1. $i(t) = i(0)e^{-R/L\,t} = 2e^{-4.7\times10^9 t}$ mA

(a) $i(100 \text{ ps}) = 2e^{-4.7\times10^9\left(100\times10^{-12}\right)} = \boxed{1.25 \text{ mA}}$

(b) $i(212.8 \text{ ps}) = 2e^{-4.7\times10^9\left(212.8\times10^{-12}\right)} = \boxed{736\ \mu\text{A}}$

(c) $v_R = -iR$

$v_R(75 \text{ ps}) = -2\left(4700\right)e^{-4.7\times10^9\left(75\times10^{-12}\right)} = \boxed{-6.608 \text{ V}}$

(d) $v_L(75 \text{ ps}) = v_R(75 \text{ ps}) = \boxed{-6.608 \text{ V}}$

2.

$$W = \frac{1}{2}Li^2 = 100 \text{ mJ at } t = 0.$$

$$Thus,\ i(0) = \sqrt{0.1} = 316 \text{ mA}$$

$$\text{and } i(t) = i(0)e^{-\frac{R}{L}t} = 316e^{-t/2} \text{ mA}$$

(a) At $t = 1$ s, $i(t) = 316e^{-1/2}$ mA $= \boxed{192 \text{ mA}}$

(b) At $t = 5$ s, $i(t) = 316e^{-5/2}$ mA $= \boxed{25.96 \text{ mA}}$

(c) At $t = 10$ s, $i(t) = 316e^{-10/2}$ mA $= \boxed{2.13 \text{ mA}}$

(d) At $t = 2$ s, $i(t) = 316e^{-1}$ mA $=$ 116.3 mA . Thus, the energy remaining is

$$W(2) = \frac{1}{2}Li(2)^2 = \boxed{13.53 \text{ mJ}}$$

3. We know that $i(t) = i(0)e^{-\frac{R}{L}t} = 2\times10^{-3}e^{-\frac{100}{L}t}$, and that $i(500\ \mu s) = 735.8\ \mu A$.

Thus, $L = \dfrac{-100\left(500\times10^{-6}\right)}{\ln\left(\dfrac{i(500\times10^{-6})}{2\times10^{-3}}\right)} = \dfrac{-100\left(500\times10^{-6}\right)}{\ln\left(\dfrac{735.8\times10^{-6}}{2\times10^{-3}}\right)} = \boxed{50\ \text{mH}}$

4. We know that $i(t) = i(0)e^{-\frac{R}{L}t} = 1.5e^{-\frac{R}{3\times10^{-3}}t}$, and that $i(2)$ = 551.8 mA.

Thus, $R = -\dfrac{3\times10^{-3}}{2}\ln\left(\dfrac{i(2)}{1.5}\right) = -\dfrac{3\times10^{-3}}{2}\ln\left(\dfrac{0.5518}{1.5}\right) = \boxed{1.50\ \text{m}\Omega}$

5. We know that $i(t) = i(0)e^{-\frac{R}{L}t} = 1.5e^{-\frac{R}{3\times10^{-3}}t}$, and that $W(0) = 1$ J; $W(10^{-3}) = 100$ mJ.

At $t = 0$, $\frac{1}{2}\left(3\times10^{-3}\right)\left[i\left(0\right)\right]^2 = 1$ therefore $i(0) = 25.82$ A.

At $t = 1$ ms, $\frac{1}{2}\left(3\times10^{-3}\right)\left[i\left(10^{-3}\right)\right]^2 = 0.1$ therefore $i(10^{-3}) = 8.165$ A.

Thus, $R = -\frac{3\times10^{-3}}{t}\ln\left(\frac{i(t)}{i(0)}\right) = -\frac{3\times10^{-3}}{0.001}\ln\left(\frac{8.165}{25.82}\right) = \boxed{3.454\ \Omega}$

6.

(a) Since the inductor current can't change instantaneously, we simply need to find $i_L$ while the switch is closed. The inductor is shorting out both of the resistors, so $\boxed{i_L(0^+) = 2\text{ A.}}$

(b) The instant after the switch is thrown, we know that 2 A flows through the inductor. By KCL, the simple circuit must have 2 A flowing through the 20-Ω resistor as well. Thus,

$$\boxed{v = 4(20) = 80\text{ V.}}$$

7. (a) Prior to the switch being thrown, the 12-Ω resistor is isolated and we have a simple two-resistor current divider (the inductor is acting like a short circuit in the DC circuit, since it has been connected in this fashion long enough for any transients to have decayed). Thus, the current $i_L$ through the inductor is simply 5(8)/ (8 + 2) = $\boxed{\text{4 A.}}$ The voltage $v$ must be $\boxed{\text{0 V.}}$

(b) The instant just after the switch is thrown, the inductor current must remain the same, so $\boxed{i_L = 4\text{ A.}}$ KCL requires that the same current must now be flowing through the 12-Ω resistor, so $v$ = 12(-4) = $\boxed{\text{-48 V.}}$

8.

(a) $i_L(0) = 4.5\text{mA},\ \text{R/L} = \dfrac{10^3}{4\times10^{-3}} = \dfrac{10^6}{4}$

$\therefore i_L = 4.5e^{-10^6 t/4}\text{mA} \therefore i_L(5\mu s) = 4.5e^{-1.25}$

$\boxed{= 1.289\text{ mA.}}$

(b) $i_{SW}(5\ \mu s) = 9 - 1.289 = \boxed{7.711\text{ mA.}}$

9.

(a) $i_L(0) = \frac{100}{50} = 2\text{A} \therefore i_L(t) = 2e^{-80t/0.2}$
$= \boxed{2e^{-400t}\text{A}, t > 0}$

(b) $i_L(0.01) = 2e^{-4} = \boxed{36.63\text{mA}}$

(c) $2e^{-400t_1} = 1,\ e^{400t_1} = 2,\ t_1 = \boxed{1.7329\text{ms}}$

10. (a)

$$L\frac{di}{dt}+5i=0 \qquad [1]$$

$v_R=-2i$ so Eq. [1] can be written as

$$L\frac{d\left(\frac{-v_R}{2}\right)}{dt}-5\left(\frac{-v_R}{2}\right)=0 \quad \text{or}$$

$$\boxed{2.5\frac{dv_R}{dt}+2.5v_R=0}$$

(b) Characteristic equation is 2.5**s** + 2.5 = 0, or **s** + 1 = 0

Solving, $\boxed{\mathbf{s}=-1,\ v_R(t)=Ae^{-t}}$

(c) At $t = 0^-$, $i(0^-) = 5$ A $= i(0^+)$. Thus, $v_R(t)=-10e^{-t}, t>0$

$$\boxed{\begin{aligned} &v_R(0^-)=\frac{2}{3}(10)= \quad 6.667\text{ V}\\ &v_R(0^+)=-10\text{ V}\\ &v_R(1)=-10e^{-1}= \quad -3.679\text{ V}\end{aligned}}$$

11.

(a) $$\frac{i}{I_o} = e^{-t/\tau}, \frac{t}{\tau} = \ell n \frac{I_o}{i}, \frac{I_o}{i} = 10 \therefore \frac{t}{\tau} = \ell n 10 = 2.303;$$

$$\frac{I_o}{i} = 100, \frac{t}{\tau} = 4.605; \frac{I_o}{i} = 1000, \frac{t}{\tau} = \boxed{6.908}$$

(b) $$\frac{i}{I_o} = e^{-t/\tau}, \frac{d(i/I_o)}{d(t/\tau)} = -e^{t/\tau}; \text{ at } t/\tau = 1, \frac{d()}{d()} = -e^{-1}$$

$$\text{Now, } y = m(x-1) + b = -e^{-1}(x-1) + e^{-1}\left(\frac{t}{\tau} = x, \frac{i}{I_o} = y\right)$$

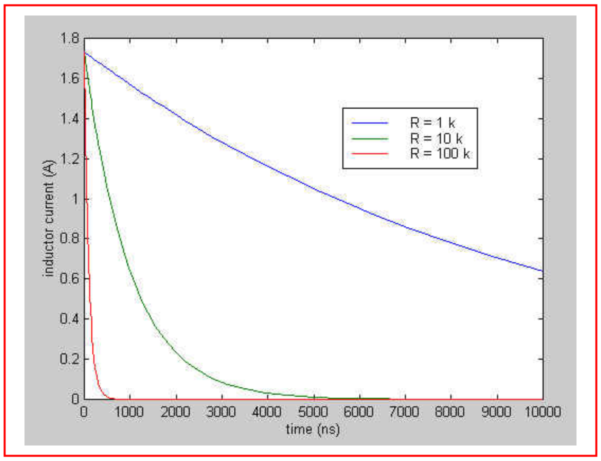
$$\text{At } y = 0, e^{-1}(x-1) = e^{-1} \therefore x = 2 \therefore t/\tau = \boxed{2}$$

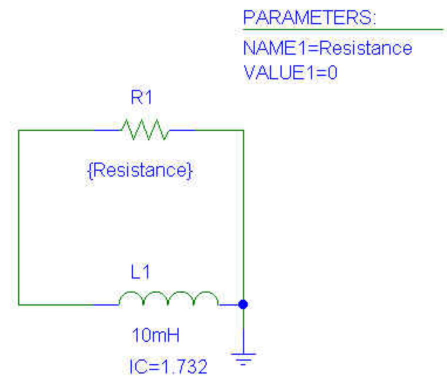
12. Reading from the graph current is at 0.37 at 2 ms

$$\boxed{\begin{array}{l} \therefore \quad \tau = 2\text{ ms} \\ \\ \mathrm{I}_0 = 10\text{ A} \end{array}}$$

13. $w = ½ Li^2$, so an initial energy of 15 mJ in a 10-mH inductor corresponds to an initial inductor current of 1.732 A. For R = 1 kΩ, $\tau$ = L/R = 10 μs, so $i_L(t) = 1.732\ e^{-0.1t}$ A. For R = 10 kΩ, $\tau$ = 1 μs so $i_L(t) = 1.732\ e^{-t}$. For R = 100 kΩ, $\tau$ = 100 ns or 0.1 μs so $i_L(t) = 1.732\ e^{-10t}$ A. For each current expression above, it is assumed that time is expressed in microseconds.

To create a sketch, we first realise that the maximum current for any of the three cases will be 1.732 A, and after one time constant (10, 1, or 0.1 μs), the current will drop to 36.79% of this value (637.2 mA); after approximately 5 time constants, the current will be close to zero.

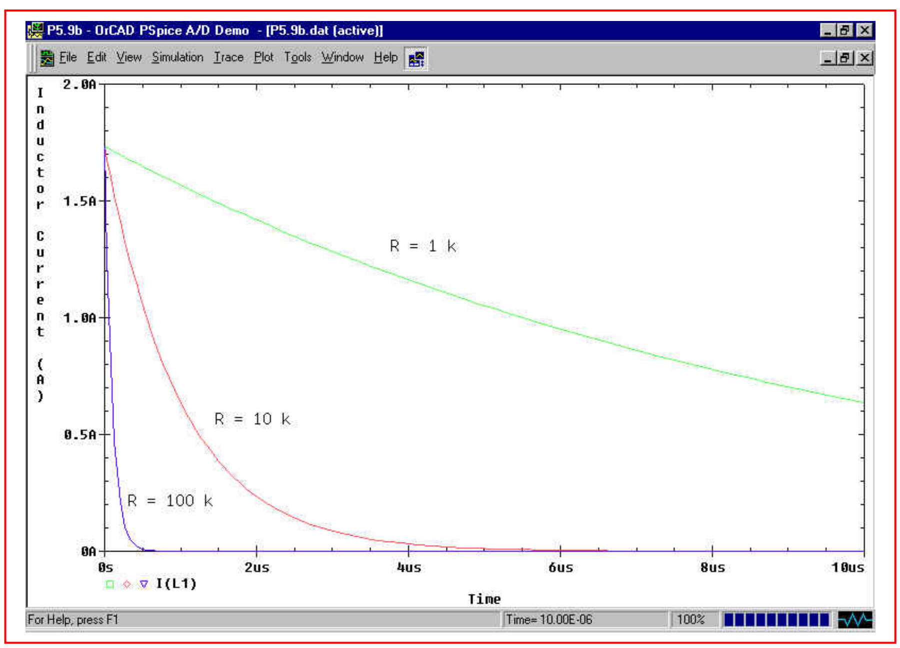



**Sketch based on hand analysis**

**Circuit used for PSpice verification**

As can be seen by comparing the two plots, which probably should have the same x-axis scale labels for easier comparison, the PSpice simulation results obtained using a parametric sweep do in fact agree with our hand calculations.



14.

(a) $$\tau = \frac{3.3\times10^{-6}}{1\times10^{6}} = \boxed{3.3\times10^{-12}}$$

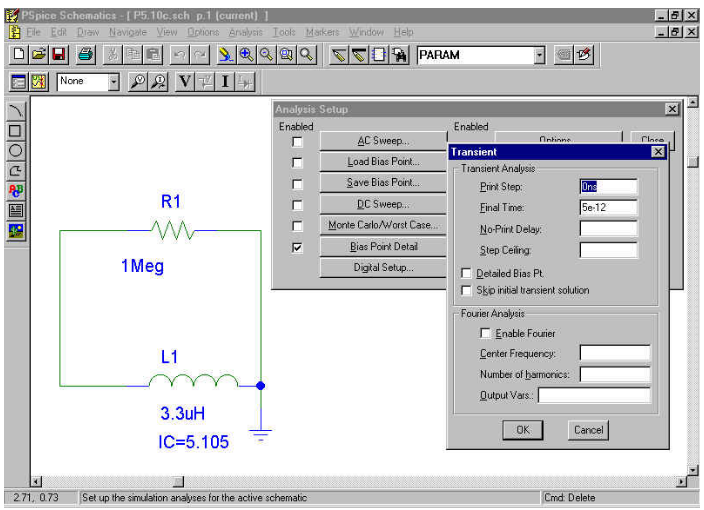
(b)

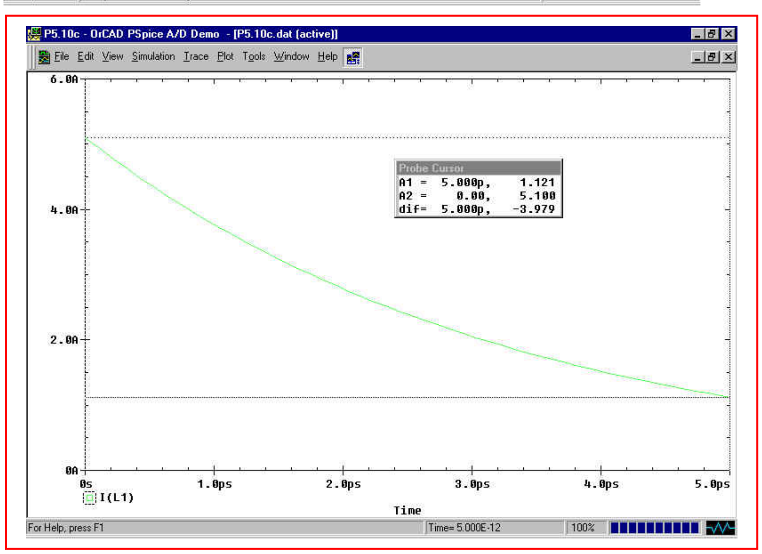
$$\omega = \frac{1}{2}.L.I_0^{\ 2}$$

$$I_0 = \sqrt{\frac{2\times 43\times10^{-6}}{3.3\times10^{-6}}} = 5.1\text{ A}$$

$$i(5\,ps) = 5.1e^{-1\times10^{6}\times5\times10^{-12}\,/\,3.3\times10^{-6}} = \boxed{1.12\text{ A}}$$

(c)




From the PSpice simulation, we see that the inductor current is 1.121 A at t = 5 ps, in agreement with the hand calculation.

15. Assume the source Thévenin resistance is zero, and assume the transient is measured to $5\tau$. Then,

$$\tau = \frac{L}{R} \quad \therefore 5\tau = \frac{5L}{R} = 100\times10^{-9} \text{ secs}$$

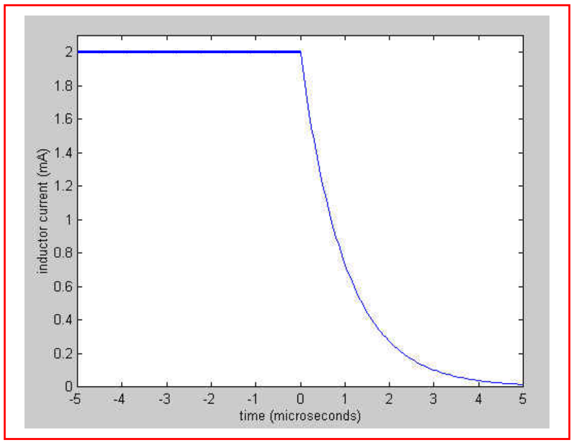
$$\therefore R > \frac{(5)(125.7)10^{-6}}{10^{-7}}$$

so R must be greater than $\boxed{6.285\ \text{k}\Omega.}$

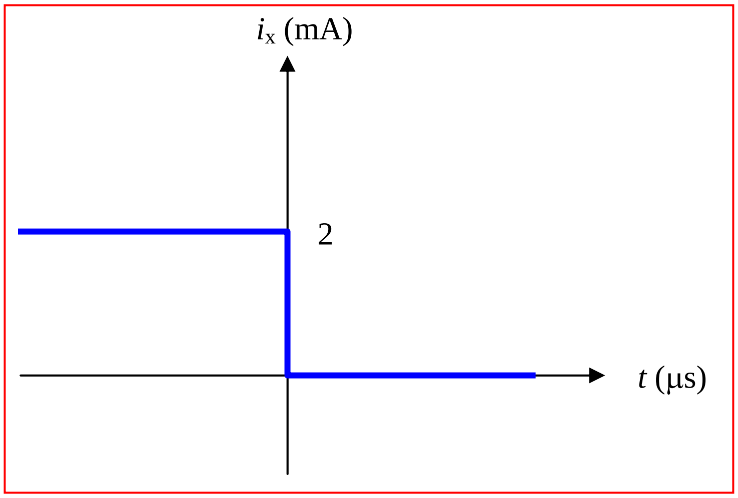
(If $1\tau$ assumed then $R > \frac{6.285}{5} = 125.7\Omega$)

16. For $t < 0$, we have a current divider with $i_L(0^-) = i_x(0^-) = 0.5$ [ 10 (1/ (1 + 1.5)] mA = 2 mA. For $t > 0$, the resistor through which $i_x$ flows is shorted, so that $i_x(t > 0) = 0$. The remaining 1-kΩ resistor and 1-mH inductor network exhibits a decaying current such that $i_L(t) = 2e^{-t/\tau}$ mA where $\tau = L/R = 1$ μS.

(a)




(b)



17. $\frac{1}{2}C\left[v(0)\right]^2 = 10^{-3}$ so $v(0) = \sqrt{\frac{2\times10^{-3}}{10^{-6}}} = 44.72$ V

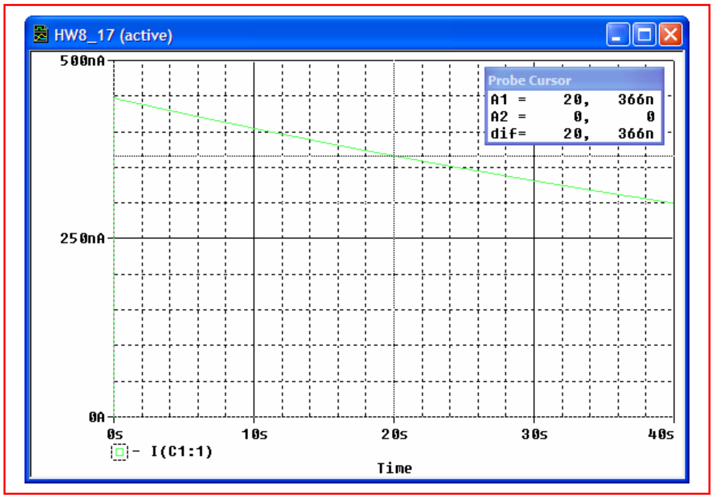
(a) τ = RC = $\boxed{100 \text{ s}}$

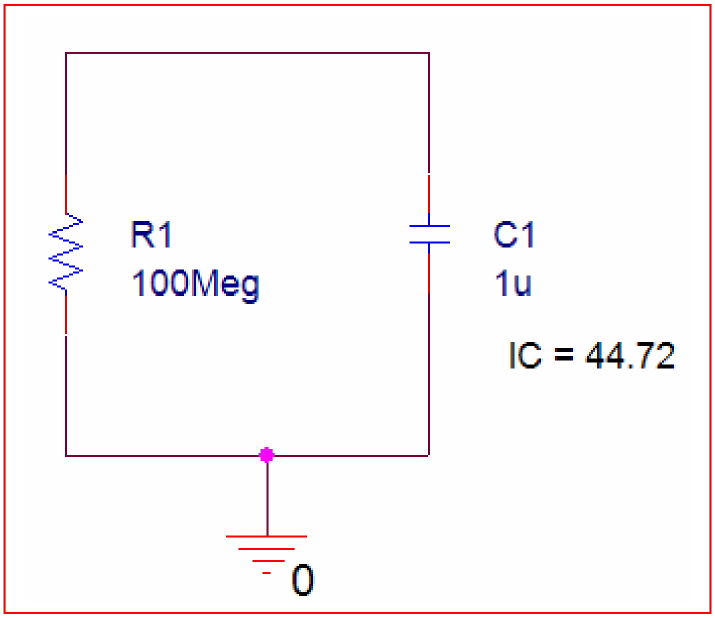
(b) $v(t) = v(0)e^{-t/RC} = 44.72e^{-0.01t}$ V

Thus, $v(20) = = 44.72e^{-0.01(20)} =$ 36.62 V .

Since $i = \frac{v}{R} = \frac{36.62}{100\times10^6} = \boxed{366 \text{ nA}}$

(c)



18. If $i(0) = 10$ A, $v(0) = 10$ V. $v(t) = v(0)e^{-t/RC} = 10e^{-t/2}$ V

(a) At $t = 1$ s, $v(1) = 10e^{-1/2} = \boxed{6.065 \text{ V}}$

(b) At $t = 2$ s, $v(2) = 10e^{-1} = \boxed{3.679 \text{ V}}$

(c) At $t = 5$ s, $v(5) = 10e^{-2.5} = \boxed{821 \text{ mV}}$

(d) At $t = 10$ s, $v(10) = 10e^{-5} = \boxed{67.4 \text{ mV}}$

19. Referring to Fig. 8.62, we note that $\tau$ = RC = 4 s. Thus,

$$v(t) = v(0)e^{-t/RC} = 5e^{-0.25t} \text{ V}.$$

(a) $v(1 \text{ ms}) = 5e^{-0.25(0.001)} = \boxed{4.999 \text{ V}}$

(b) $v(2 \text{ ms}) = 5e^{-0.25(0.002)} = 4.998$ V

Therefore $i(2 \text{ ms}) = 4.998 / 1000 = \boxed{4.998 \text{ mA}}$

(c) $v(4 \text{ ms}) = 5e^{-0.25(0.004)} = 4.995$ V

$$W = \frac{1}{2}Cv^2 = \boxed{49.9 \text{ mJ}}$$

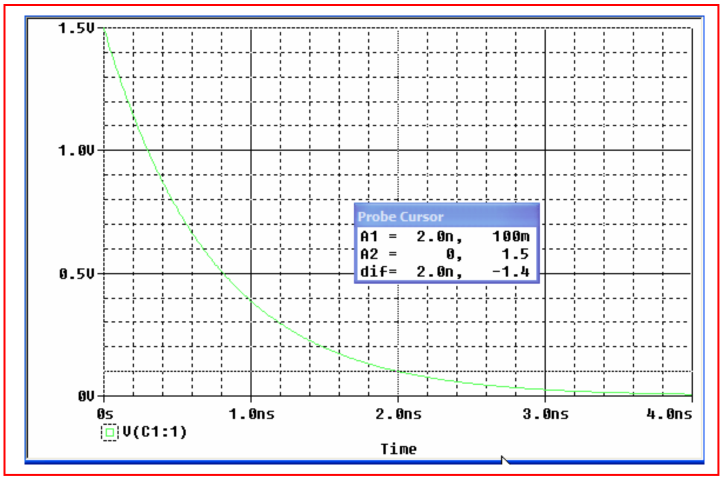
20. (a) $v(t) = v(0)e^{-t/RC} = 1.5e^{-t/RC}$ V

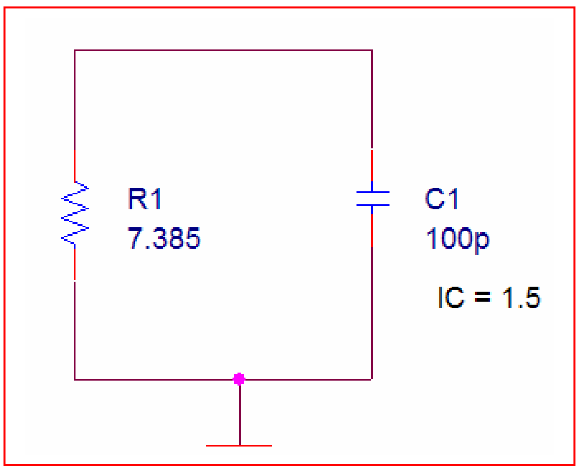
$$\frac{-t}{RC} = \ln\left[\frac{v(t)}{1.5}\right]$$

Thus,

$$R = \frac{-t}{C\ln\left[\frac{v(t)}{1.5}\right]} = \frac{-2\times10^{-9}}{10^{-10}\ln\left[\frac{0.1}{1.5}\right]} = \boxed{7.385\ \Omega}$$

(b)




We see from the PSpice simulation that our predicted voltage at 2 ns agrees with the information used to calculate R = 7.385 Ω.

21. The film acts as an intensity integrator. Assuming that we may model the intensity as a simple decaying exponential,

$$\phi(t) = \phi_o e^{-t/\tau}$$

where the time constant $\tau = R_{TH}C$ represents the effect of the Thévenin equivalent resistance of the equipment as it drains the energy stored in the two capacitors, then the intensity of the image on the film $\Phi$ is actually proportional to the integrated exposure:

$$\Phi = \text{K} \int_0^{\text{exposure time}} \phi_o e^{-t/\tau} dt$$

where K is some constant. Solving the integral, we find that

$$\Phi = -\text{K}\, \phi_o \tau \left[e^{-(\text{exposure time})/\tau} - 1\right]$$

The maximum value of this intensity function is $-\text{K}\phi_o \tau$.

With 150 ms yielding an image intensity of approximately 14% of the maximum observed and the knowledge that at 2 s no further increase is seen leads us to estimate that $1 - e^{-150\times10^{-3}/\tau} = 0.14$, assuming that we are observing single-exponential decay behavior and that the response speed of the film is not affecting the measurement. Thus, we may extract an estimate of the circuit time constant as $\tau = 994.5$ ms.

This estimate is consistent with the additional observation that at $t = 2$ s, the image appears to be saturated.

With two 50-mF capacitors connected in parallel for a total capacitance of 100 mF, we may estimate the Thévenin equivalent resistance from $\tau$ = RC as $R_{th} = \tau / C$ $\boxed{= 9.945\ \Omega.}$

22.

(a) $$v_c(0) = 8(50\|200) \times \frac{30}{50} = 192\text{V}$$

$$v_c(t) = 192e^{-3000t/24} = \boxed{192e^{-125t}\text{V}}$$

(b) $$0.1 = e^{-125t} \;\therefore \boxed{t = 18.421\text{ms}}$$

23.

(a) $v_c = 80e^{-10^6 t/100} = 80e^{-10^4 t}\text{V},\ t > 0;\ 0.5 = e^{-10^4 t}\ \therefore \boxed{t = 69.31\mu\, s}$

(b) $w_c = \dfrac{1}{2}C80^2 e^{-20{,}000t} = \dfrac{1}{4}C80^2\ \therefore \boxed{t = 34.66\mu\, s}$

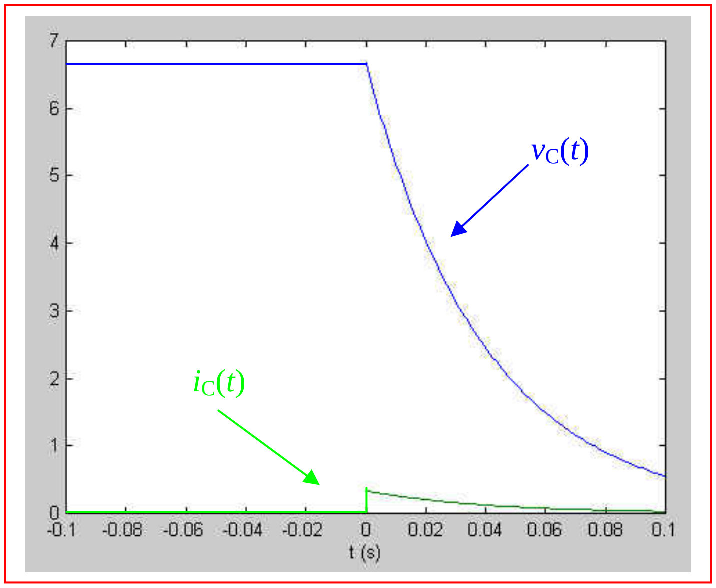
24.

$$t<0: \boxed{i_c(t)=0,} \; 10 = 5000 i_s + 10^4 \; i_s \;\therefore i_s = \frac{2}{3}\text{mA}$$

$$\therefore v_c(t) = \frac{20}{3} = \boxed{6.667\text{V}}$$

$$t>0: \; i_s = 0 \therefore v_c(t) = 6.667 e^{-t/2\times10^4\times2\times10^{-6}}$$

$$\therefore \boxed{v_c(t) = 6.667e^{-25t}\text{V}} \therefore i_c(t) = \frac{-6.667}{20\times10^3}e^{-25t} = \boxed{0.3333e^{-25t}\text{mA}}$$



25.

$$v(0^+) = 20V$$
$$i(0^+) = 0.1A$$

$$v(1.5ms) = 20e^{-1.5\times10^{-3}/50\times20\times10^{-6}} = 4.5V$$
$$i(1.5ms) = 0A$$

$$v(3ms) = 20e^{-3\times10^{-3}/50\times20\times10^{-6}} = 1V$$
$$i(3ms) = 0A$$

26.

(a) $i_L(0^-) = \frac{1}{2} \times 60 = \boxed{30 \text{ mA},}\ i_x(0^-) = \frac{2}{3} \times 30 = \boxed{20 \text{ mA}}$

(b) $i_L(0^+) = \boxed{30 \text{ mA},}\ i_x(0^+) = \boxed{-30 \text{ mA}}$

(c) $i_L(t) = 30e^{-250t/0.05} = 30e^{-5000t}\text{mA},\ i_L(0.3\text{ms})$

$= 30e^{-1.5} = \boxed{6.694\text{mA}} = -i_x$

Thus, $\boxed{i_x = -6.694 \text{ mA.}}$

27.

(a) $i_L(0) = 4\text{A} \therefore i_L(t) = 4e^{-500t}\text{A} \ (0 \le t \le 1\text{ms})$

$i_L(0.8\text{ms}) = 4e^{-0.4} = \boxed{2.681\text{A}}$

(b) $i_L(1\text{ms}) = 4e^{-0.5} = 2.426\text{A}$

$\therefore i_L(t) = 2.426e^{-250(t-0.001)}$

$\therefore i_L(2\text{ms}) = 2.426e^{-0.25} = \boxed{1.8895^{-}\text{A}}$

28.

(a) $i_L = 40e^{-50,000t}\text{mA} \therefore 10 = 40e^{-50,000t}, \ \therefore t_1 = \boxed{27.73\mu s}$

(b) $i_L(10\mu s) = 40e^{-0.5} = 24.26\text{mA} \therefore i_L$

$= 24.26e^{-(1000+R)50t}(t > 10\,\mu s)$

$\therefore 10 = 24.26e^{-(1000+R)5\times10^{-6}} \ \therefore \ell n 2.426 = 0.8863$

$= 0.25(1000 + \text{R})10^{-3}, 1000 + \text{R} = 0.8863 \times 4 \times 10^{3} \therefore \text{R} = \boxed{2545^{+}\,\Omega}$

29.

(a) $i_1(0) = 20\text{mA},\ i_2(0) = 15\text{mA}$

$\therefore v(t) = 40e^{-50000t} + 45e^{-100000t}\,\text{V} \therefore \boxed{v(0) = 85\text{V}}$

(b) $v(15\mu s) = 40e^{-0.75} + 45e^{-1.5} = \boxed{28.94\text{V}}$

(c) $\dfrac{85}{10} = 40e^{-50000t} + 45e^{-100000t}.$ Let $e^{-50000t} = x$

$\therefore 45x^2 + 40x - 8.5 = 0$

$\therefore x = \dfrac{-40 \pm \sqrt{1600 + 1530}}{90} = 0.17718, < 0$

$\therefore e^{-50000t} = 0.17718, \boxed{t = 34.61\mu s}$

30.

$$t < 0 : v_R = \frac{2R_1R_2}{R_1+R_2}, \downarrow i_L(0) = \frac{2R_1}{R_1+R_2}$$

$$t > 0 : i_L(t) = \frac{2R_1}{R_1+R_2}\, e^{-50R_2t} \therefore v_R = \frac{2R_1R_2}{R_1+R_2}\, e^{-50R_2t}$$

$$\therefore v_R(0^+) = 10 = \frac{2R_1R_2}{R_1+R_2} \therefore R_1 \| R_2 = 5\Omega. \text{ Also, } v_R(1\text{ms})$$

$$= 5 = 10e^{-50R_2/1000} \therefore 0.05R_2 = 0.6931 \therefore \boxed{R_2 = 13.863\Omega}$$

$$\therefore \frac{1}{13.863} + \frac{1}{R_1} = \frac{1}{5} \therefore \boxed{R_1 = 7.821\Omega}$$

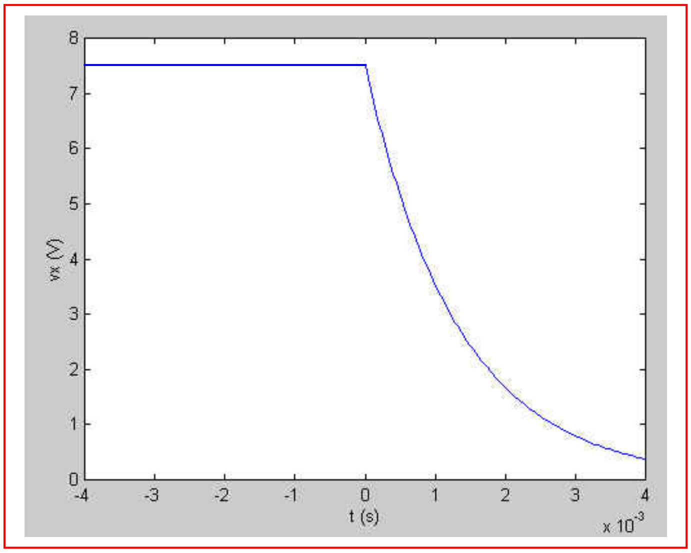
31.

(a) $i_L(0) = \frac{24}{60} = 0.4\text{A} \therefore \boxed{i_L(t) = 0.4e^{-750t}\text{A},\ t > 0}$

(b) $v_x = \frac{5}{6} \times 24 = 20\text{V},\ t < 0$

$v_x(0^+) = 50 \times 0.4 \times \frac{3}{8} = 7.5\text{V}$

$\therefore v_x(t) = 7.5e^{-750t}\text{V},\ t > 0$



32.

$$v_{in} = \frac{3i_L}{4} \times 20 + 10i_L = 25i_L$$

$$v_{in} \therefore \frac{v_{in}}{i_L} = 25\Omega \therefore i_L = 10e^{-25t/0.5} = \boxed{10e^{-50t}\text{A, } t > 0}$$

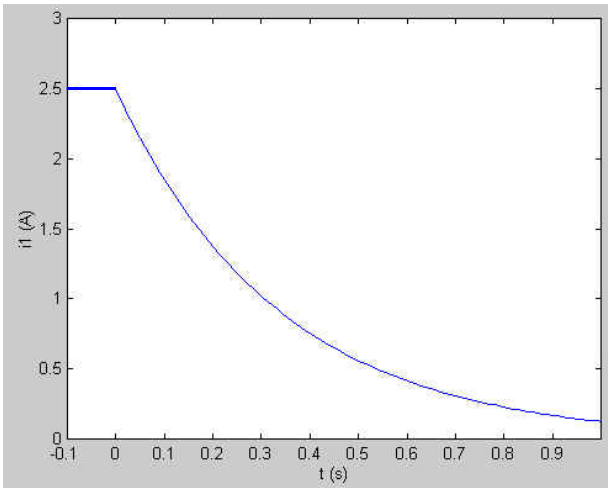
33.

$$i_L(0) = \frac{64}{4 + 40\|8} \times \frac{40}{48} = 5\text{A}$$

$$\therefore i_L = 5e^{-24t/8} = 5e^{-3t}\text{A}$$

$$\therefore i_1(t) = 2.5e^{-3t}\text{A},\ t>0;\ \boxed{i_1(-0.1) = 2.5\ \text{A}}$$

$$\boxed{i_1(0.03) = 2.285^{-}\ \text{A},\ i_1(0.1) = 1.852\ \text{A}}$$



34.

(a) $i_L(0) = 4\text{A} \therefore i_L = 4e^{-100t}\text{A},\ 0 < t < 15\,\text{ms}$

$\therefore i_L(15\text{ms}) = 4e^{-1.5} = \boxed{0.8925^+\,\text{A}}$

(b) $t > 15\,\text{ms}:\ i_L = 0.8925^+ e^{-20(t-0.015)}\text{A}$

$\therefore i_L(30\text{ms}) = 0.8925^+ e^{-0.3} = \boxed{0.6612\text{A}}$

35.

(a) $i_1(0^+) = i_1(0^-) = 10\text{A},\ i_2(0^+) = i_2(0^-) = 20\text{A} \therefore i(0^+) = \boxed{30\text{A}}$

(b) $\tau = \mathrm{L}_{eq} / \mathrm{R}_{eq} = \dfrac{0.08}{48} = \dfrac{5}{3}\text{ms} = \boxed{1.6667\text{ms}};$

(c) $i_1(0^-) = 10\text{A},\ i_2(0^-) = 20\text{A}\ ;\ \boxed{i(t) = 30e^{-600t}\text{A}}$

(d) $v = -48i = \boxed{-1440e^{-600t}\text{V}}$

(e)
$$i_1 = 10(-440)\int_0^t e^{-600t}dt + 10 = 24e^{-600t}\Big|_0^t + 10 = 24e^{-600t} - 14\text{A}$$
$$i_2 = 2.5(-1440)\int_0^t e^{-600t}dt + 20$$
$$= 6e^{-600t}\Big|_0^t + 20 = \boxed{6e^{-600t} + 14\text{A}}$$

(f)
$$\mathrm{W}_L(0) = \frac{1}{2}\times 0.1\times 10^2 + \frac{1}{2}\times 0.4\times 20^2 = 5 + 80 = 85\text{J}$$
$$\mathrm{W}_{\mathrm{L}}(\infty) = \frac{1}{2}\times 0.1\times 14^2 + \frac{1}{2}\times 0.4\times 14^2 = 9.8 + 39.2 = 49\text{J}$$
$$\mathrm{W}_{\mathrm{R}} = \int_0^\infty i^2 48dt = \int_0^\infty 900\times 48e^{-1200t}dt = \frac{900\times 48}{-1200}(-1) = 36\text{J}$$
$$\boxed{\therefore 49 + 36 = 85 \text{ checks}}$$

36.

(a) $v_c(0) = 100 \times \frac{2}{2+2} \times \frac{2}{3} = 33.33\text{V};\ i_1(0^-) = \frac{100}{2+2} \times \frac{2}{3} = 16.667\text{mA}$

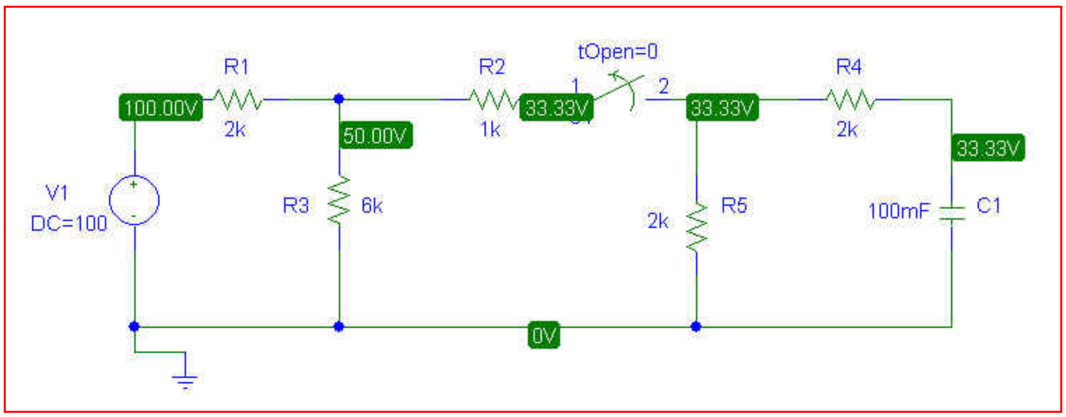
$\therefore \boxed{\mathrm{v_c}(9:59) = 33.33\text{V},\ i_1(9:59) = 16.667\text{mA}}$

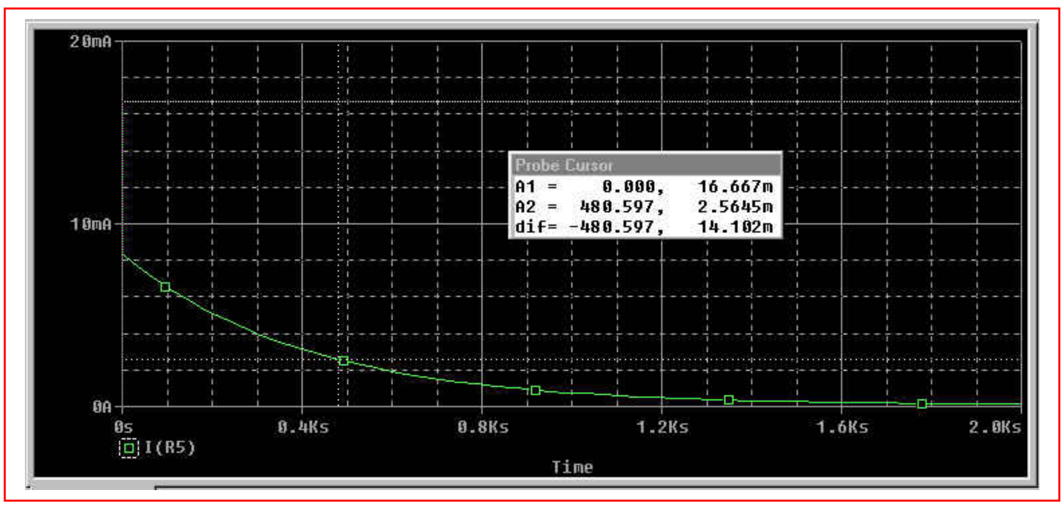
(b) $v_c(t) = 33.33e^{-t/400}, t > 10:00 \therefore v_c(10:05) = 33.33e^{-300/400}$

$\boxed{= 15.745^+\,\text{V},}\ i_1(10:05) = \frac{15.745}{4000} = \boxed{3.936\text{mA}}$

(c) $\tau = 400$ s, so $1.2\tau = 480$ s. $v_C(1.2\tau) = 33.33\ e^{-1.2} = 10.04$ V.
Using Ohm's law, we find that $i_1(1.2\tau) = v_C(1.2\tau)/\ 4000 = \boxed{2.51\text{ mA.}}$

(d) PSpice Verification:




We see from the DC analysis of the circuit that our initial value is correct; the Probe output confirms our hand calculations, especially for part (c).

37.

$$t>0:\ \frac{25i_x}{20}=1.25i_x\ \therefore 34=100(1.25i_x-0.8i_x+i_x)+25i_x\ \therefore i_x=0.2\text{A}$$

(a) $i_s(0^-)=(1.25-0.8+1)0.2=\boxed{0.290\text{ A}}$

(b) $i_x(0^-)=\boxed{0.2\text{A}}$

(c) $v_c(t)=25\times 0.2e^{-t}=5e^{-t}\text{V}\ \therefore i_x(0^+)=\frac{5}{100}=\boxed{0.05\text{A}}$

(d) $0.8i_x(0^+)=0.04\text{A}\ \therefore i_s(0^+)=\frac{34}{120}-0.04\times\frac{20}{120}=\frac{33.2}{120}=\boxed{0.2767\text{A}}$

(e) $i_x(0.4)=\frac{1}{100}\times 5e^{-0.4}=\boxed{0.03352\text{A}}$

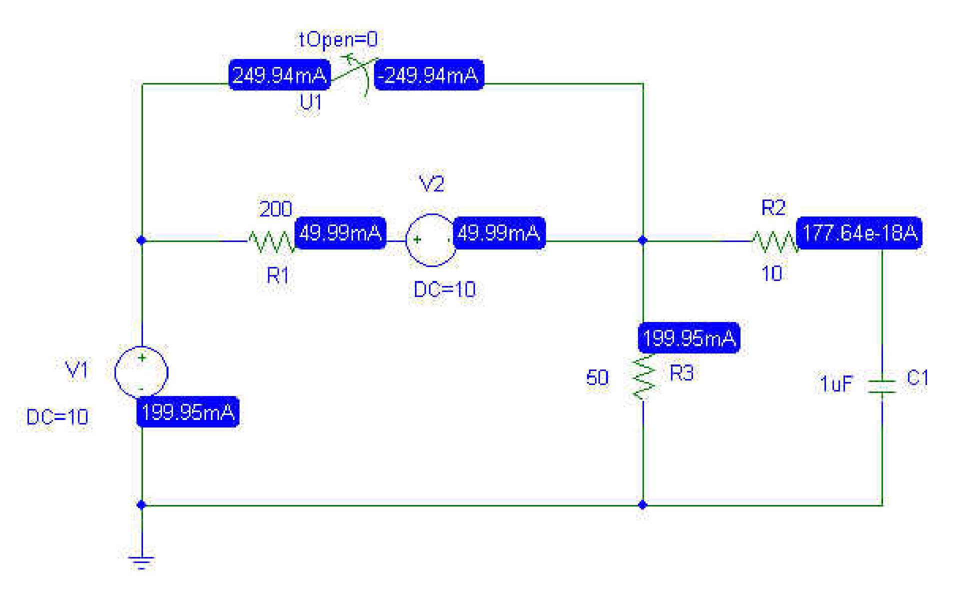
38.

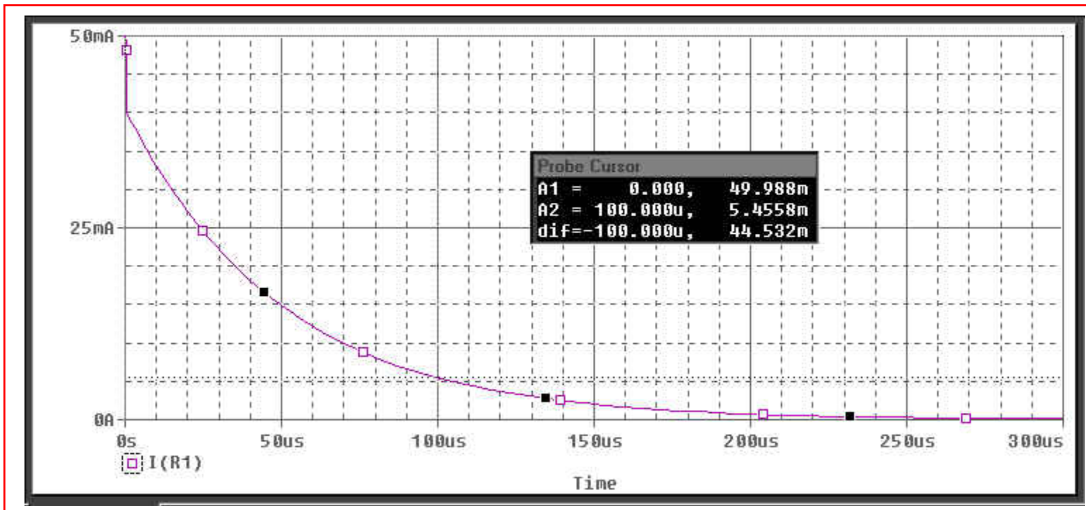
(a) $v_c(0) = 10\text{V} \therefore v_c(t) = 10e^{-10^6 t/(10+50\|200)} = \boxed{10e^{-20000t}\text{V}}$

(b) $i_A(-100\mu s) = i_A(0^-) = \dfrac{10}{200} = \boxed{50\text{mA}}$

$i_A(100\mu s) = 10e^{-2}\left(\dfrac{1}{10+40}\right)\dfrac{50}{250} = \boxed{5.413\text{mA}}$

(c) PSpice Verification.




From the DC simulation, we see that PSpice verifies our hand calculation of $i_A$ = 50 mA. The transient response plotted using Probe indicates that at 100 μs, the current is approximately 5.46 mA, which is within acceptable round-off error compared to the hand calculated value.

39.

(a) $i_1(t) = 8(-1)\dfrac{12}{12+4} = \boxed{-6\text{mA } (t<0)}$

(b) $4\|12\|6 = 2k\Omega,\ v_c(0) = 48\text{V}$

$\therefore v_c(t) = 48e^{-10^6 t/5\times2\times10^3} = 48e^{-100t}\text{V},\ t>0$

$\therefore i(t) = \boxed{12e^{-100t}\text{mA},\ t>0}$

40.

(a) $v_{CLeft}(0) = 20\text{V},\ v_{CRIGHT}(0) = 80\text{V}$

$\therefore v_{CL} = 20e^{-10^6 t/8}, v_{CR} = 80e^{-10^6 t/0.8}$

$\therefore v_{out} = v_{CR} - v_{CL} = \boxed{80e^{-1,250,000t} - 20e^{-125,000t}\text{V},\ t>0}$

(b) $v_{out}(0^+) = \boxed{60\text{V}};\ v_{out}(1\mu s) = 80e^{-1.25} - 20e^{-0.125} = \boxed{5.270\text{V}}$

$v_{out}(5\mu s) = 80e^{-6.25} - 20e^{-0.625} = \boxed{-10.551\text{V}}$

41. (a) $t<0: \dfrac{v_c - 0.25v_c}{5} + \dfrac{v_c}{10} + \dfrac{v_c - 40}{4} = 0 \therefore v_c = 20\text{V}\,(t<0)$

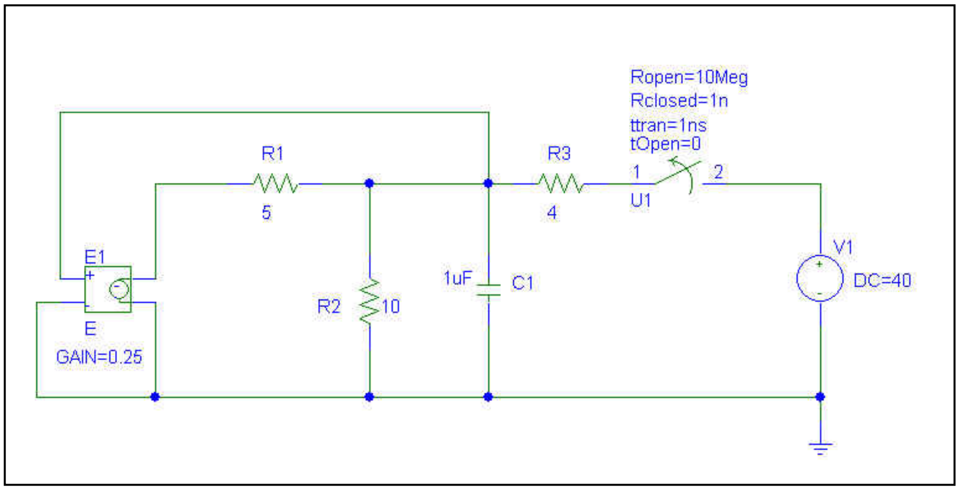
$t>0$: Apply $v_c = 1\text{V} \therefore \dfrac{1-0.25}{5} + 0.1 - i_{in} = 0.25\text{A}$

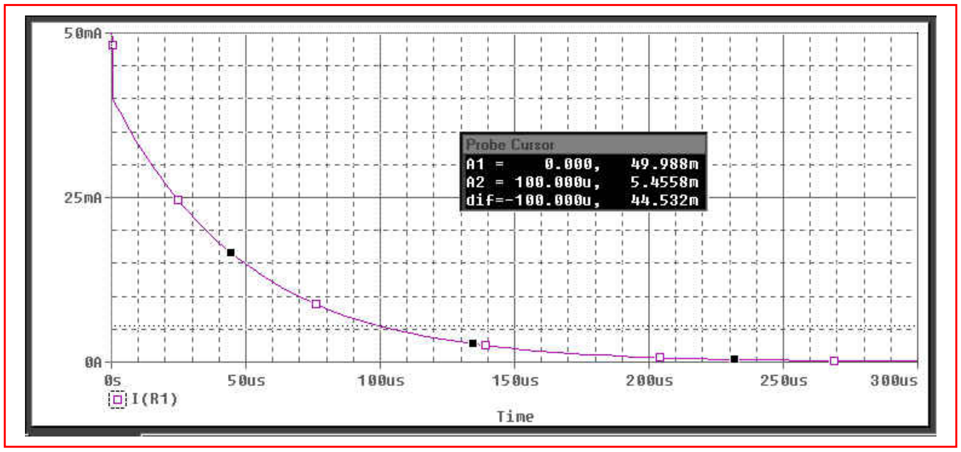
$$\therefore \text{R}_{eq} = \frac{1}{0.25} = 4\Omega$$

$$\therefore v_c(t) = 20e^{-10^6 t/4} = \boxed{20e^{-250{,}000t}\text{V}\,(t>0)}$$

(b) $v_C(3\ \mu\text{s}) = \boxed{9.447\ \text{V}}$

(c) PSpice verification. Note that the switch parameters had to be changed in order to perform this simulation.




As can be seen from the simulation results, our hand calculations are accurate.

42. $t<0: \; v_c(0)=60\text{V}$

$0<t<1\text{ms}: \; v_c=60e^{-10^6 t/(R_o+1000)} \therefore \frac{50}{60}e^{-500/(R_o+1000)}$

$\therefore \frac{500}{\text{R}_o+1000}=\ell n\,1.2=0.18232 \therefore \frac{\text{R}_o}{500}+2=5.4848, R_o=\boxed{1742.4\Omega}$

$\therefore v_c(1\text{ms})=60e^{-1000/2742.4}=41.67\text{V}$

$t>1\text{ms}: v_c=41.67e^{-10^6(t-10^{-3})}/(1742.4+\text{R}_1\|1000)$

$\therefore 25=41.67e^{-1000()} \therefore 0.5108=\frac{.1000}{1742.4+\text{R}_1\|1000}, 1742.4+\text{R}_1\|1000$

$=1957.6, \; \text{R}_1\|1000=215.2\frac{1}{\text{R}_1}+10^{-3}=\frac{1}{215.2}\therefore \text{R}_1=\boxed{274.2\Omega}$

43.

(a) With the switch closed, define a nodal voltage $V_1$ at the top of the 5-kΩ resistor. Then,

$0 = (V_1 – 100)/ 2 + (V_1 – V_C)/ 3 + V_1/ 5$ [1]
$0 = V_C/ 10 + (V_C – V_1)/ 3 + (V_C – 100)$ [2]

Solving, we find that $V_C = v_C(0^-) = \boxed{99.76 \text{ V.}}$

(b) $t > 0:\ \text{R}_{eq} = 10 \| 6.5 = 3.939 k\Omega \therefore v_c = 87.59 e^{-10^7 t/3939} = \boxed{87.59 e^{-2539t} \text{V} \,(t > 0)}$

44. $t < 0$:

$12 = 4i_1 + 20i_1 \therefore i_1 = 0.5\text{mA} \therefore v_c(0) = 6i_1 + 20i_1 = 26i_1$

$v_c(0) = 13\text{V}$

$t > 0$: Apply $\leftarrow 1\text{mA} \therefore 1 + 0.6i_1 = i_1 \therefore i_1 = 2.5\text{mA}; \pm v_{in} = 30i_1 = 75\text{V} \therefore \text{R}_{eq} = 75k\Omega$

$\therefore v_c(t) = 13e^{-t/75\times10^3\times2\times10^{-9}} = 13e^{-10^6 t/150} = 13e^{-6667t}$

$\therefore i_1(t) = \dfrac{v_o}{3\times10^4} = \boxed{0.4333e^{-6667t}\text{mA}\ (t>0)}$

45.

(a) $v_1(0^-) = \boxed{100\text{V.}}\ v_2(0^-) = 0,\ v_R(0^-) = \boxed{0}$

(b) $v_1(0^-) = \boxed{100\text{V.}}\ v_2(0^+) = 0,\ v_R(0^+) = \boxed{100\text{V}}$

(c) $\tau = \dfrac{20 \times 5}{20+5} \times 10^{-6} \times 2\ 10^4 = \boxed{8 \times 10^{-2}\,s}$

(d) $v_R(t) = \boxed{100e^{-12.5t}\text{V},\ t > 0}$

(e) $i(t) = \dfrac{v_R(t)}{2 \times 10^4} = \boxed{5e^{-12.5t}\text{mA}}$

(f) $v_1(t) = \dfrac{10^6}{20}\displaystyle\int_o^t -5 \times 10^{-3} e^{-12.5t} dt + 100 = \dfrac{10^3}{50} e^{-12.5t} \Big|_o^t + 100 = \boxed{-20e^{-12.5t} + 80\text{V}}$

$v_2(t) = \dfrac{1000}{5}\displaystyle\int_o^t 5e^{-12.5t} dt + 0 = -80e^{-12.5t} \Big|_o^t + 0 = \boxed{-80e^{-12.5t} + 80\text{V}}$

(g) $w_{c1}(\infty) = \dfrac{1}{2} \times 20 \times 10^{-6} \times 80^2 = 64\text{mJ},\ w_{c2}(\infty)\dfrac{1}{2} \times 5 \times 10^{-6} \times 80^2 = \boxed{16\text{mJ}}$

$w_{c1}(0) = \dfrac{1}{2} \times 20 \times 10^{-6} \times 100^2 = \boxed{100\text{mJ}},\ w_{c2}(0) = 0$

$w_R = \displaystyle\int_o^\infty 25 \times 10^{-6} e^{-25t} \times 2 \times 10^4 dt = \dfrac{25}{-25} \times 2 \times 10^4 (-1) 10^{-6} = \boxed{20\text{mJ}}$

$\boxed{64 + 16 + 20 = 100 \text{ checks}}$

46.

(a) $t < 0:\ i_s = 1\text{mA} \therefore \pm\ v_c(0) = 10\text{V},\ \downarrow i_L(0) = -1\text{mA} \therefore v_x(0) = \boxed{10\text{V}, t < 0}$

(b) $t > 0:\ v_c(t) = 10e^{-t/10^4 \times 20\times 10^{-9}} = 10e^{-5000t}\text{V}$

$\text{i}_\text{L}(t) = -10^{-3}e - 10^{3t/0.1} = -10^{-3}e^{-10000t}\text{A} \therefore \pm v_L(t) = e^{-10000t}\text{V},\ t > 0$

$\therefore v_x = v_c - v_L(t) = \boxed{10e^{-5000t} - e^{-10000t}\text{V},\ t > 0}$

47.

(a) $t<0:\ v_s = 20\text{V} \therefore v_c = 20\text{V},\ i_L = 20\text{mA} \therefore \boxed{i_x(t) = 20\text{mA},\ t<0}$

(b) $t>0:\ v_s = 0 \therefore i_L(t) = 0.02e^{-10000t}\text{A};\ v_c(t) = 20e^{-t/2\times10^{-8}10^{4}} = 20e^{-5000t}\text{V}$

$\downarrow i_c(t) = 2\times10^{-8}\times20(-5000)\,e^{-5000t} = -2e^{-5000t}\text{mA}$

$i_x(t) = i_L(t) + i_c(t) = 0.02e^{-10000t} - 0.002e^{-5000t}\text{A} = \boxed{20e^{-10000t} - 2e^{-5000t}\text{mA}}$

48.

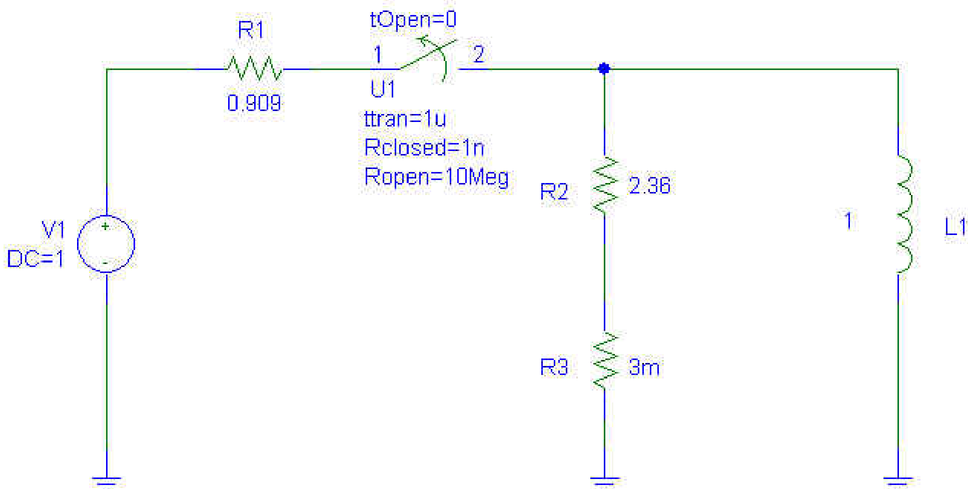
$$i_L(0^-) = \frac{V}{R} = \frac{1}{0.909} = 1.1\,\text{A}$$

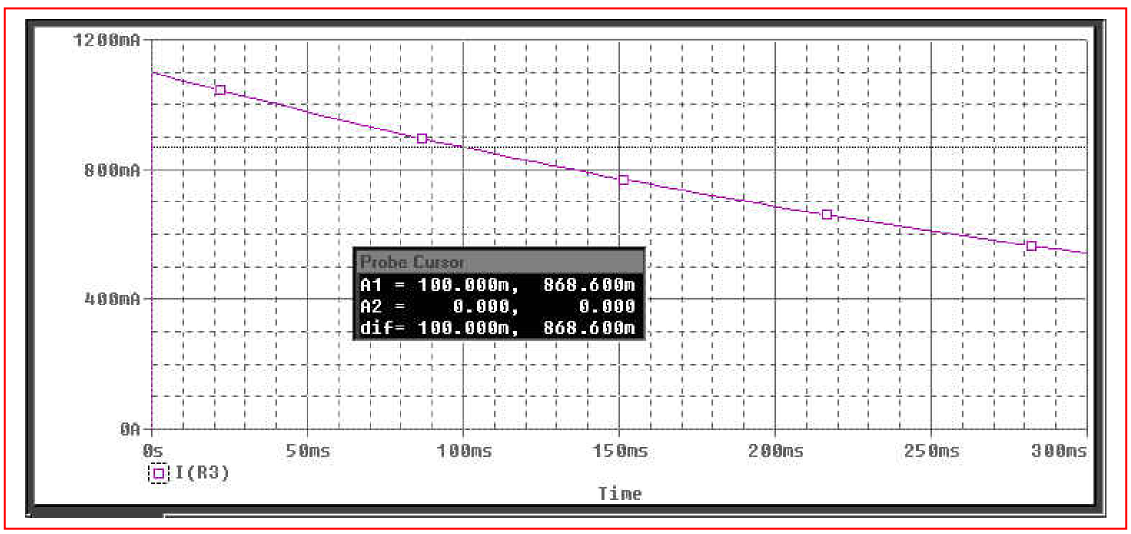
$$t > 0: \;\; i_L(t) \; = \; e^{-2.363t} \;\; \text{A}$$

$$i_L(0.1s) = 1.1e^{-2.363\times 0.1} = 0.8685\,\text{A}$$

$\boxed{\therefore \text{since the current has dropped to less than 1 A prior to } t = 100 \text{ ms, the fuse does not blow}}$.

PSpice verification: Note that the switch properties were changed.




We see from the simulation result that the current through the fuse (R3) is 869 mA, in agreement with our hand calculation.

49. $\boxed{v(t) = 6u(t) - 6u(t-2) + 3u(t-4)\ \text{V}}$

50. $\boxed{i(t) = 2u(t) + 2u(t-2) - 8u(t-3) + 6u(t-4) \text{ A}}$

51. (a) $f(-1) = 6 + 6 - 3 = \boxed{9}$

(b) $f(0^-) = 6 + 6 - 3 = \boxed{9}$

(c) $f(0^+) = 6 + 6 - 3 = \boxed{9}$

(d) $f(1.5) = 0 + 6 - 3 = \boxed{3}$

(e) $f(3) = 0 + 6 - 3 = \boxed{3}$

52. (a) $g(-1) = 0 - 6 + 3 = \boxed{-3}$

(b) $g(0^+) = 9 - 6 + 3 = \boxed{6}$

(c) $g(5) = 9 - 6 + 3 = \boxed{6}$

(d) $g(11) = 9 - 6 + 3 = \boxed{6}$

(e) $g(30) = 9 - 6 + 3 = \boxed{6}$

53. (a) $v_A = 300u(t-1)\,\text{V},\ v_B = -120u(t+1)\,\text{V};\ i_c = 3u(-t)\,\text{A}$

$$t=-1.5:\ i_1(-1.5) = 3\times\frac{100}{300} = \boxed{1\text{A}}$$

$$t=0.5:\ i_1(-0.5) = \frac{-120}{300}+1 = \boxed{0.6\text{A};}$$

$$t=0.5:\ i_1 = -\frac{120}{300} = -0.4\text{A};\ t=1.5:\ i_1 = \frac{300}{300}-\frac{120}{300} = \boxed{0.6\text{A}}$$

54.

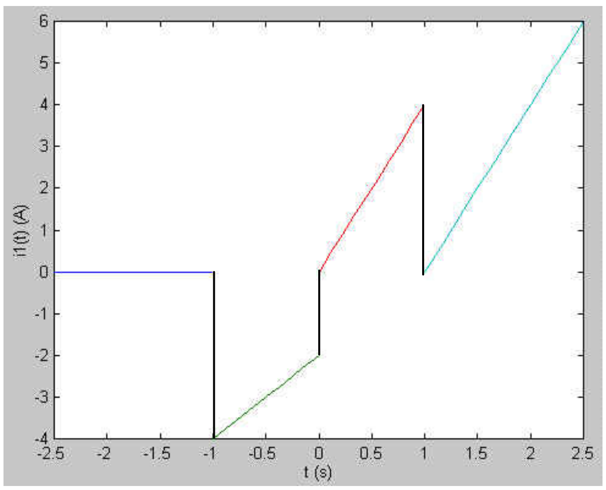
` $v_A = 600tu(t+1)\,v,\ v_B = 600(t+1)u(t)\,\text{V},\ i_c = 6(t-1)u(t-1)\text{A}$

(a) $t = -1.5: i_1 = 0;\ t = -0.5: i_1 = 600(-0.5)/300 = \boxed{-1\text{A}}$

$$t = 0.5: i_1 = \frac{600(0.5)}{300} + \frac{600(1.5)}{300} = \boxed{4\text{A}}$$

$$t = 1.5: i_1 = \frac{600(1.5)}{300} + \frac{600(2.5)}{300} + \frac{1}{3} \times 6 \times 0.5 = 3 + 5 + 1 = \boxed{9\text{A}}$$

(b)



55.

(a) $2u(-1) - 3u(1) + 4u(3) = -3 + 4 = \boxed{1}$

(b) $[5 - u(2)]\,[2 + u(1)]\,[1 - u(-1)]$
$= 4 \times 3 \times 1 = \boxed{12}$

(c) $4e^{-u(1)}u(1) = 4e^{-1} = \boxed{1.4715^{+}}$

56.

(a) $$t<0:\ i_x = \frac{100}{50} + 0 + 10\times\frac{20}{50} = \boxed{6\text{A}}$$

$$t>0:\ i_x = 0 + \frac{60}{30} + 0 = \boxed{2\text{A}}$$

(b) $t < 0$: The voltage source is shorting out the 30-Ω resistor, so $\boxed{i_x = 0.}$

$t > 0$: $i_x = 60/\,30 = \boxed{2\text{ A}}$.

57. $t = -0.5:$ $50 \| 25 = 16.667,\ i_x = \dfrac{200}{66.67} - 2\dfrac{1/50}{1/50 + 1/25 + 1/50} = 3 - \dfrac{1}{2} = \boxed{2.5\text{A}}$

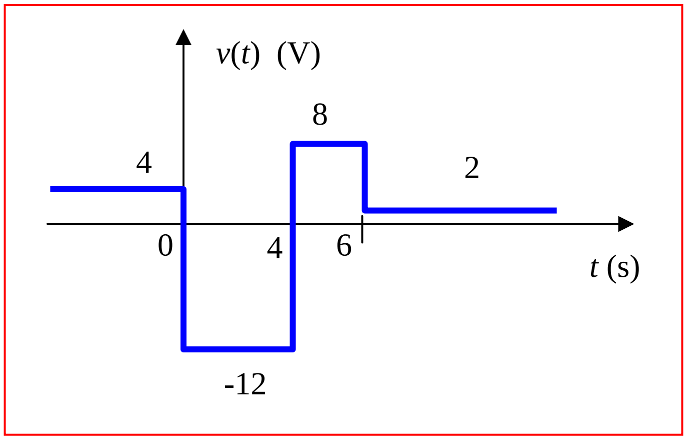
$t = 0.5:$ $i_x = \dfrac{200}{66.67} = \boxed{3\text{A}}$

$t = 1.5:$ $i_x = 3 - \dfrac{100}{66.67} \times \dfrac{1}{3} = \boxed{2.5\text{A}}$

$t = 2.5:$ $i_x = \dfrac{200 - 100}{50} = \boxed{2\text{A}}$

$t = 3.5:$ $i_x = -\dfrac{100}{50} = \boxed{-2\text{A}}$

58. $\boxed{v(t) = 4 - 16u(t) + 20u(t-4) - 6u(t-6)\,\text{V}}$



59. (a) $7\ u(t) - 0.2\ u(t) + 8(t-2) + 3$

$\boxed{v(1) = 9.8 \text{ volts}}$

(b) $\boxed{\text{Resistor of value } 2\Omega}$

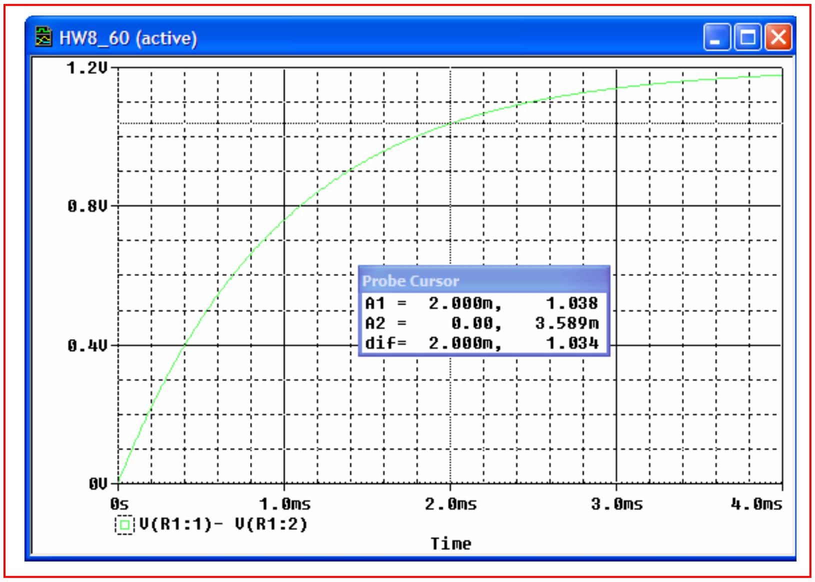
60.

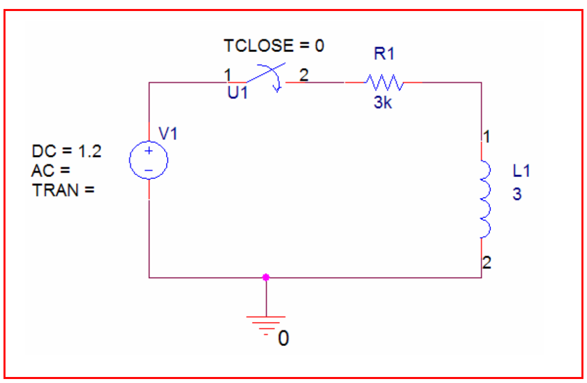
$$i(t) = \frac{V_o}{R}\left(1 - e^{-\frac{R}{L}t}\right)u(t) \text{ A} \quad \text{and} \quad v_R(t) = i(t)R$$

(a) $v_R(t) = V_o\left(1 - e^{-\frac{R}{L}t}\right)u(t) \text{ V} = \boxed{1.2\left(1 - e^{-1000t}\right)u(t) \text{ V}}$

(b) $v_R(2\times10^{-3}) = 1.2\left(1 - e^{-2}\right) \text{ V} = \boxed{1.038 \text{ V}}$

(c)



61.

(a) $\boxed{i_L(t) = (2 - 2e^{-200000t})\,u(t)\ \text{ mA}}$

(b) $v_L(t) = \mathrm{L}i_L' = 15\times10^{-3}\times10^{-3}(-2)$

$(-200000e^{-200000t})\ u(t) = \boxed{6e^{-200000t}u(t)\mathrm{V}}$

62.

(a) $i_L(t) = 2 + 2(1 - e^{-2.5t})u(t)\text{ A} \therefore i_1(-0.5) = \boxed{2\text{A}}$

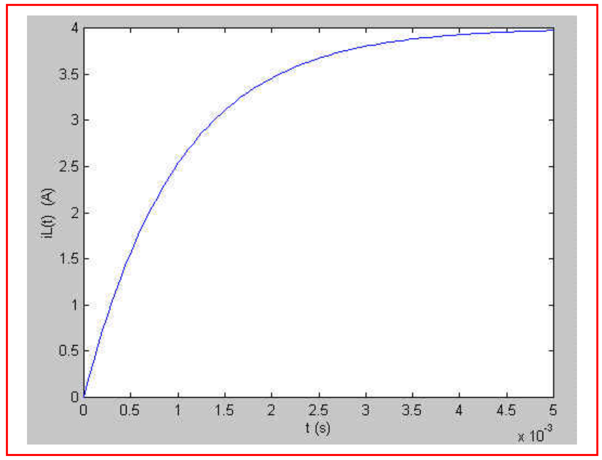
(b) $i_L(0.5) = 2 + 2(1 - e^{-1.25}) = \boxed{3.427\text{A}}$

(c) $i_L(1.5) = 2 + 2(1 - e^{-3.75}) = \boxed{3.953\text{A}}$

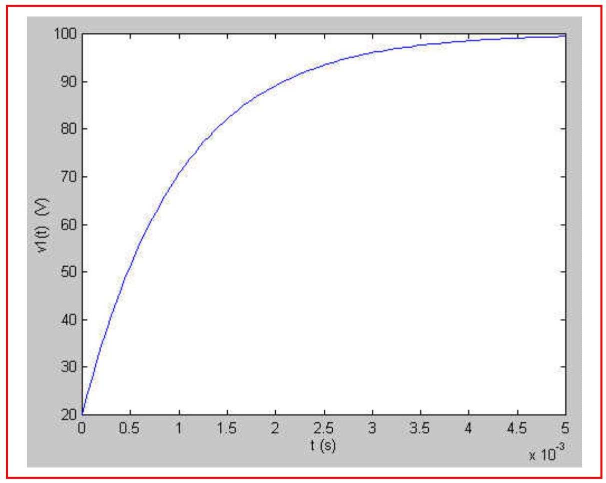
63.

(a) $$i_L(t) = (4 - 4e^{-20t/0.02})u(t)$$

$$\therefore \boxed{i_L(t) = 4(1 - e^{-1000t})u(t)\text{A}}$$




(b) $$\boxed{v_1(t) = (100 - 80e^{-1000t})u(t)\text{V}}$$

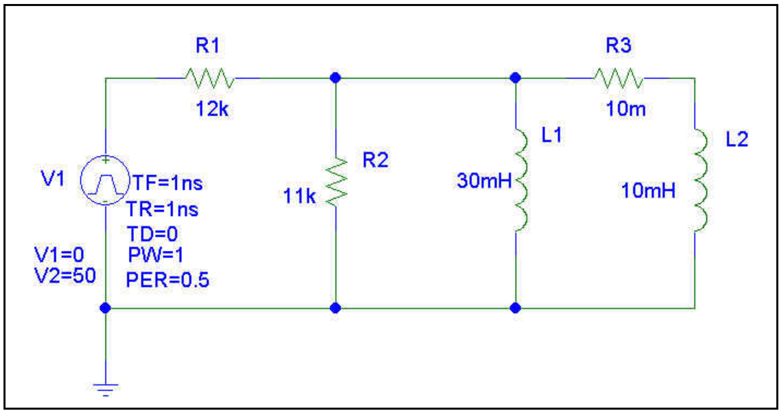


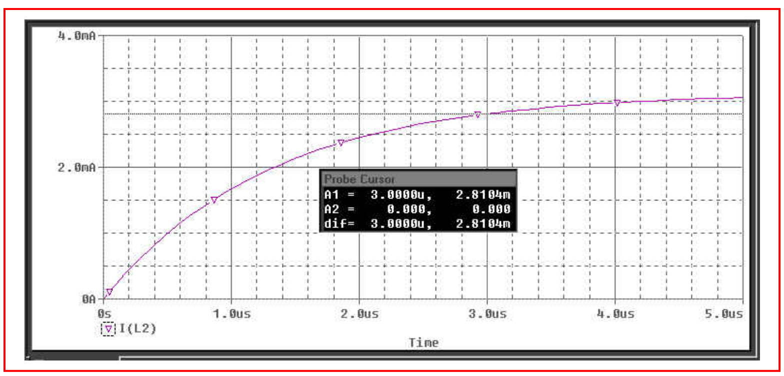
64. (a) $\boxed{0 \text{ W}}$

(b) The total inductance is 30 || 10 = 7.5 mH. The Thévenin equivalent resistance is 12 || 11 = 5.739 kΩ. Thus, the circuit time constant is L/R = 1.307 μs. The final value of the total current flowing into the parallel inductor combination is 50/12 mA = 4.167 mA. This will be divided between the two inductors, so that $i(\infty)$ = (4.167)(30)/ (30 + 10) = 3.125 mA.

We may therefore write $i(t) = 3.125[1 - e^{-10^6 t/1.307}]$ A. Solving at $t$ = 3 μs, we find $\boxed{2.810 \text{ A.}}$

(c) PSpice verification




We see from the Probe output that our hand calculations are correct by verifying using the cursor tool at $t$ = 3 μs.

65. $\tau = L/R_{TH} = \dfrac{30\times10^{-6}}{5\,||\,10} = \dfrac{30\times10^{-6}}{3.333} = 9\times10^{-6}$ s

(a) $i(t) = i_f(t) + i_n(t)$

$i_n = Ae^{-10^6 t/9}$ and $i_f = \dfrac{9}{5}$

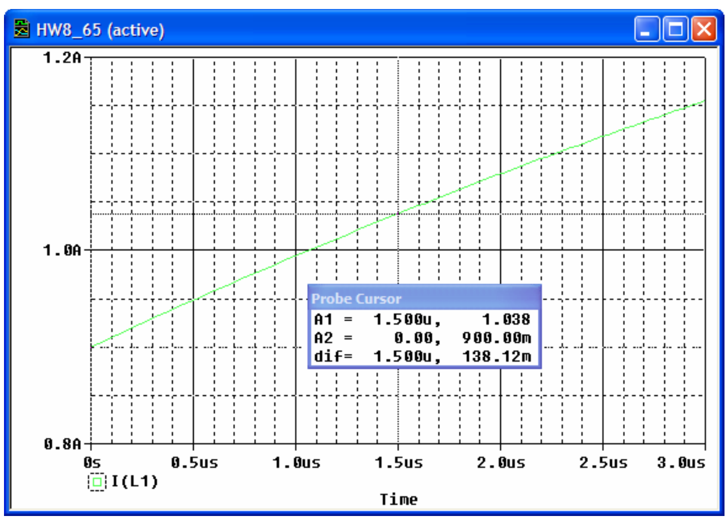
Thus, $i(t) = \dfrac{9}{5} + Ae^{-\frac{10^6}{9}t}$

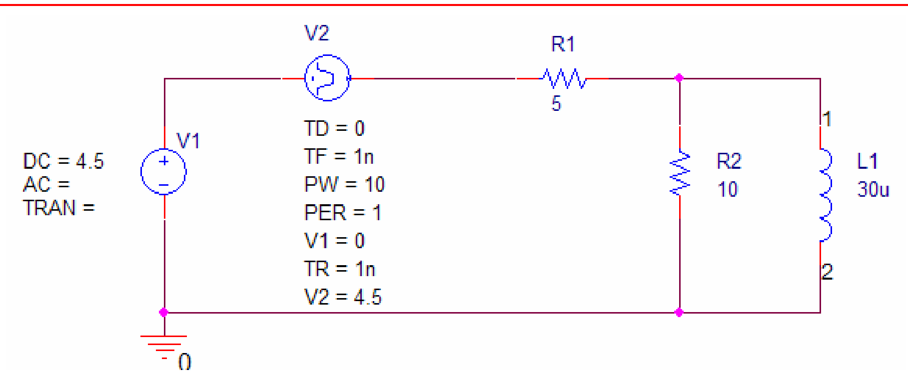
At $t = 0$, $i(0^-) = i(0^+) = 4.5/5$. Thus, $A = –4.5/5 = 0.9$
so

$$\boxed{i(t) = \frac{9}{5} - 0.9e^{-\frac{10^6}{9}t} \text{ A}}$$

(b) At $t = 1.5$ μs, $i = i(t) = \dfrac{9}{5} - 0.9e^{-\frac{1.5}{9}t} = \boxed{1.038 \text{ A}}$

(c)



66. $\tau = \text{L/R}_{\text{eq}} = \dfrac{45\times10^{-3}}{10\,||\,5} = \dfrac{45\times10^{-3}}{3.333} = 0.0135 \text{ s}$

(a) $v_R(t) = v_f + v_n$

$v_f(t) = 0$ since inductor acts as a short circuit.

Thus, $v_R(t) = v_n = Ae^{-74.07t}$ .

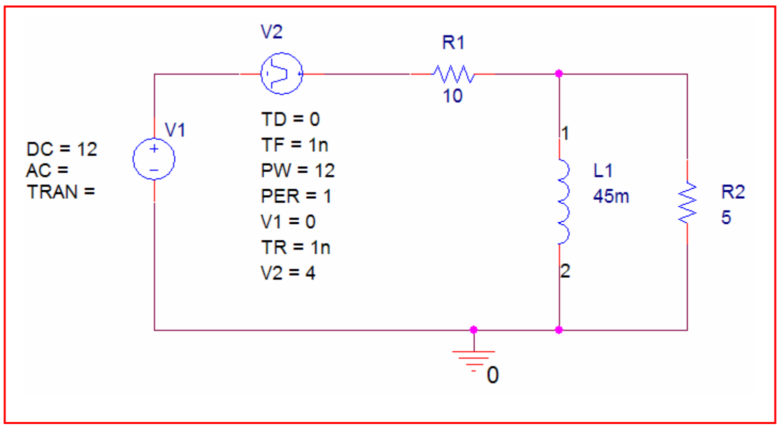
At $t = 0$, $i_L = 12/10 = 1.2$ A $= i_L(0^-) = i_L(0^+)$.

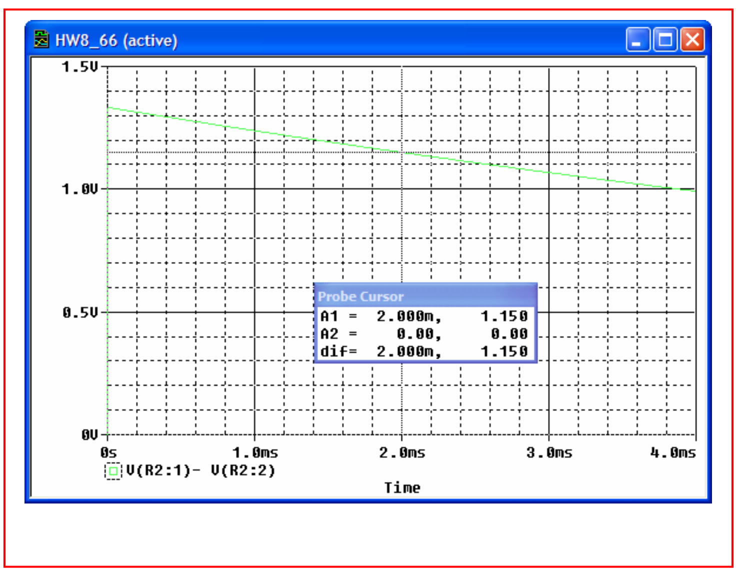
Writing KVL for this instant in time, $16 - 10(1.2 + v_R/5) = v_R$

Therefore $v_R(0^+) = \dfrac{4}{3}$ V and hence $\boxed{v_R(t) = \dfrac{4}{3}e^{-74.07t} \text{ V}}$

(b) At $t = 2$ ms, $v_R(2 \text{ ms}) = \dfrac{4}{3}e^{-74.07\left(2\times10^{-3}\right)}$ V $=$ $\boxed{1.15 \text{ V}}$

(c)



67. $\tau = \dfrac{L}{R_{eq}} = \dfrac{5\times10^{-3}}{100} = 50\ \mu\text{s}$

$v_1(t) = v_{1f} + v_{1n}$ where $v_{1f} = 6$ V since the inductor acts as a short circuit

Therefore $v_1(t) = 6 + Ae^{-\frac{10^6 t}{50}}$.

At $t = 0^-$, $i_L = 0 = i_L(0^+)$. Thus, $v_1(0^+) = 0$ since no current flows through the resistor.

Hence $v_1(t) = 6\left(1 - e^{-\frac{10^6 t}{50}}\right)$ V.

At $t = 27$ μs, $v_1(27\times10^{-6}) = 6\left(1 - e^{-\frac{27}{50}}\right) = \boxed{2.5\text{ V}}$

68.

(a) $\boxed{i_L(t) = 10A,\ t < 0}$

(b) $i_L(t) = 8 + 2e^{-5t/0.5}$

$\therefore \boxed{i_L(t) = 8 + 2e^{-10t}\text{A},\ t > 0}$

69.

(a) $\boxed{i_L(t) = 2\text{A},\ t>0}$

(b) $i_L(t) = 5 - e^{-4t/0.1}$

$\therefore \boxed{i_L(t) = 5 - 3e^{-40t}\ \text{A},\ t>0}$

70.

(a) $\boxed{0,\ 0}$

(b) $\boxed{0,\ 200\text{V}}$

(c) $\boxed{1\text{A},\ 100\text{V}}$

(d)

$$\tau = \frac{50\times10^{-3}}{200} = \frac{1}{4}\text{ms} \therefore i_L = 1(1-e^{-4000t})u(t)\text{A},\ i_L(0.2\text{ms}) = \boxed{0.5507\text{A}}$$

$$v_1(t) = (100+100e^{-4000t})u(t)\text{V},\ v_1(0.2\text{ms}) = \boxed{144.93\text{V}}$$

71. $$\frac{di}{dt} + \mathrm{P}i = \mathrm{Q},\ i = e^{-Pt}\int \mathrm{Q}e^{Pt}dt + Ae^{-Pt},\ \mathrm{R} = 125\Omega,\ \mathrm{L} = 5\mathrm{H}$$

$$\therefore \mathrm{L}\frac{di}{dt}\mathrm{LP}i = \mathrm{LQ} \therefore \mathrm{LP} = 5\mathrm{P} = \mathrm{R} = 125 \therefore \mathrm{P} = 25$$

(a) $$\mathrm{Q}(t) = \frac{10}{\mathrm{L}} = 2 \therefore i = e^{-25t}\int_o^t 2e^{25t}dt + \mathrm{A}e^{-25t} = e^{-25t}\times\frac{2}{25}e^{25t}\Big|_o^t + \mathrm{A}e^{-25t}$$

$$\therefore i = \frac{2}{25} + \mathrm{A}e^{-25t},\ i(0) = \frac{10}{125} = \frac{2}{25} \therefore \mathrm{A} = 0 \therefore i = \frac{2}{25} = \boxed{0.08\mathrm{A}}$$

(b) $$\mathrm{Q}(t) = \frac{10u(t)}{5} = 2u(t) \therefore i = e^{-25t}\int_o^t 2e^{25t}dt + \mathrm{A}e^{-25t} = \frac{2}{25} + \mathrm{A}e^{-25t}$$

$$i(0) = 0 \therefore \mathrm{A} = -\frac{2}{25} \therefore \boxed{i(t) = 0.08(1-e^{-25t})\mathrm{A},\ t>0}$$

(c) $$\mathrm{Q}(t) = \frac{10+10u(t)}{5} = 2+2u(t) \therefore \boxed{i = 0.16 - 0.08e^{-25t}\mathrm{A},\ t>0}$$

(d) $$\mathrm{Q}(t) = \frac{10u(t)\cos 50t}{5} = 2u(t)\cos 50t \therefore i = e^{-25t}\int_o^t 2\cos 50t \times e^{25t}dt + Ae^{-25t}$$

$$\therefore i = 2e^{-25t}\left[\frac{e^{25t}}{50^2+25^2}(25\cos 50t + 50\sin 50t)\right]_o^t + \mathrm{A}e^{-25t}$$

$$= 2e^{-25t}\left[\frac{e^{25t}}{3125}(25\cos 50t + 50\sin 50t) - \frac{1}{3125}\times 25\right] + \mathrm{A}e^{-25t}$$

$$= \frac{2}{125}\cos 50t + \frac{4}{125}\sin 50t - \frac{2}{125}e^{-25t} + \mathrm{A}e^{-25t}$$

$$i(0) = 0 \therefore 0 = \frac{2}{125} - \frac{2}{125} + \mathrm{A} \therefore \mathrm{A} = 0$$

$$\therefore \boxed{i(t) = 0.016\cos 50t + 0.032\sin 50t - 0.016e^{-25t}\mathrm{A},\ t>0}$$

72.

(a) $i_L(t) = \frac{100}{20} - \frac{100}{5} = \boxed{-15\text{A},\ t<0}$

(b) $i_L(0^+) = i_L(0^-) = \boxed{-15\text{A}}$

(c) $i_L(\infty) = \frac{100}{20} = \boxed{5\text{A}}$

(d) $i_L(t) = \boxed{5 - 20e^{-40t}\text{A},\ t>0}$

73. $i_L(0^-) = \dfrac{18}{60+30} \times \dfrac{1}{2} = 0.1\text{A} \therefore i_L(0^+) = 0.1\text{A}$

$\mathrm{i_L}(\infty) = 0.1 + 0.1 = 0.2\text{A}$

$\therefore i_L(t) = 0.2 - 0.1e^{-9000t}\text{A},\ t > 0$

$\therefore i_L(t) = 0.1u(-t) + (0.2 - 0.1e^{-9000t})u(t)\text{A}$

or, $\boxed{i_L(t) = 0.1 + (0.1 - 0.1e^{-9000t})u(t)\text{A}}$

74.

(a) $i_x(0^-) = \frac{30}{7.5} \times \frac{3}{4} = 3\text{A},\ i_L(0^-) = \boxed{4\text{A}}$

(b) $i_x(0^+) = i_L(0^+) = \boxed{4\text{A}}$

(c) $i_x(\infty) = i_L(\infty) = 3\text{A}$

$\therefore i_x(t) = 3 + 1e^{-10t/0.5} = 3 + e^{-20t}\text{A} \therefore i_x(0.04)$

$= 3 + e^{-0.8} = \boxed{3.449\text{A}}$

75.

(a) $i_x(0^-) = i_L(0^-) = \dfrac{30}{10} = \boxed{3\text{A}}$

(b) $i_x(0^+) = \dfrac{30}{30+7.5} \times \dfrac{30}{40} + 3 \times \dfrac{15}{10+15} = \boxed{2.4\text{A}}$

(c) $i_x(\infty) = \dfrac{30}{7.5} \times \dfrac{30}{40} = 3\text{A} \therefore i_x(t) = 3 - 0.6e^{-6t/0.5}$

$= 3 - 0.6e^{-12t} \therefore i_x(0.04) = 3 - 0.6e^{-0.48} = \boxed{2.629\text{A}}$

76. $\text{OC}: v_x = 0,\ v_{oc} = 4u(t)\text{V}$

$$\text{SC}: 0.1u(t) = \frac{v_x - 0.2v_x}{40} + \frac{v_x}{60}, 12u(t) = 0.6v_x + 2v_x$$

$$\therefore v_x = \frac{12u(t)}{2.6} \therefore i_{ab} = \frac{v_x}{60} = \frac{12u(t)}{2.6 \times 60} = \frac{u(t)}{13}$$

$$\therefore R_{th} = 4 \times 13 = 52\Omega \therefore i_L = \frac{4u(t)}{52}(1 - e^{-52t/0.2})u(t) = \frac{u(t)}{13}(1 - e^{-260t})u(t)$$

$$\therefore v_x = 60i_L = \boxed{4.615^{+}(1 - e^{-260t})u(t)\text{V}}$$

77.

(a) $\text{OC}: -100 + 30i_1 + 20i_1 = 0,\ i_1 = 2\text{A}$

$\therefore v_{oc} = 80u(t)\text{V}$

$\text{SC}: i_1 = 10\text{A}, \downarrow i_{sc} = 10 + \dfrac{20 \times 10}{20} = 20\text{A}$

$\therefore \text{R}_{th} = 4\Omega \therefore i_L(t) = \boxed{20(1 - e^{-40t})u(t)\text{A}}$

(b) $v_L = 0.1 \times 20 \times 40e^{-40t}u(t) = 80e^{-40t}u(t)$

$\therefore i_1(t) = \dfrac{100u(t) - 80e^{-40t}u(t)}{10} = \boxed{10 - 8e^{-40t}u(t)\text{A}}$

78. $\tau = R_{eq}C = (5)(2) = 10$ s

Thus, $v_n(t) = Ae^{-0.2t}$.

$v = v_n + v_f = Ae^{-0.1t} + Be^{-5t}$.

At $t$ = 0, $v$(0) = 0 since no source exists prior to $t$ = 0. Thus, A + B = 0 [1].

As $t \to \infty$, $v(\infty) \to 0$. We need another equation.

$$i(0) = C\frac{dv}{dt} = \frac{4.7}{5}(2) \quad \text{therefore} \quad \left.\frac{dv}{dt}\right|_{t=0^+} = \frac{4.7}{5} \quad \text{or} \quad -0.1A - 5B = \frac{4.7}{5} \quad [2]$$

Solving our two equations, we find that A = –B = 0.192.

Thus, $\boxed{v(t) = 0.192\left(e^{-0.1t} - e^{-5t}\right)}$

79. Begin by transforming the circuit such that it contains a 9.4 cos 4$t$ $u$($t$) V voltage source in series with a 5 Ω resistor, in series with the 2 F capacitor.

Then we find that

$$9.4\cos 4t = 5i + v$$
$$= (5)(2)\frac{dv}{dt} + v$$

or $\frac{dv}{dt} + 0.1v = 0.94\cos 4t$, so that $v(t) = e^{-0.1t}\int\left(0.94\cos 4t\right)e^{0.1t}dt + Ae^{-0.1t}$

Performing the integration, we find that

$$v(t) = 0.94\left[\frac{10\cos 4t + 400\sin 4t}{1+1600}\right] + Ae^{-0.1t}.$$

At $t$ = 0, $v$ = 0, so that $A = -\frac{0.94}{1601}\left(10\right)$

and $\boxed{v(t) = \frac{0.94}{1601}\left[-10e^{-0.1t} + 10\cos 4t + 400\sin 4t\right]}$

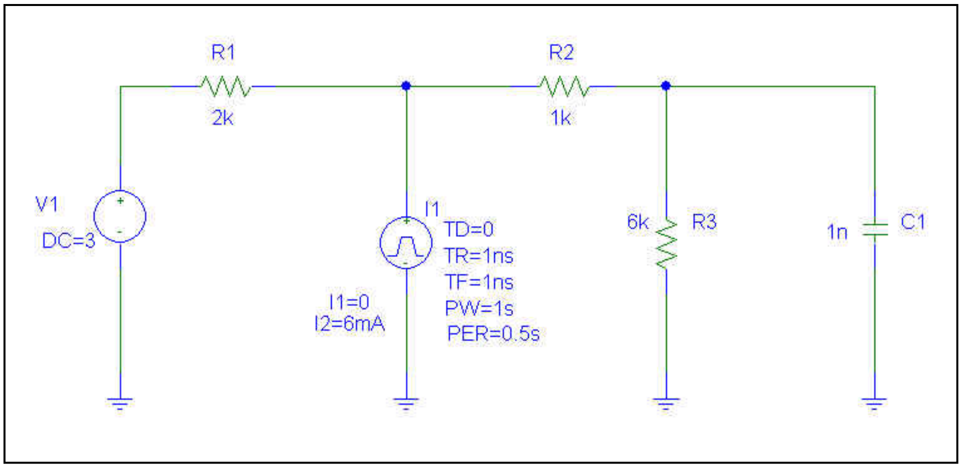
80. (a) $v_c(0^-) = \frac{6}{9} \times 3 = 2\text{V} = v_c(0^+)$

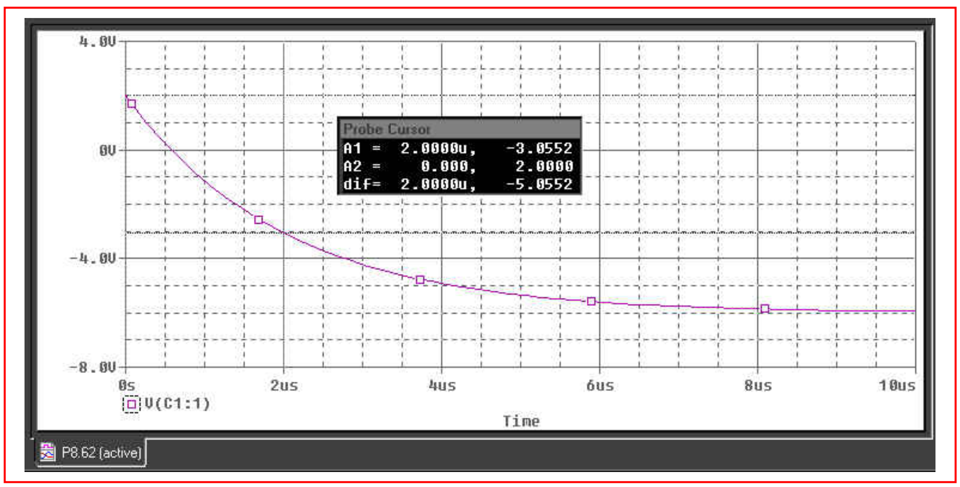
$$v_c(\infty) = 2 - 6(2\|7)\frac{6}{7} = -6\text{V}$$

$$\therefore v_c(t) = -6 + 8e^{-10^9 t/2\times10^3} = -6 + 8e^{-500000t}\text{V},\ t > 0$$

$$v_c(-2\mu s) = v_c(0^-) = 2\text{V},\ v_c(2\mu s) = -6 + 8e^{-1} = \boxed{-3.057\text{V}}$$

(b) PSpice verification.




As can be seen from the plot above, the PSpice simulation results confirm our hand calculations of $v_C(t < 0)$ = 2 V and $v_C(t = 2\ \mu s)$ = -3.06 V

81. $\tau = RC = 2\times10^{-3}(50) = 0.1$

$v_n = Ae^{-10t}$

$v_C(t) = v_{Cn} + v_{Cf} = Ae^{-10t} + 4.5$ since $v_C(\infty) = 4.5$ V

Since $v_C(0^-) = v_C(0^+) = 0$

$v_C(t) = -4.5e^{-10t} + 4.5 = \boxed{4.5\left(1 - e^{-10t}\right)}$

82. $i_A(0^-) = \frac{10}{1} = 10\text{mA},\ i_A(\infty) = 2.5\text{mA},\ v_c(0) = 0$

$$i_A(0^+) = \frac{10}{1.75} \times \frac{1}{4}\ 1.4286\text{mA} \therefore \boxed{i_A = 10\text{mA},\ t < 0}$$

$$i_A = 2.5 + (1.4286 - 2.5)\,e^{-10^8 t/1.75\times 10^3} = \boxed{2.5 - 1.0714e^{-57140t}\text{mA},\ t > 0}$$

83. $i_A(0^-) = \frac{10}{4} = 2.5\text{mA},\ i_A(\infty) = 10\text{mA}$

$$v_c(0) = 7.5\text{V} \therefore i_A(0^+) = \frac{10}{1} + \frac{7.5}{1} = 17.5\text{mA}$$

$$\boxed{i_A = 10 + 7.5e^{-10^8 t/10^3} = 10 + 7.5e^{-10^5 t}\text{mA},\ t > 0,\ i_A = 2.5\text{mA}\ t < 0}$$

84.

(a) $i_{in}(-1.5) = \boxed{0}$

(b) $i_{in}(1.5) = \boxed{0}$

85.

(a)

$$v_s = -12u(-t) + 24u(t)\text{V}$$

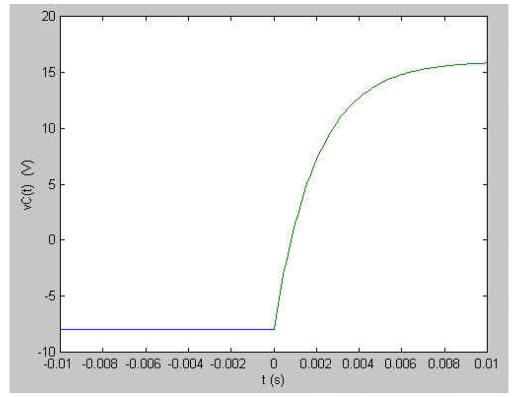
$$t<0:\ v_c(0^-) = -8\text{V} \therefore v_c(0^+) = -8\text{V}$$

$$t>0:\ v_c(\infty) = \frac{2}{3}\times 24 = 16\text{V}$$

$$\text{RC} = \frac{200}{30}\times 10^3 \times 3\times 10^{-7} = 2\times 10^{-3}$$

$$\therefore v_c(t) = 16 - 24e^{-500t}\text{V},\ t>0$$

$$\therefore \boxed{v_c(t) = -8u(-t) + (16-24e^{-500t})u(t)}$$

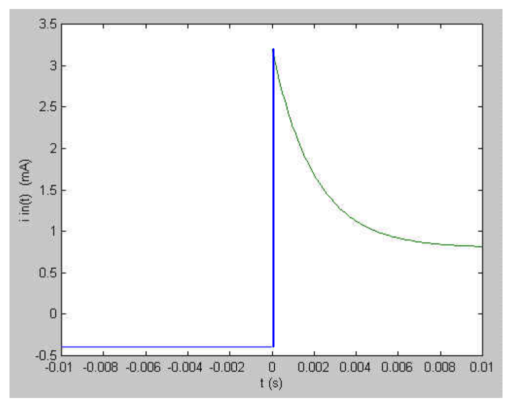



(b)

$$i_{in}(0^-) = \frac{-12}{30} = -0.4\text{mA},\ i_{in}(0^+) = \frac{24+8}{10} = 3.2\text{mA}$$

$$i_{in}(\infty) = \frac{24}{30} = 0.8\text{mA}$$

$$\boxed{i_{in}(t) = -0.4u(t) + (0.8 + 2.4e^{-500t})u(t)\text{mA}}$$



86. $$\text{OC}: \frac{-v_x}{100} - \frac{v_x}{100} + \frac{3 - v_x}{100} = 0 \therefore v_x = 1,\ v_{oc} = 3 - 1 = 2\text{V}$$

$$\text{SC}: v_x = 3\text{V} \therefore i_{sc} = \frac{v_x}{100} + \frac{v_x}{100} = 0.06\text{A}$$

$$\therefore \text{R}_{th} = v_{oc} / i_{sc} = 2 / 0.06 = 33.33\Omega$$

$$\therefore v_c = v_{oc}(1 - e^{-t/R_{th}C}) = 2(1 - e^{-10^6 t/33.33})$$

$$\boxed{= 2(1 - e^{-30,000t})\text{ V},\ t > 0}$$

87.

$$v_c(0^-) = 10\text{V} = v_c(0^+),\ i_{in}(0^-) = 0$$
$$i_{in}(0^+) = 0 \therefore i_{in}(t) = 0 \text{ for all } t$$

$$0 < t < 0.5s:\ v_c = 10(1 - e^{-2.5t})\text{V}$$
$$\boxed{v_c(0.4) = 6.321\text{V}},\ v_c(0.5) = 7.135\text{V}$$

$$t > 0.5:\ \frac{20-10}{12} = \frac{5}{6}\text{A} \therefore v_c(\infty) = 10 + 8 + \frac{5}{6} = \frac{50}{3}\text{V},\ 4\|8 = \frac{8}{3}\Omega$$
$$v_c(t) = \frac{50}{3} + \left(7.135 - \frac{50}{3}\right)e^{-0.375\times 20(t-0.5)} = 16.667 - 9.532e^{-7.5(t-0.5)}\text{V}$$
$$\therefore v_c(0.8) = 16.667 - 9.532e^{-7.5(0.3)} = \boxed{15.662\text{V}}$$

88.

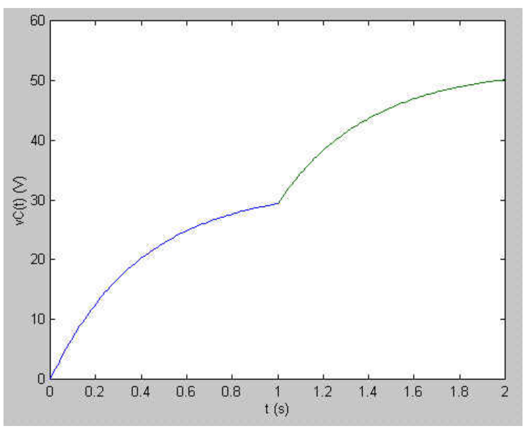
(a) For $t < 0$, there are no active sources, and so $\boxed{v_C = 0.}$

For $0 < t < 1$, only the 40-V source is active. $R_{th} = 5\text{k} \,||\, 20\text{ k} = 4\text{ k}\Omega$ and hence $\tau = R_{th}C = 0.4$ s. The "final" value (assuming no other source is ever added) is found by voltage division to be $v_C(\infty) = 40(20)/(20 + 5) = 32$ V. Thus, we may write $v_C(t) = 32 + [0 - 32]\, e^{-t/0.4}$ V $= \boxed{32(1 - e^{-2.5t}) \text{ V.}}$

For $t > 1$, we now have two sources operating, although the circuit time constant remains unchanged. We define a new time axis temporarily: $t' = t - 1$. Then $v_C(t' = 0^+) = v_C(t = 1) = 29.37$ V. This is the voltage across the capacitor when the second source kicks on. The new final voltage is found to be $v_C(\infty) = 40(20)/(20 + 5) + 100(5)/(20 + 5) = 52$ V.

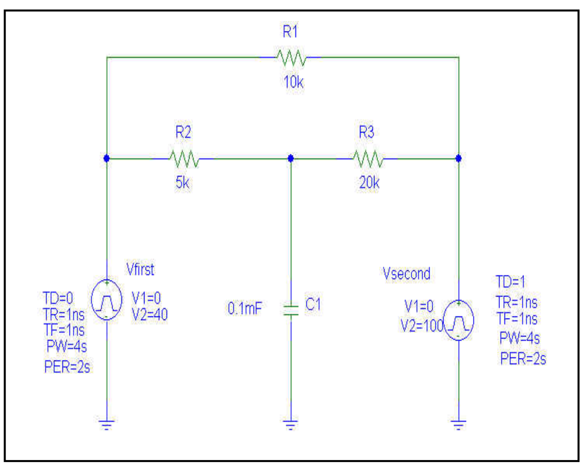
Thus, $v_C(t') = 52 + [29.37 - 52]\, e^{-2.5t'} = \boxed{52 - 22.63\, e^{-2.5(t-1)} \text{ V.}}$

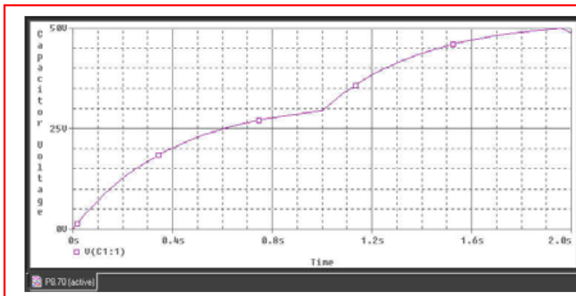
(b)




For $t < 0$, $v_C = 0$.

(c)



We see from the simulation results that our hand calculations and sketch are indeed correct.

89.

(a) $t<0:\ 8(10+20)=240\text{V}=\boxed{v_R(t)=80\text{V},\ t<0}$

(b) $t<0:\ v_c(t)=8\times 30=240\text{V}\ \therefore v_c(0^+)=240\text{V}$

$t=(\infty):\ v_c(\infty)=\dfrac{1}{2}\times 8\,(10+10)=80\text{V}$

$\therefore v_c(t)=80+160e^{-t/10\times10^{-6}}\ =80+160e^{-100000t}\text{V}$

$\therefore v_R(t)=\boxed{80+160e^{-100000t}\text{V},\ t>0}$

(c) $t<0:\ v_R(t)=\boxed{80\text{V}}$

(d) $v_c(0^-)=80\text{V},\ v_c(\infty)=240\text{V}\ \therefore v_c(t)=240-160e^{-t/50\times10^{-6}}\ =240-160e^{-20000t}\text{V}$

$v_R(0^-)=80\text{V},\ v_R(0^+)=8\dfrac{20}{30+20}\times10+\dfrac{80}{50}\times10=32+16=48\text{V}$

$v_R(\infty)=80\text{V}\ \therefore v_R(t)=\boxed{80-32e^{-20000t}\text{V},\ t>0}$

90. $t < 0: \ v_c = 0$

$0 < t < 1\text{ms}: v_c = 9(1 - e^{-10^6 t/(R_1+100)})$

$\therefore 8 = 9(1 - e^{-1000/(R_1+100)}), \ \frac{1}{9} = e^{-1000/(R_1+100)}$

$\therefore \frac{1000}{\text{R}_1 + 100} = 2.197, \ \text{R}_1 = \boxed{355.1\Omega}$

$t > 1\text{ms}: v_c = 8e^{-10^6 t'/(R_2+100)}, \ t' = t - 10^{-3} \ \therefore 1 - 8e^{-1000}(\text{R}_2 + 100)$

$\therefore \frac{1000}{\text{R}_2 + 100} = 2.079, \ \text{R}_2 = 480.9 - 100 = \boxed{380.9\Omega}$

91. $v_{x,L} = 200e^{-2000t}\text{V}$

$$v_{x,c} = 100(1 - e^{-1000t})\text{V}$$

$$v_x = v_{x,L} - v_{x,c} = 0$$

$$\therefore 200e^{-2000t} = 100 - 100e^{-1000t}$$

$$\therefore 100e^{-1000t} + 200(e^{-1000t})^2 - 100 = 0,$$

$$e^{-1000t} = \frac{-100 \pm \sqrt{10,000 + 80,000}}{400} = -0.25 \pm 0.75$$

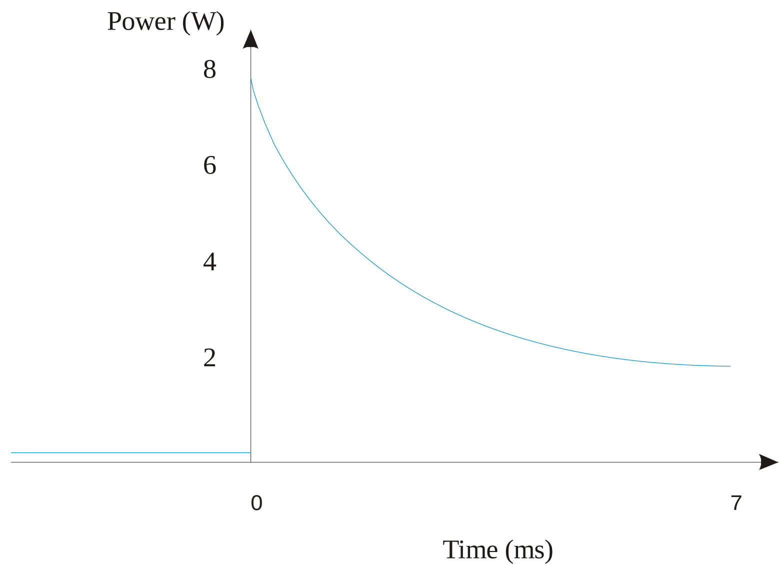
$$\therefore e^{-1000t} = 0.5,\ t = \boxed{0.6931\text{ms}}$$

92.

$$P(t<0) = I^2R = 0.001^2 \times 10^3 = 0.001\,\text{W}$$

$$V_{init} = I.R = 7\times10^{-3}\times900 = 6.3\,\text{V}$$
$$P_{init} = \frac{V^2}{R} = 0.08\,\text{W}$$

$$V_{final} = 7\times10^{-3}\times900\Omega//1000\Omega = 3.3\,\text{V}$$
$$P_{final} = \frac{V^2}{R} = 0.02\,\text{W}$$



93. For $t < 0$, the voltage across all three capacitors is simply 9 (4.7)/ 5.7 = 7.421 V. The circuit time constant is $\tau = RC = 4700\ (0.5455\times10^{-6}) = 2.564$ ms.

When the circuit was first constructed, we assume no energy was stored in any of the capacitors, and hence the voltage across each was zero. When the switch was closed, the capacitors began to charge according to ½ $Cv^2$. The capacitors charge with the same current flowing through each, so that by KCL we may write

$$C_1 \frac{dv_1}{dt} = C_2 \frac{dv_2}{dt} = C_3 \frac{dv_3}{dt}$$

With no initial energy stored, integration yields the relationship $C_1v_1 = C_2v_2 = C_3v_3$ throughout the charging (*i.e.* until the switch is eventually opened). Thus, just prior to the switch being thrown at what we now call $t = 0$, the total voltage across the capacitor string is 7.421 V, and the individual voltages may be found by solving:

$$\begin{aligned} v_1 + v_2 + v_3 &= 7.421 \\ 10^{-6}\, v_1 - 2\times10^{-6}\, v_2 &= 0 \\ 2\times10^{-6}\, v_2 - 3\times10^{-6}\, v_3 &= 0 \end{aligned}$$

so that $v_2 = 2.024$ V.

With the initial voltage across the 2-uF capacitor now known, we may write

$$v(t) = 2.024\, e^{-t/\,2.564\times10^{-3}} \text{ V}$$

(a) $v(t = 5.45 \text{ ms}) = \boxed{241.6 \text{ mV.}}$

(b) The voltage across the entire capacitor string can be written as $7.421\, e^{-t/\,2.564\times10^{-3}}$ V. Thus, the voltage across the 4.7-kΩ resistor at $t = 1.7$ ms = 3.824 V and the dissipated power is therefore $\boxed{3.111 \text{ mW.}}$

(c) Energy stored at $t = 0$ is ½ $Cv^2 = 0.5(0.5455\times10^{-6})(7.421)^2 = \boxed{15.02\ \mu\text{J.}}$

94. voltage follower $\therefore v_o(t) = v_2(t)$

$$v_2(t) = 1.25u(t)\text{V} = v_o(t)$$

$$v_x(t) = 1.25e^{-10^6/0.5\times 200}u(t)$$

$$= \boxed{1.25e^{-10{,}000t}\,u(t)\text{V}}$$

95. This is a voltage follower $\therefore v_o(t) = v_2(t)$, where $v_2(t)$ is defined at the non-inverting input. The time constant of the RC input circuit is 0.008(1000+250) = 10 s.

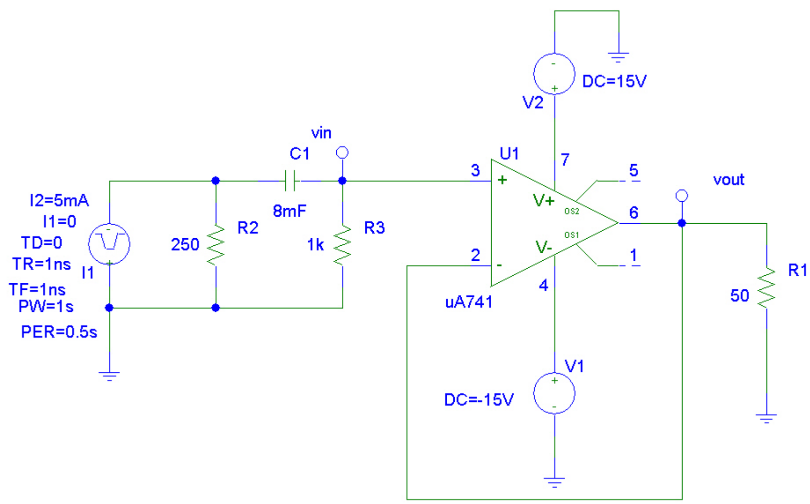
Considering initial conditions: $v_C(0^-) = 0 \therefore v_C(0^+) = 0$.
Applying KVL at $t = 0^+$,

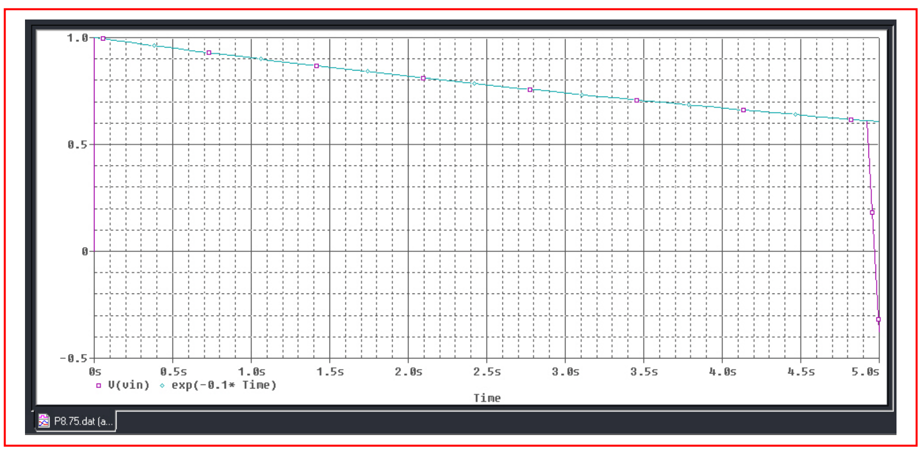
$$5 = v_{250}/250 + v_2/1000.$$

Since at $t = 0^+$ $v_{250} = v_2$, we find that $v_2(0^+) = 1$ V.
As $t \to \infty$, $v_2 \to 0$, so we may write,

$$v_o(t) = v_2(t) = \boxed{1.0e^{-t/10}\, u(t) \text{ V.}}$$

PSpice verification:

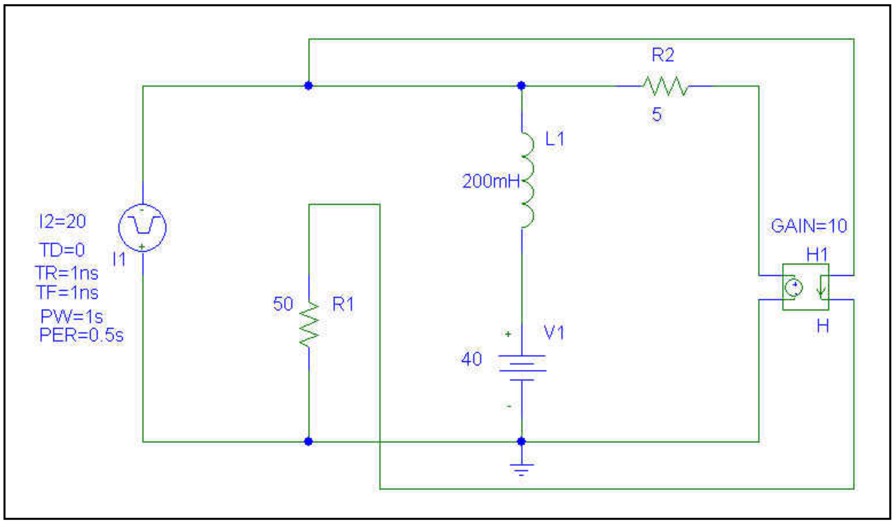


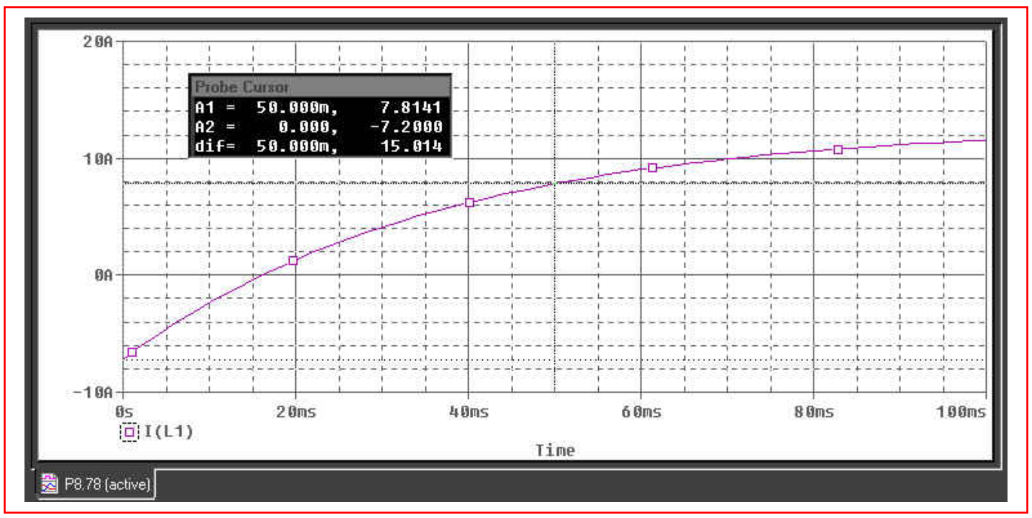




In plotting both the hand-derived result and the PSpice simulation result, we see that the ideal op amp approximation holds very well for this particular circuit. Although the 741 contains internal capacitors, it does not introduce any shorter time constants than that of the input circuit.

96. For $t < 0$, the current source is an open circuit and so $i_1 = 40/50 = 0.8$ A. The current through the 5-Ω resistor is $[40 - 10(0.8)]/5 = 7.2$ A, so the inductor current is equal to $\boxed{-7.2 \text{ A}}$

PSpice Simulation




From the PSpice simulation, we see that our $t < 0$ calculation is indeed correct, and find that the inductor current at $t = 50$ ms is $\boxed{7.82 \text{ A.}}$

97. (a) $v_1 = 0$ (virtual gnd) $\therefore i = \dfrac{4}{10^4} e^{-20,000t} u(t)\text{A}$

$$\therefore v_c = 10^7 \int_o^t \frac{4}{10^4} e^{-20,000t} dt = -0.2 e^{-20,000t} \Big|_o^t$$

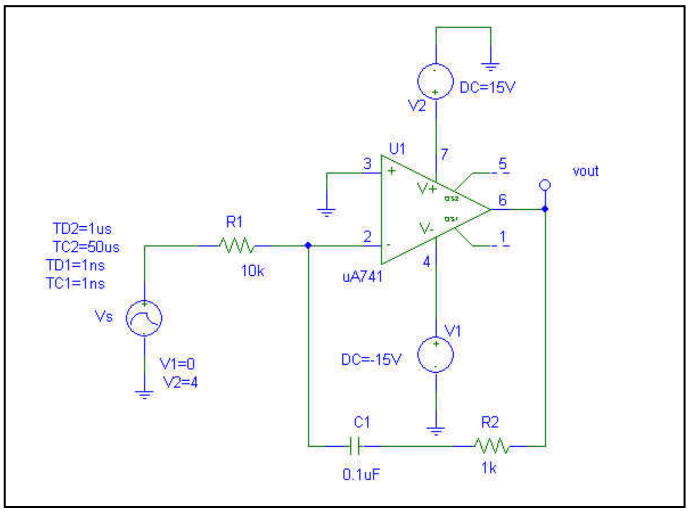
$$\therefore v_c(t) = 0.2(1 - e^{-20,000t}) u(t)$$

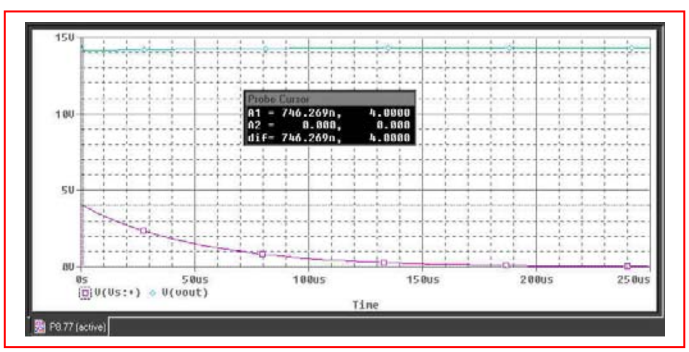
$$\therefore v_R(t) = 10^3\, i(t) = 0.4 e^{-20,000t} u(t)\text{V}$$

$$\therefore v_o(t) = -v_c(t) - v_R(t) = (-0.2 + 0.2e^{-20,000t} - 0.4e^{-20,000t}) u(t)$$

And we may write $\boxed{v_o(t) = -0.2[1 + e^{-20\times 10^3 t}]u(t) \text{ V.}}$

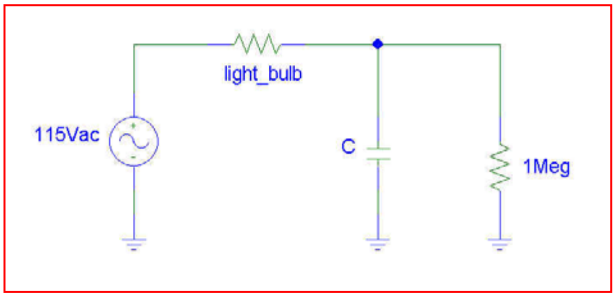
(b) PSpice verification:




We can see from the simulation result that our ideal op amp approximation is not providing a great deal of accuracy in modeling the transient response of an op amp in this particular circuit; the output was predicted to be negative for $t > 0$.

98. One possible solution of many: implement a capacitor to retain charge; assuming the light is left on long enough to fully charge the capacitor, the stored charge will run the lightbulb after the wall switch is turned off. Taking a 40-W light bulb connected to 115 V, we estimate the resistance of the light bulb (which changes with its temperature) as 330.6 Ω. We define "on" for the light bulb somewhat arbitrarily as 50% intensity, taking intensity as proportional to the dissipated power. Thus, we need at least 20 W (246 mA or 81.33 V) to the light bulb for 5 seconds after the light switch is turned off.




The circuit above contains a 1-MΩ resistor in parallel with the capacitor to allow current to flow through the light bulb when the light switch is on. In order to determine the required capacitor size, we first recognise that it will see a Thevenin equivalent resistance of 1 MΩ || 330.6 Ω = 330.5 Ω. We want $v_C(t = 5\text{s}) = 81.33 = 115e^{-5/\tau}$, so we need a circuit time constant of $t$ = 14.43 s and a capacitor value of $\tau / R_{th} = \boxed{43.67 \text{ mF.}}$

99. Assume at least 1 μA required otherwise alarm triggers.

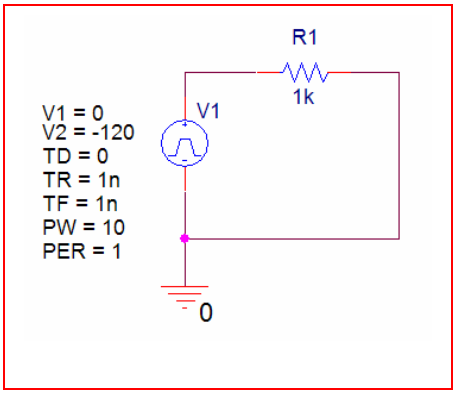
Add capacitor C.

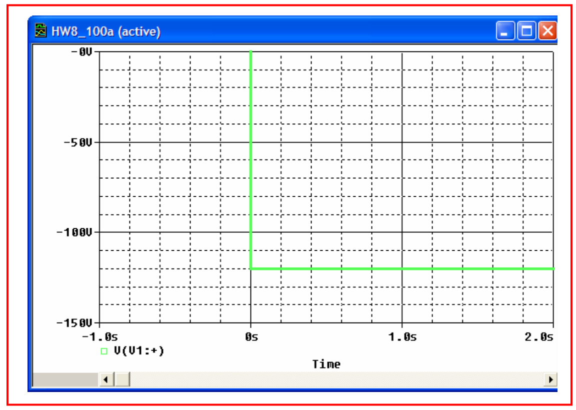
$$v_c(1) = 1 \text{ volt}$$

$$v_c(0) = \frac{1000}{1002.37}.1.5 = 1.496 \text{ volts}$$

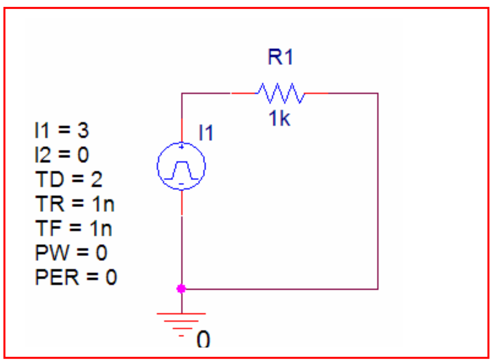
$$\therefore \text{ We have } 1 = 1.496e^{-\frac{1}{10^6 C}} \quad \text{or} \quad C = \frac{1}{10^6 \ell n(1.496)} = \boxed{2.48\mu\text{F}}$$

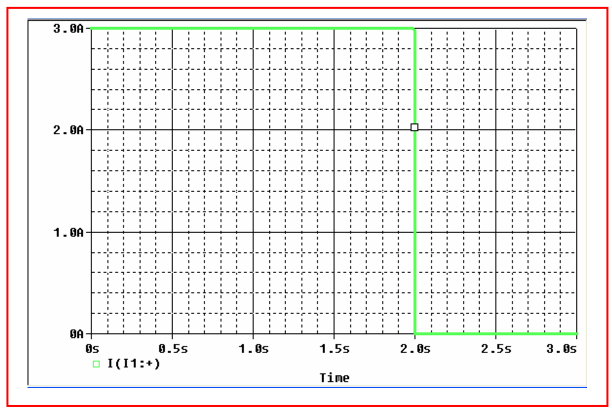
100. (a) Note that negative times are not permitted in PSpice. The only way to model this situation is to shift the time axis by a fixed amount, e.g., $t' = t + 1$.



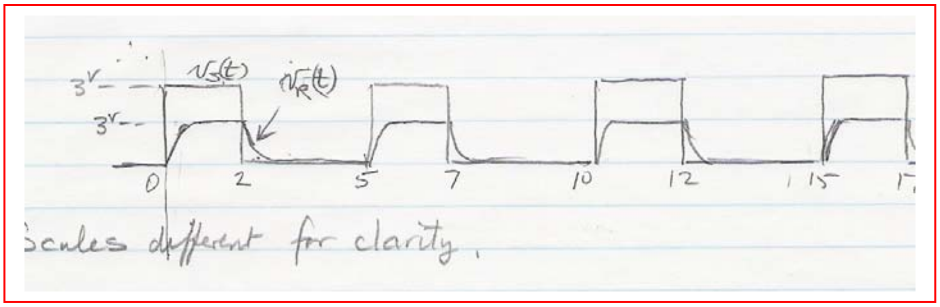




(b) Negative times are not permitted in PSpice. The only way to model this situation is to shift the time axis by a fixed amount, e.g., $t' = t + 2$ .

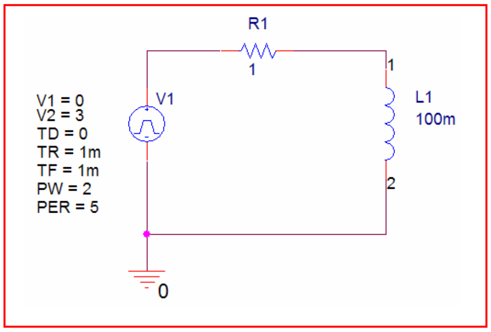


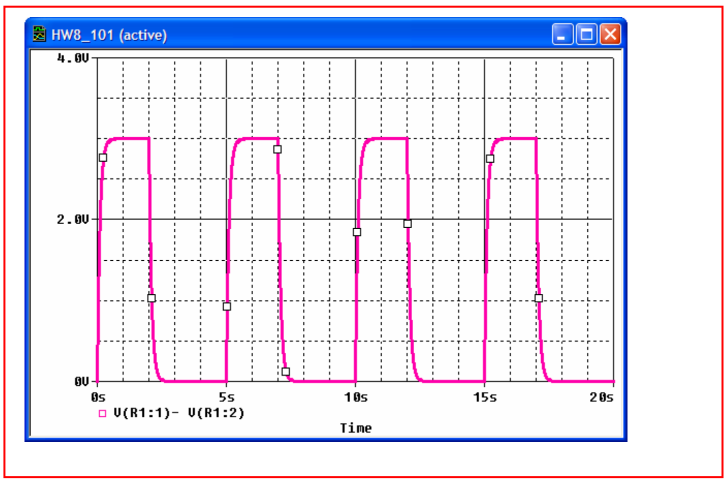



101. (a) $\tau = L / R = 0.1$ s. This is much less than either the period or pulsewidth.

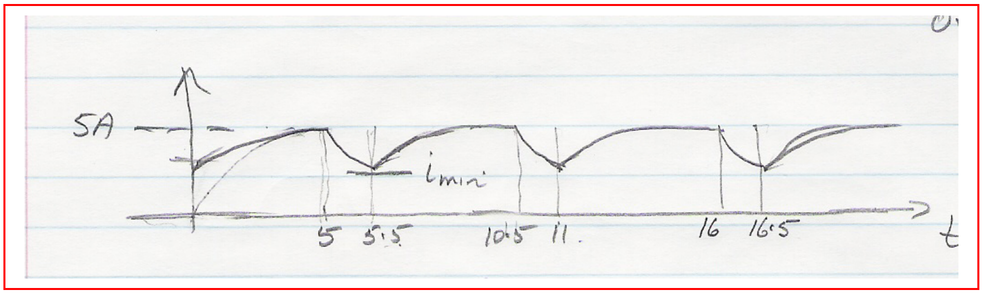



(b)

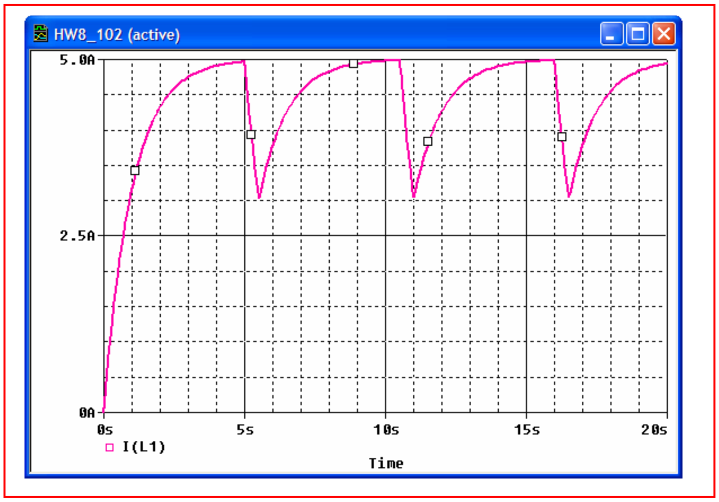


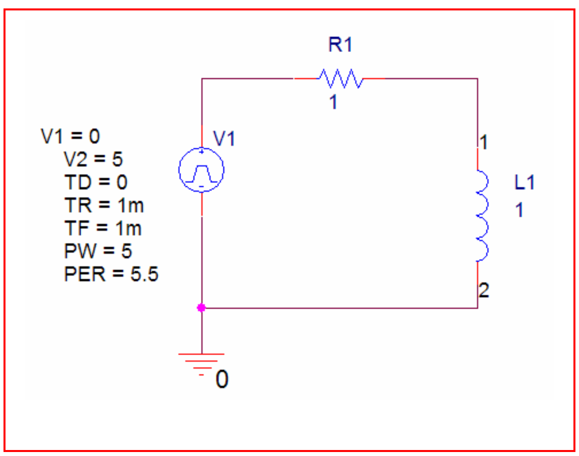



102. (a) $\tau = L / R = 1$ s. This is much less than either the period or pulsewidth.



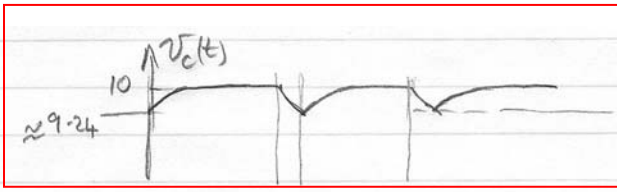

(b)



103.

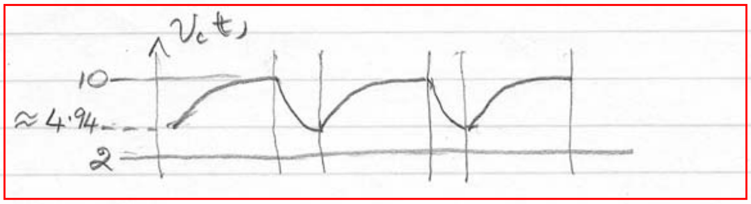
(a) 0.1 RC



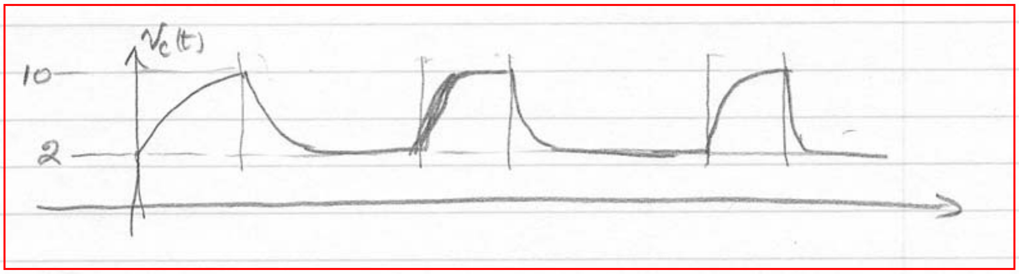

$\approx 2 + 8e^{-0.1}$

$\approx 9.24.$

(b) RC



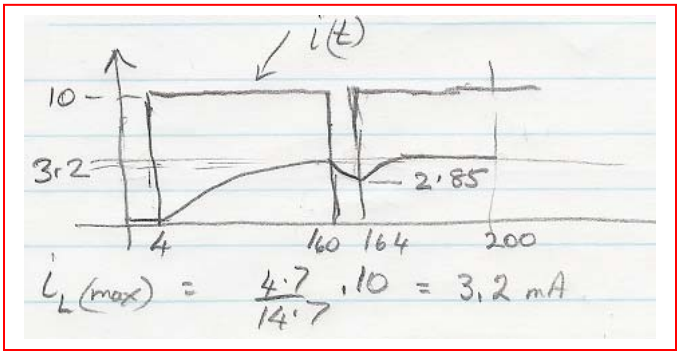

(c) 10RC



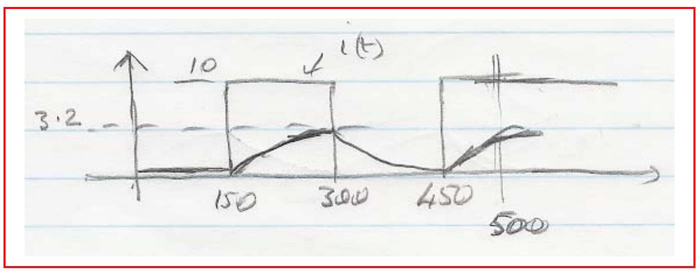
104. $\tau = \dfrac{L}{R_{eq}} = \dfrac{500\times10^{-6}}{14.7\times10^{3}} = 34\text{ ns}$

The transient response will therefore have the form $Ae^{-29.4\times10^{6}t}$.

(a)




(b)




(c)