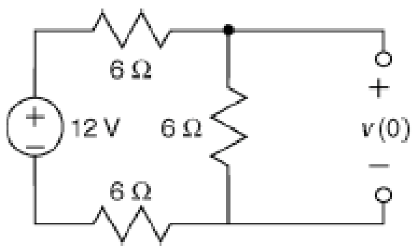
P8.3-1

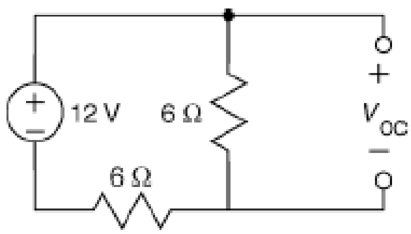


Here is the circuit before $t = 0$, when the switch is open and the circuit is at steady state. The open switch is modeled as an open circuit.

A capacitor in a steady-state dc circuit acts like an open circuit, so an open circuit replaces the capacitor. The voltage across that open circuit is the initial capacitor voltage, $v(0)$.

By voltage division

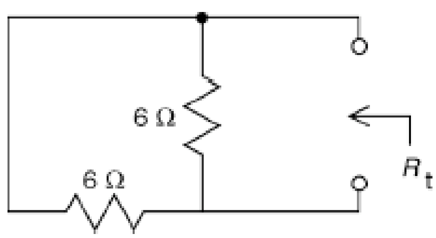
$$v(0) = \frac{6}{6+6+6}(12) = 4 \text{ V}$$



Next, consider the circuit after the switch closes. The closed switch is modeled as a short circuit.

We need to find the Thevenin equivalent of the part of the circuit connected to the capacitor. Here's the circuit used to calculate the open circuit voltage, V_{oc}.

$$V_{oc} = \frac{6}{6+6}(12) = 6 \text{ V}$$



Here is the circuit that is used to determine R_t. A short circuit has replaced the closed switch. Independent sources are set to zero when calculating R_t, so the voltage source has been replaced by a short circuit.

$$R_t = \frac{(6)(6)}{6+6} = 3 \ \Omega$$

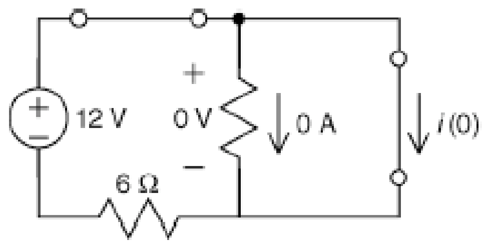
Then

$$\tau = R_t\, C = 3(0.25) = 0.75 \text{ s}$$

Finally,

$$v(t) = V_{oc} + \left(v(0) - V_{oc}\right) e^{-t/\tau} = 6 - 2\, e^{-1.33\, t} \text{ V} \quad \text{for } t > 0$$

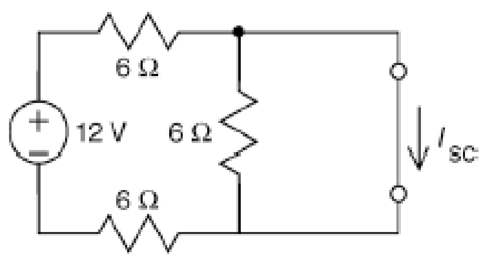
P8.3-2



Here is the circuit before $t = 0$, when the switch is closed and the circuit is at steady state. The closed switch is modeled as a short circuit.

An inductor in a steady-state dc circuit acts like an short circuit, so a short circuit replaces the inductor. The current in that short circuit is the initial inductor current, $i(0)$.

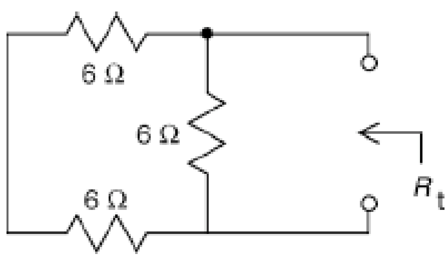
$$i(0) = \frac{12}{6} = 2 \text{ A}$$



Next, consider the circuit after the switch opens. The open switch is modeled as an open circuit.

We need to find the Norton equivalent of the part of the circuit connected to the inductor. Here's the circuit used to calculate the short circuit current, I_{sc}.

$$I_{sc} = \frac{12}{6+6} = 1 \text{ A}$$



Here is the circuit that is used to determine R_t. An open circuit has replaced the open switch. Independent sources are set to zero when calculating R_t, so the voltage source has been replaced by an short circuit.

$$R_t = \frac{(6+6)(6)}{(6+6)+6} = 4 \ \Omega$$

Then

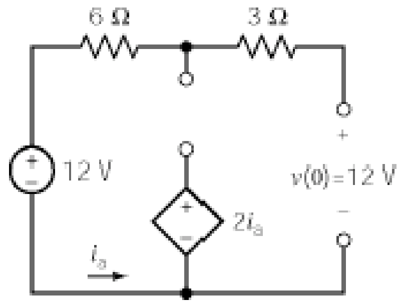
$$\tau = \frac{L}{R_t} = \frac{8}{4} = 2 \text{ s}$$

Finally,

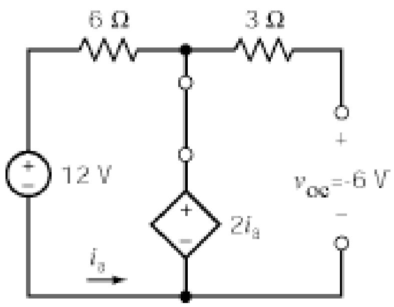
$$i(t) = I_{sc} + \left(i(0) - I_{sc}\right)e^{-t/\tau} = 1 + e^{-0.5\,t} \text{ A} \quad \text{for } t > 0$$

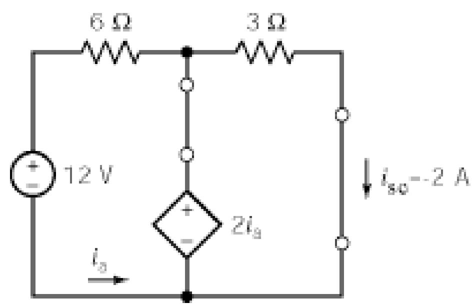
P8.3-3

Before the switch closes:



After the switch closes:



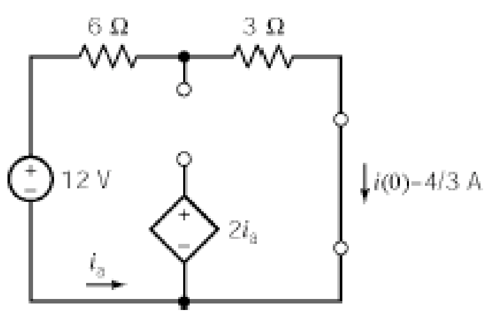


Therefore $R_t = \dfrac{-6}{-2} = 3\ \Omega$ so $\tau = 3(0.05) = 0.15$ s.

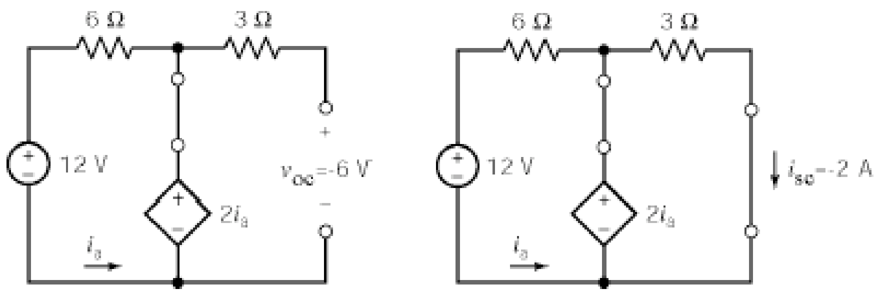
Finally, $v(t) = v_{oc} + (v(0) - v_{oc})\, e^{-t/\tau} = -6 + 18\, e^{-6.67t}$ V for $t > 0$

P8.3-4

Before the switch closes:



After the switch closes:

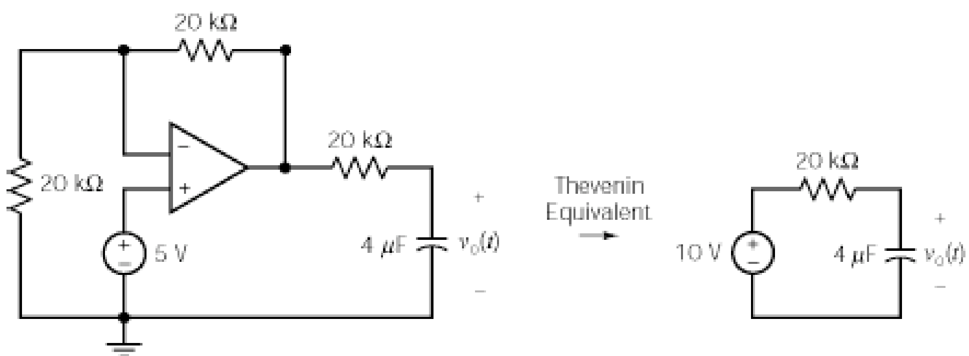


Therefore $R_t = \frac{-6}{-2} = 3\ \Omega$ so $\tau = \frac{6}{3} = 2$ s.

Finally, $i(t) = i_{sc} + (i(0) - i_{sc})\, e^{-\frac{t}{\tau}} = -2 + \frac{10}{3} e^{-0.5t}$ A for $t > 0$

P8.3-5

Before the switch opens, $v_o(t) = 5$ V $\Rightarrow v_o(0) = 5$ V. After the switch opens the part of the circuit connected to the capacitor can be replaced by it's Thevenin equivalent circuit to get:



Therefore $\tau = (20 \times 10^3)(4 \times 10^{-6}) = 0.08$ s.

Next, $v_C(t) = v_{oc} + (v(0) - v_{oc})\, e^{-\frac{t}{\tau}} = 10 - 5\, e^{-12.5t}$ V for $t > 0$

Finally, $v_0(t) = v_C(t) = 10 - 5\, e^{-12.5t}$ V for $t > 0$

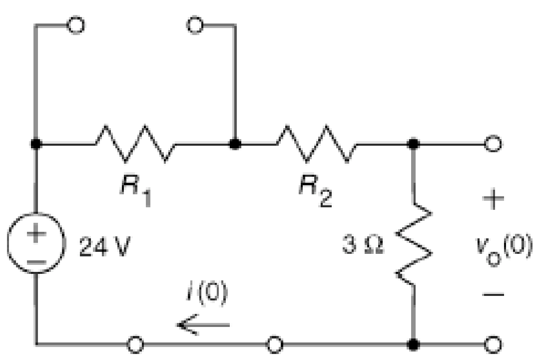
P8.3-9:

Before the switch closes, the circuit will be at steady state. Because the only input to this circuit is the constant voltage of the voltage source, all of the element currents and voltages, including the inductor current, will have constant values. Closing the switch disturbs the circuit by shorting out the resistor R_1. Eventually the disturbance dies out and the circuit is again at steady state. All the element currents and voltages will again have constant values, but probably different constant values than they had before the switch closed.

The inductor current is equal to the current in the 3 Ω resistor. Consequently,

$$i(t) = \frac{v_o(t)}{3} = \frac{6 - 3\,e^{-0.35\,t}}{3} = 2 - e^{-0.35\,t} \text{ A when } t > 0$$

In the absence of unbounded voltages, the current in any inductor is continuous. Consequently, the value of the inductor current immediately before $t = 0$ is equal to the value immediately after $t = 0$.



Here is the circuit before $t = 0$, when the switch is open and the circuit is at steady state. The open switch is modeled as an open circuit. An inductor in a steady-state dc circuit acts like a short circuit, so a short circuit replaces the inductor. The current in that short circuit is the steady state inductor current, $i(0)$. Apply KVL to the loop to get

$$R_1\, i(0) + R_2\, i(0) + 3\, i(0) - 24 = 0$$

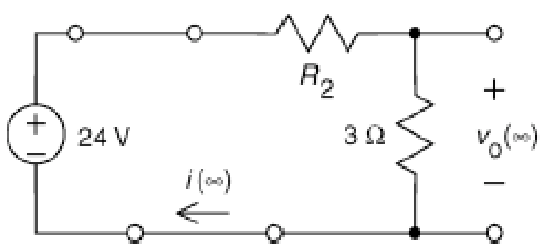
$$\Rightarrow \quad i(0) = \frac{24}{R_1 + R_2 + 3}$$

The value of $i(0)$ can also be obtained by setting $t = 0$ in the equation for $i(t)$. Do so gives

$$i(0) = 2 - e^{0} = 1 \text{ A}$$

Consequently,

$$1 = \frac{24}{R_1 + R_2 + 3} \quad \Rightarrow \quad R_1 + R_2 = 21$$



Next, consider the circuit after the switch closes. Here is the circuit at $t = \infty$, when the switch is closed and the circuit is at steady state. The closed switch is modeled as a short circuit. The combination of resistor and a short circuit connected is equivalent to a short circuit. Consequently, a short circuit replaces the switch and the resistor R_1.

An inductor in a steady-state dc circuit acts like a short circuit, so a short circuit replaces the inductor. The current in that short circuit is the steady state inductor current, $i(\infty)$. Apply KVL to the loop to get

$$R_2\, i(\infty) + 3\, i(\infty) - 24 = 0 \quad \Rightarrow \quad i(\infty) = \frac{24}{R_2 + 3}$$

The value of $i(\infty)$ can also be obtained by setting $t = \infty$ in the equation for $i(t)$. Doing so gives

$$i(\infty) = 2 - e^{-\infty} = 2 \text{ A}$$

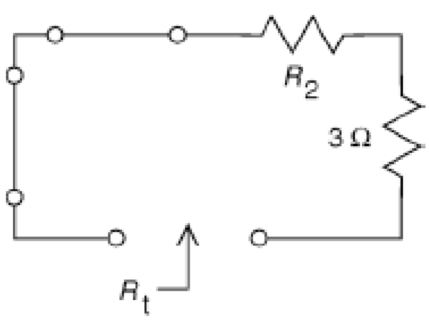
Consequently

$$2 = \frac{24}{R_2 + 3} \quad \Rightarrow \quad R_2 = 9 \ \Omega$$

Then

$$R_1 = 12 \ \Omega$$

Finally, the exponential part of $i(t)$ is known to be of the form $e^{-t/\tau}$ where $\tau = \frac{L}{R_t}$ and R_t is the Thevenin resistance of the part of the circuit that is connected to the inductor.



Here is shows the circuit that is used to determine R_t. A short circuit has replaced combination of resistor R_1 and the closed switch. Independent sources are set to zero when calculating R_t, so the voltage source has been replaced by an short circuit.

$$R_t = R_2 + 3 = 9 + 3 = 12 \ \Omega$$

so

$$\tau = \frac{L}{R_t} = \frac{L}{12}$$

From the equation for $i(t)$

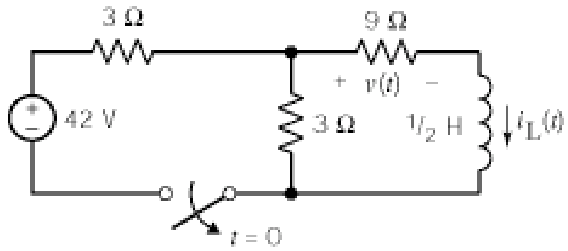
$$-0.35\, t = -\frac{t}{\tau} \quad \Rightarrow \quad \tau = 2.857 \text{ s}$$

Consequently,

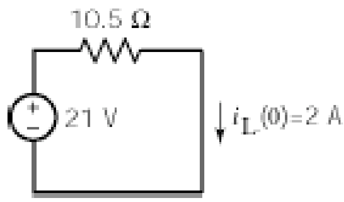
$$2.857 = \frac{L}{12} \quad \Rightarrow \quad L = 34.28 \text{ H}$$

P8.3-10

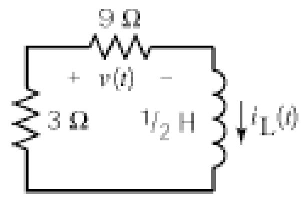
First, use source transformations to obtain the equivalent circuit



for $t < 0$:



for $t > 0$:



So $i_L(0) = 2$ A, $I_{sc} = 0$, $R_t = 3+9=12\ \Omega$, $\tau = \frac{L}{R_t} = \frac{\frac{1}{2}}{12} = \frac{1}{24}$ s

and $i_L(t) = 2e^{-24t} \quad t > 0$

Finally $v(t) = 9\, i_L(t) = 18\, e^{-24t} \quad t>0$