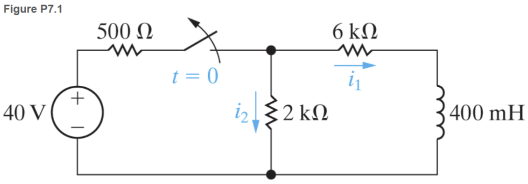
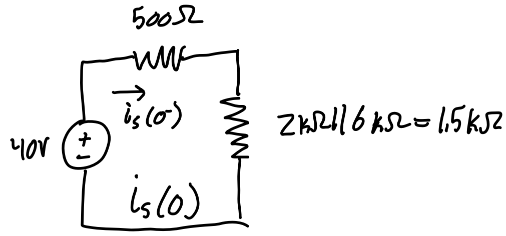
7.1 PSPICE MULTISIM The switch in the circuit in Fig. P 7.1 has been closed for a long time before opening at $t = 0$.

Figure P7.1





a) Find $i_1(0^-)$ and $i_2(0^-)$.
b) Find $i_1(0^+)$ and $i_2(0^+)$.
c) Find $i_1(t)$ for $t \geq 0$.
d) Find $i_2(t)$ for $t \geq 0^+$.
e) Explain why $i_2(0^-) \neq i_2(0^+)$.

$$i_s = \frac{40}{2K} = 20mA$$

a) $$\boxed{\begin{aligned} i_1(0^-) &= \frac{2K}{2K+6K}(20mA) = 5mA \\ i_2(0^-) &= \frac{6K}{2K+6K}(20mA) = 15mA \end{aligned}}$$

b) $$\boxed{\begin{aligned} i_1(0^+) &= i_1(0^-) = 5mA \\ i_2(0^+) &= -i_1(0^+) = -5mA \end{aligned}}$$

c) $$\tau = \frac{L}{R} = \frac{400mH}{8K\Omega}$$

$$\tau = 5\times10^{-5}\,sec$$

$$i_1(t) = 5e^{\frac{-t}{5\times10^{-5}}}\,mA$$

$$\boxed{i_1(t) = 5e^{-(20K)t}\,mA}$$

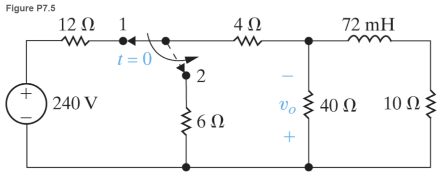
d) $$i_2(t) = -i_1(t)$$

$$\boxed{i_2(t) = -5e^{-(20K)t}\,mA}$$

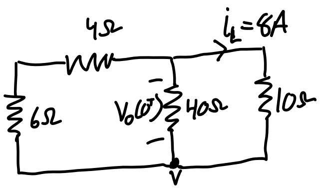
e) when the switch opens the current in the resistor changes instantly. befor the switch opent $i_2(0^-) = 15mA$ but after $i_2(0^+) = -5mA$

7.5 PSPICE MULTISIM The switch in the circuit in Fig. P 7.5 has been in position 1 for a long time. At $t = 0$, the switch moves instantaneously to position 2. Find $v_o(t)$ for $t \geq 0^+$.

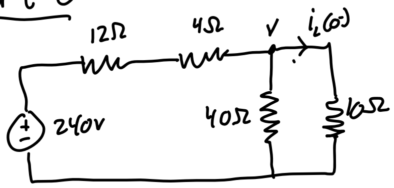
Figure P7.5



$$\tau = \frac{L}{R} = \frac{72mH}{18\Omega} = 4\,ms$$



for $t<0$



$$\frac{V-240}{16} + \frac{V}{40} + \frac{V}{10} = 0$$

$$V = 80V$$

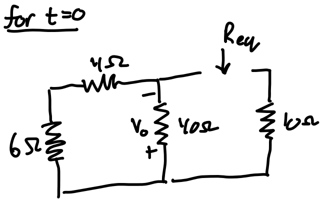
$$i_L(0^-) = \frac{80}{10} = 8A$$

KCL

$$\frac{V_o}{10} + \frac{V_o}{40} = 8A$$

$$V_o(0^+) = 64V$$

for $t=0$



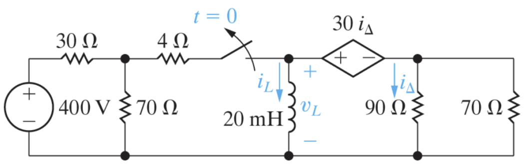
$$R_{eq} = (6+4)\|40 + 10 = 18\Omega$$

$$V_o = V_o(0^+)\,e^{-t/\tau}$$

$$\boxed{V_o = 64e^{-250t}\,V}$$

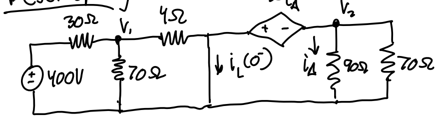
7.15 The switch in **Fig. P 7.15** has been closed for a long time before opening at $t = 0$. Find

Figure P7.15



a) $i_L(t), \quad t \geq 0.$
b) $v_L(t), \quad t \geq 0^+.$
c) $i_\Delta(t), \quad t \geq 0^+.$

Befor opening



$$\frac{V_1 - 400}{30} + \frac{V_1}{70} + \frac{V_1}{4} = 0$$

$$14(V_1 - 400) + 6V_1 + 105V_1 = 0$$

$$125 V_1 = 5600$$

$$V_1 = 44.8V$$

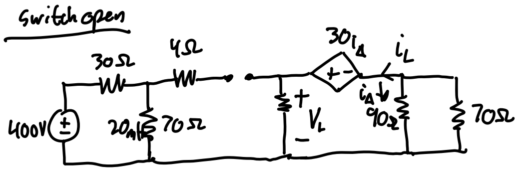
KVL

$$0 - 30 i_\Delta - 90 i_\Delta = 0$$

$$i_\Delta = 0$$

a) $\therefore \boxed{i_L(t) = \frac{V_1}{4} = 11.2\,A}$

Switch open



KVL

$$V_L - 30 i_\Delta - 90 i_\Delta = 0$$

$$V_L = 120 i_\Delta = L\frac{di_L}{dt} \leftarrow ①$$

$$i_L + i_\Delta + \frac{90 i_\Delta}{70} = 0$$

$$i_\Delta = \frac{-i_L}{2.28}$$

from ①

$$20\times10^{-3}\frac{di_\Delta}{dt} = 120\,\frac{-i_L}{2.28}$$

$$(20\times10^{-3}s + 52.63)\, i_\Delta = 0$$

$F(s) = 0$

$$20\times10^{-3}s + 52.63 = 0$$

$$s = -2.6\times10^{3}$$

$$\therefore i_L = i_L(0)e^{-2.6\times10^3 t}$$

$$V_L(t) = L\frac{di_L(t)}{dt} = 20\times10^{-3}\frac{d}{dt}(11.2\times e^{-2.6\times10^3 t})$$

$$V_L(t) = 20\times10^{-3}\times 11.2\times e^{-2.6\times10^3 t}\times(-2.6\times10^3)$$

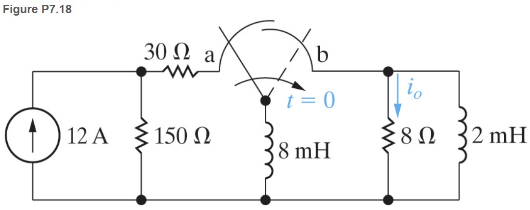
b) $\boxed{V_L(t) = -582.4\,e^{-2.6\times10^3 t}\,V}$

$$i_\Delta(t) = \frac{-i_L(t)}{2.28} = \frac{11.2\times e^{-2.6\times10^3 t}}{2.28}$$

c) $\boxed{i_\Delta(t) = -4.91\times e^{-2.6\times10^3 t}\,A}$

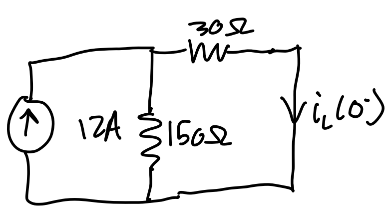
7.18 PSPICE MULTISIM In the circuit shown in **Fig. P 7.18**, the switch has been in position a for a long time. At $t = 0$, it moves instantaneously from a to b.

Figure P7.18



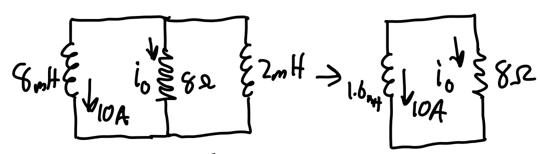
a) Find $i_o(t)$ for $t \geq 0$.

before opening



$$i_L(0^-) = \frac{150}{30+150}(12) = 10A$$

for $t \geq 0$



$$(8mH)\,\|\,(2mH) = 1.6mH$$

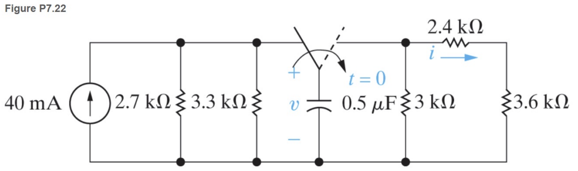
$$\tau = \frac{L}{R} = \frac{1.6\times10^{-3}}{8} = 200\times10^{-6}$$

$$\frac{1}{\tau} = 5000$$

$$\boxed{i_o = -10e^{-5000t}\,A}$$

7.22 The switch in the circuit in **Fig. P 7.22** has been in the left position for a long time. At $t = 0$ it moves to the right position and stays there.

Figure P7.22



a) Write the expression for the capacitor voltage, $v(t)$, for $t \geq 0$.

b) Write the expression for the current through the $40\ \mathrm{k\Omega}$ resistor, $i(t)$, for $t \geq 0^+$.

Initial voltage

$$V(0) = (40\times10^{-3})(1.485\times10^{3}) = 59.4\,V$$

$$\frac{1}{R} = \frac{1}{2.7} + \frac{1}{3.3} = 1.485$$

Req for cap

$$R_{eq} = 3k\Omega \,||\, (2.4+3.6)k\Omega = 2k\Omega$$

$$\tau = R_{eq}C = (2\times10^{3})(0.5\times10^{-6}) = 1.0\text{ ns}$$

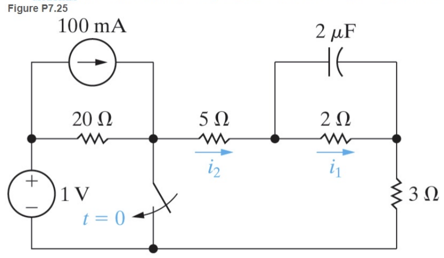
a) $\boxed{V(t) = V_0 e^{-\frac{t}{\tau}} = 59.4e^{-1000t}\,V}$

$$i(t) = \frac{v(t)}{R} = \frac{59.4e^{-1000t}}{(2.4+3.6)k}$$

b) $\boxed{i(t) = 9.9e^{-1000t}\,mA}$

7.25 PSPICE MULTISIM The switch in the circuit in **Fig. P 7.25** is closed at $t = 0$ after being open for a long time.

Figure P7.25



a) Find $i_1(0^-)$ and $i_2(0^-)$.

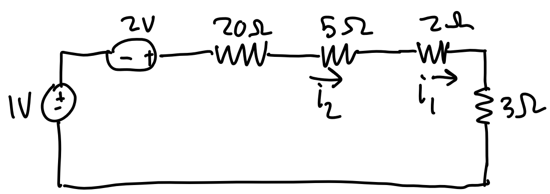
b) Find $i_1(0^+)$ and $i_2(0^+)$.

c) Explain why $i_1(0^-) = i_1(0^+)$.

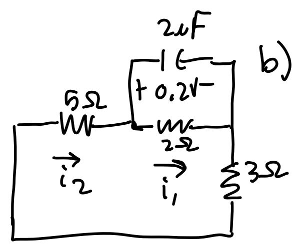
d) Explain why $i_2(0^-) \neq i_2(0^+)$.

e) Find $i_1(t)$ for $t \geq 0$.

f) Find $i_2(t)$ for $t \geq 0^+$.



a) $\boxed{i_1(0^-) = i_2(0^-) = \frac{V}{R} = \frac{3V}{30\Omega} = 100mA}$



b) $\boxed{\begin{aligned} i_1(0^+) &= \frac{0.2}{2} = 100mA \\ i_2(0^+) &= \frac{-0.2}{8} = -25mA \end{aligned}}$

c) Since capacitors do not change voltages instantly $i_1(0^-) = i_1(0^+)$ for a certain amount of time

d) flipping a switch instantly changes the current running through a restive path

$$\tau = R_{eq}C = 1.6(2\times10^{-6}) = 3.2\,\mu s$$

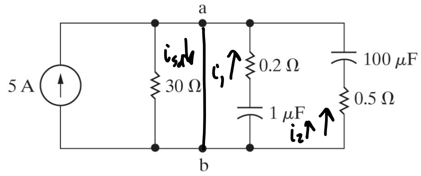
$$V_c = 0.2e^{-\frac{t}{\tau}} = 0.2e^{-312\times10^{3}t}\,V$$

e) $\boxed{i_1 = \frac{V_c}{2} = 0.1e^{-312\times10^{3}t}\,A}$

f) $\boxed{i_2 = \frac{-V_c}{8} = -25e^{-312\times10^{3}t}\,mA}$

7.34 PSPICE MULTISIM After the circuit in **Fig. P 7.34** has been in operation for a long time, a screwdriver is inadvertently connected across the terminals a, b. Assume the resistance of the screwdriver is negligible.

Figure P7.34



a) Find the current in the screwdriver at $t = 0^+$ and $t = \infty$.

b) Derive the expression for the current in the screwdriver for $t \geq 0^+$.

$$V = (5A)(30\Omega) = 150V$$

a) $$\boxed{\begin{array}{l} i_{sd}(0^+) = 5 + \frac{150}{0.2} + \frac{150}{0.5} = 1.055 \times 10^3 mA \\ i_{sd}(\infty) = 5A \end{array}}$$

$$i_{sd}(t) = 5 + i_1(t) + i_2(t)$$

$$\tau_1 = 0.2(10^{-6}) = 0.2\,\mu s$$

$$\tau_2 = 0.5 \times (100 \times 10^{-6}) = 50\,\mu s$$

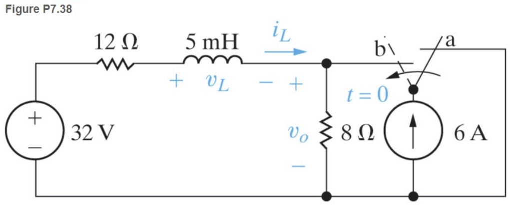
$$i_1 = \frac{150}{0.2} e^{-5\times10^6 t} = 750 e^{-5\times10^6 t} A$$

$$i_2 = \frac{150}{0.5} e^{-20000t} = 300 e^{-20{,}000t} A$$

b) $$\boxed{i_{sd} = 5 + 750 e^{-5\times10^6 t} + 300 e^{-20\times10^3 t} A}$$

7.38 PSPICE MULTISIM The switch in the circuit shown in **Fig. P 7.38** has been in position a for a long time before moving to position b at $t = 0$.

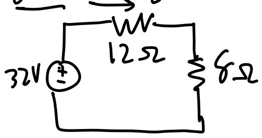
Figure P7.38



a) Find the numerical expressions for $i_L(t)$ and $v_o(t)$ for $t \geq 0$.

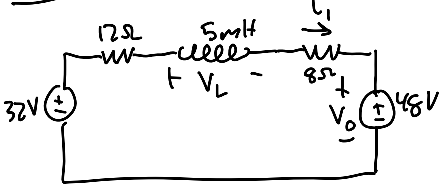
b) Find the numerical values of $v_L(0^+)$ and $v_o(0^+)$.

$t < 0$



$$i_L(0^-) = \frac{32}{20} = 1.6A$$

$t \geq 0$



$$i_L(\infty) = \frac{32-48}{20} = -0.8A$$

$$\tau = \frac{L}{R} = \frac{5\times10^{-3}}{20} = 250\,\mu s$$

$$i_L(t) = -0.8 + 1.6e^{-4000t} + 0.8e^{-4000t}$$

a.1) $$\boxed{i_L(t) = -0.8 + 2.4e^{-4000t} A}$$

$$V_o = 8 i_L + 48$$

$$V_o(t) = 8(-0.8 + 2.4e^{-4000t}) + 48$$

a.2) $$\boxed{V_o(t) = 41.6 + 19.2e^{-4000t} V}$$

$$V_L = L\frac{di_L}{dt} = (5\times10^{-3})(-4\times10^3)(2.4e^{-4000t})$$
$$= -48e^{-4000t} V$$

b.1) $$\boxed{V_L(0^+) = -48}$$

$$V_o(0^+) = 48 + (8)(1.6)$$

b.2) $$\boxed{V_o(0^+) = 60.8V}$$