constant



1. initial ~~condition~~ value
   dc or steady state value <u>before</u> switch opens



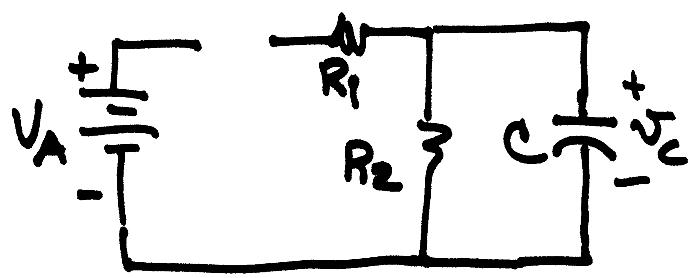
$i_c = C\frac{dv_c}{dt}$

capacitor acting like an open

$V_{R_2} = \frac{R_2}{R_1+R_2} V_A$

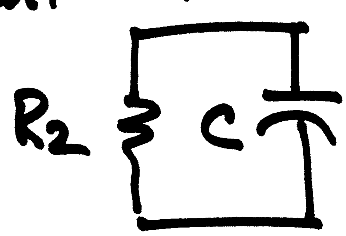
$v_c(0) = V_{R_2} = \frac{R_2}{R_1+R_2} V_A$

2. final value $t \to \infty$



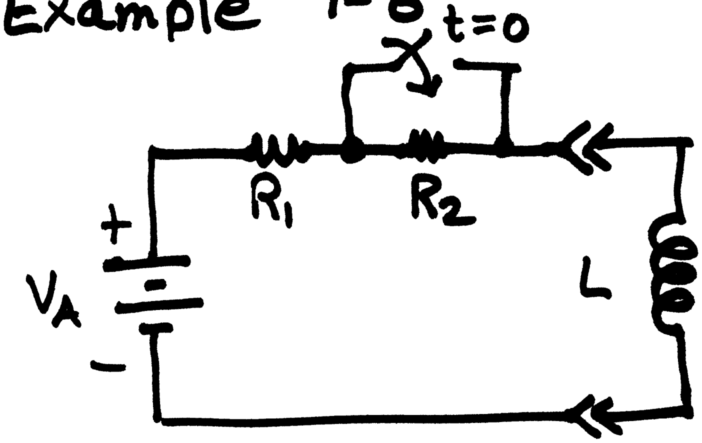
$v_c(\infty) = 0$

3. Time constant $t \geq 0$

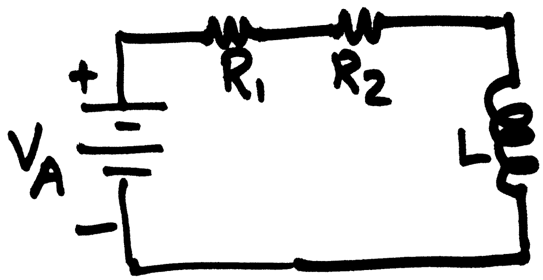


$T_c = \frac{1}{R_2 C}$

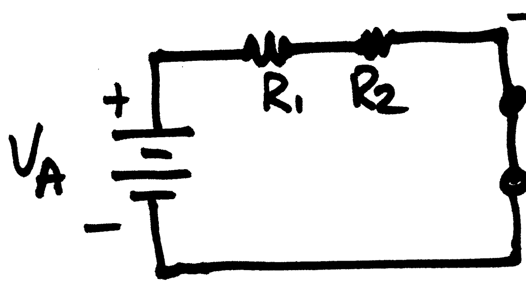
Example 7-8



1. initial value $t < 0$ <u>steady state</u>

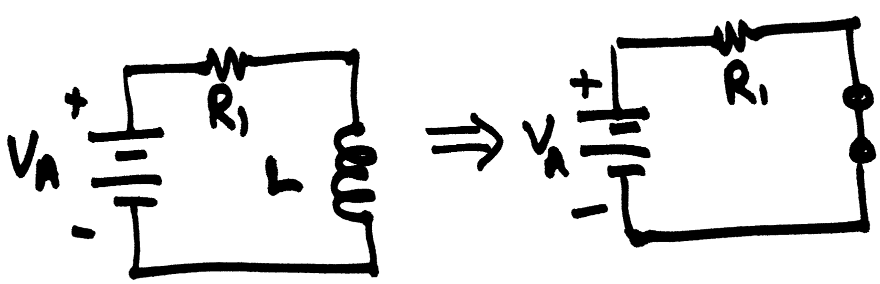


$$v_L = L\cancelto{0}{\frac{di_L}{dt}} = 0$$



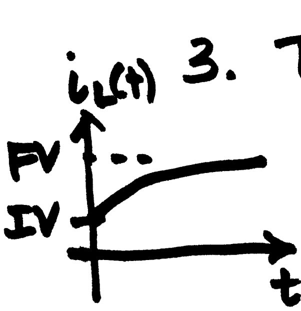
$$i_L(0) = \frac{V_A}{R_1+R_2} = IV$$

2. Final value $t \to \infty$



$$i_L(\infty) = \frac{V_A}{R_1} = FV$$

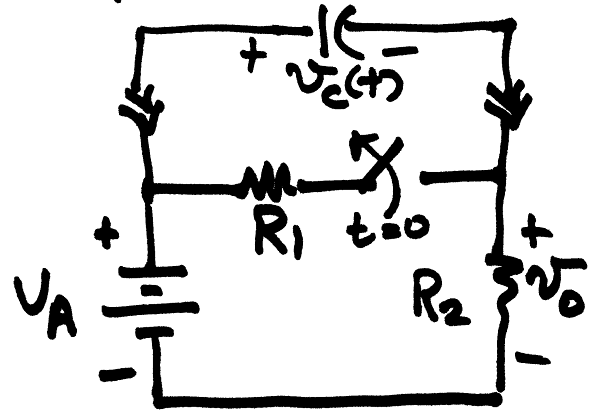
3. Time constant $t \geq 0$



$$T_c = \frac{L}{R_1}$$

Final solution $i_L(t) = \left[\frac{V_A}{R_1+R_2} - \frac{V_A}{R_1}\right] e^{-\frac{t}{L/R_1}} + \frac{V_A}{R_1}$

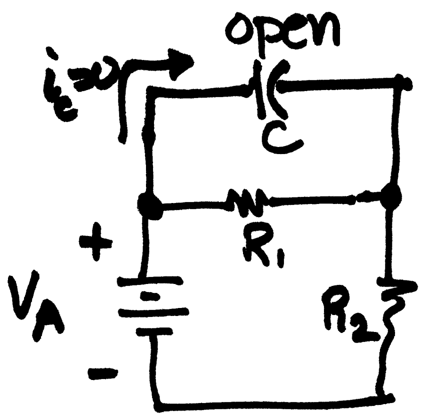
Example 7-9



want $v_o(t)$

0. Recognize that we will find $v_c(t)$ first.
   state variable

1. initial value $t<0$
   steady state

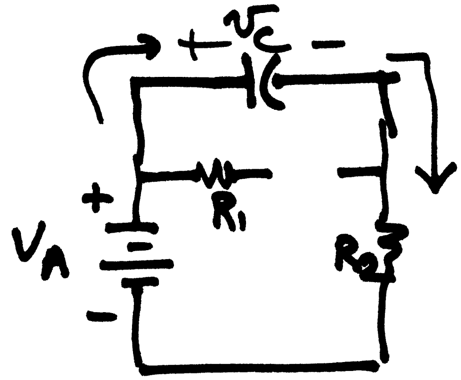


$$i_c = C\cancel{\frac{dv_c}{dt}}^{\,0} = 0$$

$$v_c(0) = \frac{R_1}{R_1+R_2} V_A = IV$$

voltage divider

2. Final value $t \to \infty$

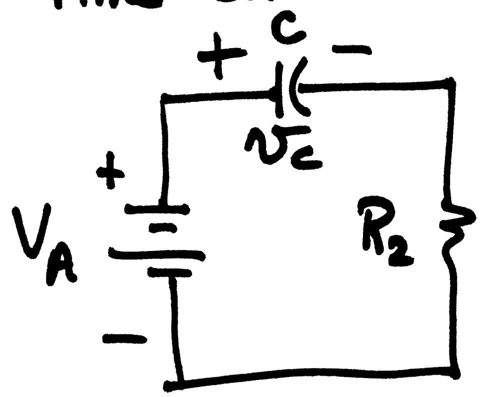


capacitor is fully charged to V_A

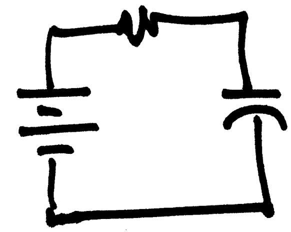
$$-V_A + v_c(\infty) + v_{R_2}(\infty) = 0$$

$$v_c(\infty) = V_A$$

3. Time constant



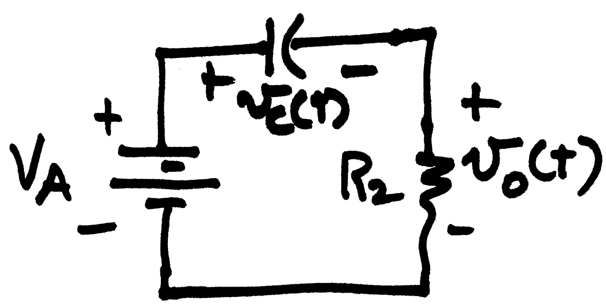
$T_c = R_2 C$



$$v_c(t) = (IV - FV)e^{-\frac{t}{T_c}} + FV \qquad t \geq 0$$

$$= \left(\frac{R_1}{R_1+R_2}V_A - V_A\right)e^{-\frac{t}{R_2C}} + V_A$$

4. find $v_o(t)$ in terms of $v_c(t)$ $t \geq 0$



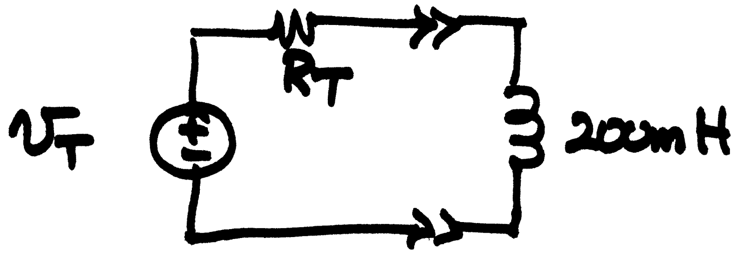
KVL:

$-V_A + v_c(t) + v_o(t) = 0$

$v_o(t) = V_A - v_c(t)$

Example 7-10

$$i_L(t) = 50 + 100e^{-5000t} \quad mA$$



(a) [redacted] identify forced and natural responses

natural solution always of form Ke^{st}

$$i_{natural} = 100e^{-5000t}$$

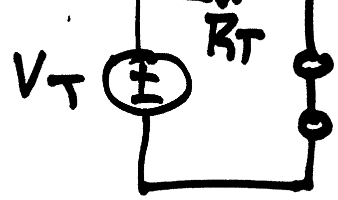
$$i_{TOTAL} = i_{NATURAL} + \underset{FORCED}{i_{DC}}$$

$$i_{FORCED} \doteq 50$$

(b) identify time constant $T_c = \frac{1}{5000} = 0.2mS.$

(c) identify Thevenin equivalent circuit.

$$T_c = \frac{L}{R_T} \qquad R_T = \frac{L}{T_c} = \frac{200mH}{0.2 \times 10^{-3} \text{ seconds}} = 1000\,\Omega$$



$t \to \infty$
inductor
looks like a short

$$i_L(\infty) = 50mA$$

$$V_T = R_T i_L(\infty)$$

$$= (1000)(50mA)$$

$$= 50 \text{ volts}$$