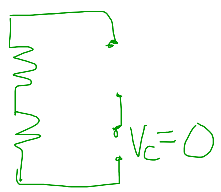
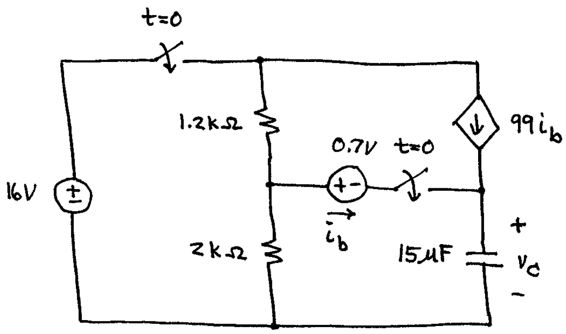
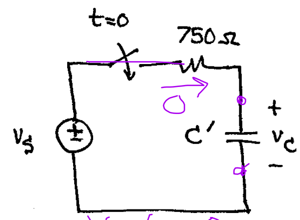
4.

$(t=0^-)$

$i_b=0$







I.V. $V_c=0$

$V_c(t\to\infty)=V_s$

$\tau=750(C')$

a. Find $v_c(t)$ for $t>0$ for circuit on left

b. Find v_s and C' values that make circuit on right have same v_c as circuit on left. Assume $v_c(0^-)=0V$.

sol'n: a) $v_c(0+) = v_c(0^-) = 0V$ since v_c can't change instantly

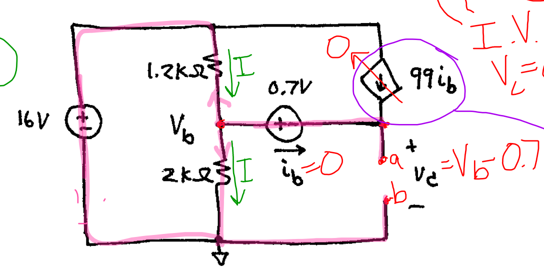
Now find $v_c(t\to\infty)$.

$t\to\infty$: C = open
switches closed

$(t=0^+)$

I.V. $V_c=0$

$$\frac{V_b}{2K}+\frac{V_b-16}{1.2K}=0$$



Dep. src has internal R

If we sum currents at node above C, we have $-i_b-99i_b=0A \Rightarrow i_b=0$.

Thus, $99i_b$ src = open.

$\therefore\ v_c = v_b - 0.7V$

sol'n: 4.a) cont. We use v-divider formula to find v_b:

$$v_b = 16V \cdot \frac{2\,k\Omega}{1.2k\Omega + 2\,k\Omega} = 16V \cdot \frac{2\,k\Omega}{3.2\,k\Omega}$$

$$v_b = 16V \cdot \frac{20\,k\Omega}{32\,k\Omega} = \frac{1}{2} \cdot 20\,V$$

$$\underline{v_b = 10\ V}$$

$$v_c(t \to \infty) = 10V - 0.7V \doteq \boxed{9.3\,V}$$

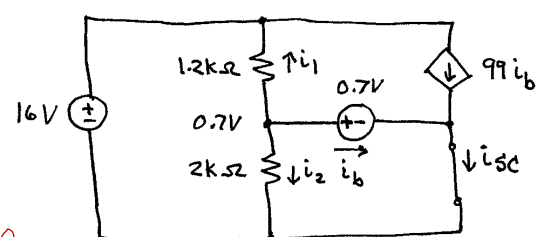
Now we find $R_{Th}C$. First, we find

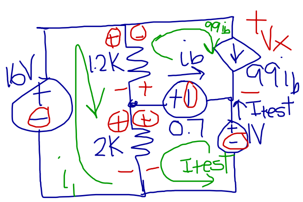
v_{Th} = v across terminals where C connected but with C removed

But this is the same as $v_c(t\to\infty)$.

$$v_{Th} = 9.3V$$

Now short the terminals where C connected and find i_{sc}.





$-I_{test} - i_b - 99i_b = 0$

$I_{test} = -100 i_b$

$-V_b + 2K(i_1 + I_{test}) + 1.2K(i_1 - 99i_b) = 0$

$+2K(i_1 + I_{test}) - 1.7 = 0$

$I_{test} = \frac{1}{7.5}$

$R_{th} = 7.5\,\Omega$

From current summation at node above C, $i_{sc} = i_b + 99i_b = 100\,i_b$.

Because of 0.7V src, we 0.7V at center node. We get i_b from current summation at this node.

sol'n: 4.a) cont.

$$i_1 = \frac{0.7V - 16V}{1.2k\Omega} = -\frac{15.3V}{1.2k\Omega}$$

$$i_2 = \frac{0.7V}{2k\Omega}$$

$$i_1 + i_2 + i_b = 0A$$

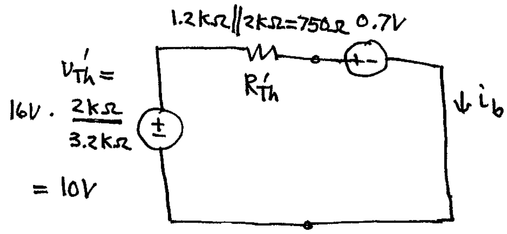
$$i_b = -(i_1+i_2) = \frac{15.3V}{1.2k\Omega} - \frac{0.7V}{2k\Omega}$$

$$i_{sc} = 100\, i_b = 100\left(\frac{15.3V}{1.2k\Omega} - \frac{0.7V}{2k\Omega}\right)$$

$$R_{Th} = \frac{V_{Th}}{i_{sc}} = \frac{9.3V}{100\left(\frac{15.3V}{1.2k\Omega} - \frac{0.7V}{2k\Omega}\right)}$$

$$R_{Th} = 7.5\Omega$$

This worked, but a better approach is to use a Thevenin equiv of 16V, 1.2kΩ, and 2kΩ.



We have $i_b = \frac{V_{Th}' - 0.7V}{R_{Th}'} = \frac{9.3V}{750\Omega}$

$$i_{sc} = 100\, i_b = \frac{9.3V}{750\Omega} \cdot 100$$

$$R_{Th} = \frac{V_{Th}}{i_{sc}} = \frac{9.3V}{\frac{9.3V \cdot 100}{750\Omega}} = \frac{750\Omega}{100} = 7.5\Omega$$

sol'n: 4.a) cont. Plug values into general sol'n.

$$v_C(t>0) = \underset{\underset{9.3V}{\shortparallel}}{v_C(t\to\infty)} + [\underset{\underset{0}{\shortparallel}}{v_C(0^+)} - \underset{\underset{9.3V}{\shortparallel}}{v_C(t\to\infty)}]e^{-t/R_{Th}C}$$

$R_{Th} = 7.5$

$$R_{Th}C = 7.5\Omega \cdot 15\mu F = 112.5\ \mu s$$

$$\boxed{v_C(t>0) = 9.3V\left[1 - e^{-t/112.5\mu s}\right]}$$

4.b) For circuit on right, we have $v_C(0^+) = v_C(0^-) = 0V$ (given).

We also have $v_C(t\to\infty) = v_S$ and $RC' = 750\Omega \cdot C'$.

$V_C = V_S + (0 - V_S)e^{-t/750C'}$, $V_S = 9.3V$, $750C' = 112.5\mu$

To make the v_C's the same for the two circuits, we use $\boxed{v_S = 9.3V}$ and

T needs to be equal
$112.5\mu = 750\Omega \cdot C'$

$$C' = \frac{RC}{750\Omega} = \frac{7.5\Omega \cdot 15\mu F}{750\Omega} = 150\ nF$$

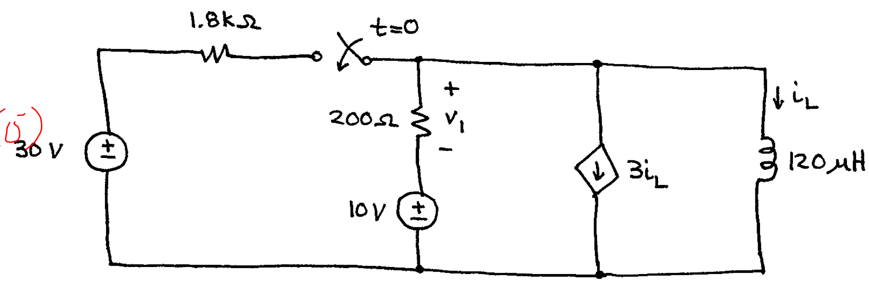
$$\boxed{C' = 150\ nF}$$

3.

$(t=0^-)$ L→wire
solve for i_L

$(t=0^+)$ L→ $I_{src}=i_L(0^-)$
I.V.

$(t\to\infty)$ L→wire
FINAL
τ



Find $v_1(t)$ for $t>0$.

sol'n: Find i_L for $t=0^-$.

$t=0^-$: Switch is open. L = wire.

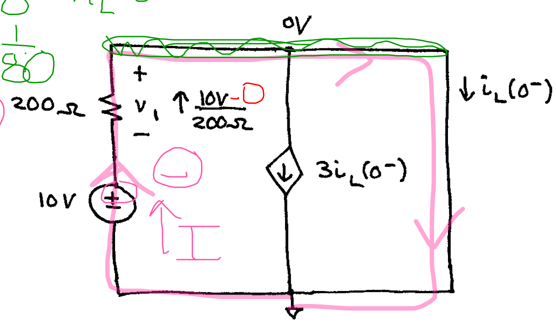
30V and 1.8kΩ not connected.

$\Sigma I: -\frac{1}{20}+4i_L=0$

$i_L=\frac{1}{80}$

$+10-I(200)=0$

$I=\frac{10}{200}$



Because L = wire, we have 10V across 200Ω (so 10V src + $V_{200\Omega}$ = 0 V).

Thus, current $\frac{10V}{200\Omega}$ flows upward thru 200Ω. This current equals $3i_L(0^-)+i_L(0^-)$.

$$\therefore \frac{10V}{200\Omega} = 3i_L(0^-) + i_L(0^-) = 4i_L(0^-)$$

$$50\,mA = 4i_L(0^-)$$

$$i_L(0^-) = \frac{50\,mA}{4} = 12.5\,mA$$

ECE 1000 HW #5 sol'n cont. Sp 05

sol'n: 3. cont. Now find $v_1(t=0^+)$.

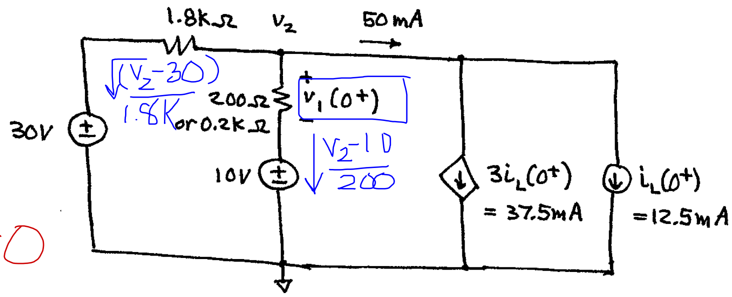
$t=0^+$: Switch is closed.

L = current source at $t=0^+$

$i_L(0^+) = i_L(0^-)$ since i_L doesn't

$\quad\ \ = 12.5$ mA change instantly

$(t=0^+)$



$V_2 - V_1 - 10 = 0$

OR

$V_1 = IR = \frac{(V_2-10)200}{200}$

Use node voltage to find v_2.

$$\frac{V_2 - 30V}{1.8k\Omega} + \frac{V_2 - 10V}{0.2k\Omega} + 50mA = 0\,A$$

$$V_2\left(\frac{1}{1.8k\Omega} + \frac{1}{0.2k\Omega}\right) = \frac{30V}{1.8k\Omega} + \underbrace{\frac{10V}{0.2k\Omega}}_{=\cancel{50mA}} - \cancel{50mA}$$

$$V_2\left(\frac{1}{1.8k\Omega} + \frac{1}{0.2k\Omega}\right)\cdot 1.8k\Omega = 30V$$

$$V_2\ (1+9) = 30V$$

$$V_2 = \frac{30V}{10} = 3V$$

$$10V + v_1(0^+) = V_2 = 3V$$

$$\boxed{v_1(0^+) = -7V}$$

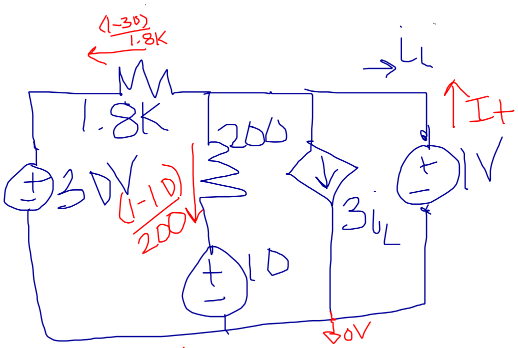
I.V.

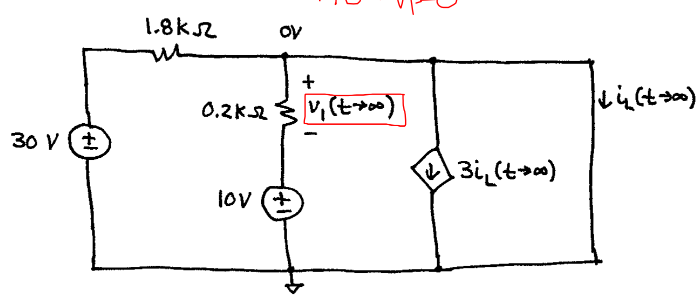
sol'n: 3. cont. Now find $v_1(t\to\infty)$.

$t\to\infty$: Switch is closed.

$L =$ wire

$+10+V_1=0$





$I_t = -i_L$

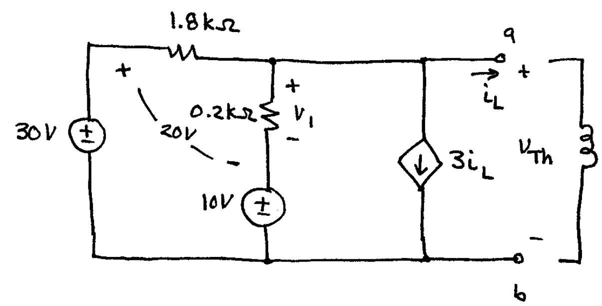
$$\frac{(1-30)}{1.8K}+\frac{(1-10)}{200}+4i_L=0$$

$$i_L = \frac{1}{720}$$

$$R_{th} = |-720|$$

The voltage across 10V src and 0.2kΩ is 0V. ∴ $\boxed{v_1(t\to\infty) = -10V}$

Now find time constant $\frac{L}{R_{Th}}$. R_{Th} is for circuit where L is connected.



$V_{Th} = V_{a,b}$ open circ

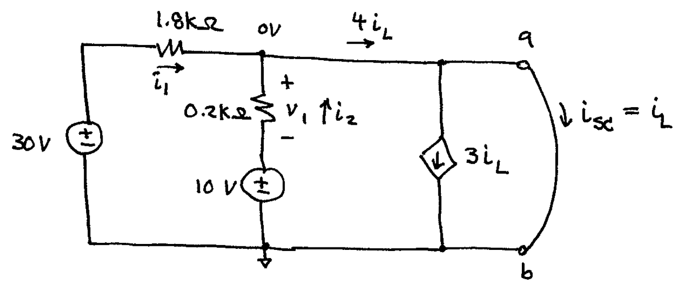
$i_L = 0$ so we treat $3i_L$ src as open circuit.

We could use node voltage method to find $v_{a,b}$, but a simpler approach is to observe that we have 20V across 1.8kΩ and 0.2 kΩ in series.

sol'n: 3. cont. Using a voltage divider, $v_1 = 20V \cdot \frac{0.2k\Omega}{0.2k + 1.8k\Omega} = 2V.$

$\therefore\ V_{Th} = V_{ab\ open\ circ} = 10V + v_1 = 12V$

Now short a, b terminals to find i_{sc}.



This is the same circuit as for $t \to \infty$.
Using the value of 0V on the top node, we can find i_1 and i_2:

$i_1 = \frac{30V}{1.8k\Omega}$ $\quad i_2 = \frac{10V}{0.2k\Omega}$

Summing currents, we have

$-i_1 - i_2 + 4i_L = 0A$

or $\quad i_L = i_{sc} = \frac{i_1 + i_2}{4} = \frac{\frac{30V}{1.8k\Omega} + \frac{10V}{0.2k\Omega}}{4}$

$i_{sc} = \frac{\frac{30V}{1.8k\Omega} + \frac{9 \cdot 10V}{1.8k\Omega}}{4} = \frac{120V}{4(1.8k\Omega)}$

$i_{sc} = \frac{30V}{1.8k\Omega}$

$R_{Th} = V_{Th}/i_{sc} = \frac{12V}{30V/1.8k\Omega} = 1.8k\Omega\ \frac{12V}{30V}$

$R_{Th} = 1.8k\Omega \cdot \frac{2}{5} = \frac{3.6k\Omega}{5} = 720\Omega$

sol'n: 3. cont. Our time constant is $\frac{L}{R_{Th}} = \frac{120\,\mu H}{720\,\Omega} = \frac{1}{6}\,\mu s.$

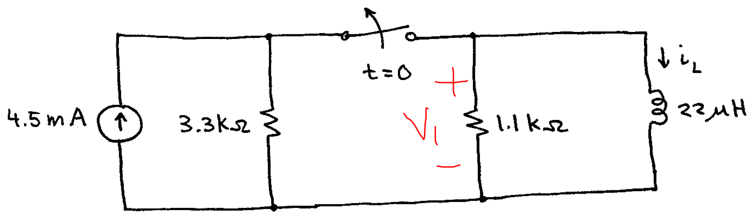
Plug values into general sol'n:

$$v_1(t>0) = v_1(t\to\infty) + [v_1(0^+) - v(t\to\infty)]\,e^{-t/L/R_{Th}}$$

$$v_1(t>0) = -10V + [-7V - -10V]\,e^{-t/\frac{1}{6}\mu s}$$

$$\boxed{v_1(t>0) = -10V + 3V\,e^{-t/\frac{1}{6}\mu s}}$$

2.



Find $i_L(t)$ for $t > 0$. Find $V_1(t)$

sol'n: We use general sol'n:

$$i_L(t>0) = i_L(t\to\infty) + [i_L(t=0^+) - i_L(t\to\infty)]\, e^{-t/L/R_{Th}}$$

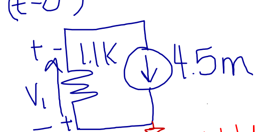
To find $i_L(t=0^+)$, we start at $t=0^-$.

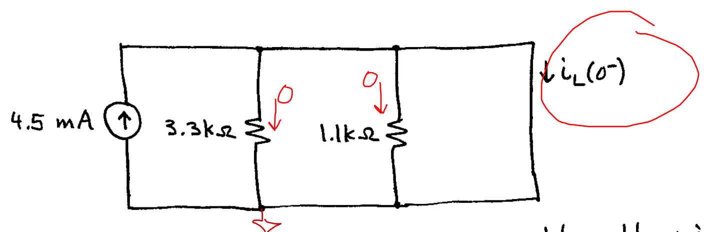
$t=0^-$: Treat L as wire when circuit has been sitting for a long time, (so $\frac{di_L}{dt} = 0 \Rightarrow v_L = L\frac{di_L}{dt} = 0$).

Find $i_L(0^-)$ because $i_L(0^+) = i_L(0^-)$.

Switch is closed at $t = 0^-$.

$(t=0^+)$





INITIAL VALUE

$i_L(t=0^+) = 4.5m$

$V_1(t=0^+) = 4.9V$

All the current will flow thru the wire.

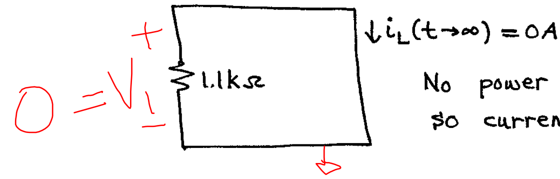
$i_L(0^-) = 4.5$ mA

Since the energy stored by the inductor cannot change instantly, $i_L(0^+) = i_L(0^-)$.

$\therefore\ i_L(0^+) = 4.5$ mA

sol'n: 2. cont. To find $i_L(t\to\infty)$, we again treat L as wire.

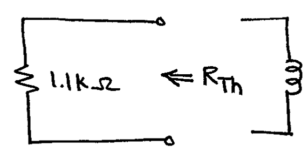
$t\to\infty$: Switch open. 4.5mA and 3.3kΩ not connected.



No power source so current = 0A.

$i_L(t\to\infty) = 0\,A$

The time constant is $\frac{L}{R_{Th}}$ where R_{Th} is from the Thevenin equivalent of circuit (for $t>0$) where L is connected.



$$R_{Th} = 1.1\,k\Omega$$

$$\frac{L}{R_{Th}} = \frac{22\,\mu H}{1.1\,k\Omega} = 20\text{ ns}$$

Plug quantities into general sol'n:

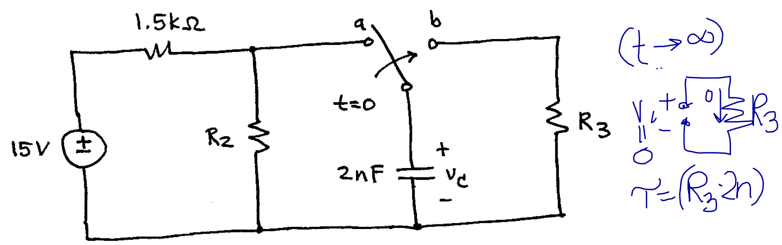
$$i_L(t>0) = 0A + [4.5mA - 0A]\, e^{-t/20ns}$$

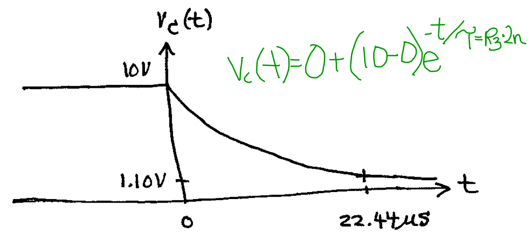
or $\boxed{i_L(t>0) = 4.5\,mA\; e^{-t/20ns}}$

$$\boxed{V_1(t>0) = 0 + [4.9V - 0]\,e^{-t/20nsec}}$$

ECE 1000 HW #5 sol'n Sp05

1.



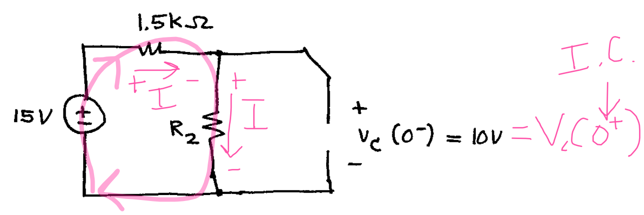


Find R_2 and R_3 to give above plot.

sol'n: R_2 determines init voltage on C.

From plot, $v_c(t=0^-) = 10V$.

Circuit model at $t=0^-$: C acts like open circuit.



Use v-divider. $v_c(0^-) = 15V \cdot \dfrac{R_2}{R_2 + 1.5k\Omega} = 10V$

$\therefore \dfrac{R_2}{R_2 + 1.5k\Omega} = \dfrac{2}{3}$ or $3R_2 = 2(R_2 + 1.5k\Omega)$

$\boxed{R_2 = 3k\Omega}$

R_3 determines the time constant $= R_3 C$

Using the general sol'n for $v_c(t)$ we have:

Sol'n: 1. cont.

$$v_C(t>0) = \underbrace{v_C(t\to\infty)}_{=\,0V} + \Big[\underbrace{v_C(t=0^+)}_{=\,v_C(0^-)\,=\,10V} - \underbrace{v_C(t\to\infty)}_{=\,0V}\Big]e^{-t/R_3C}$$

$$v_C(t>0) = 10V\,e^{-t/R_3C} \qquad \text{where } C = 2nF$$

From the plot, we have $v_C(22.44\mu s) = 1.10V$.

$$\therefore\ 1.10V = 10V\,e^{-22.44\mu s/R_3C}$$

Solve for R_3:

$$\ln\frac{1.10V}{10V} = -22.44\,\mu s/R_3C$$

$$R_3 = \frac{-22.44\,\mu s/2nF}{\ln\frac{1.10V}{10V}}$$

$$\boxed{R_3 \doteq 5.1\,k\Omega}$$