Problem 1: No matter what is asked, for RC circuit, always find capacitor voltage first. Need $v(0)$, $v(\infty)$ and $R_{eq}$ with respect to capacitor.

Find $v(0)$ from circuit before switch, i.e., $t < 0$

For $t > 0$, the switch is connected to position b

Find $v(\infty)$ as the capacitor voltage under DC condition. Also by voltage division:

$$v(\infty) = \frac{3}{3+6} \times 12 = 4V$$

To find $R_{eq}$ with respect to the capacitor, turn off voltage source with short circuit:

$$R_{eq} = \frac{3}{6} = 2\Omega$$

Now form the solution:

$$v(t) = v(\infty) + (v(0) - v(\infty))e^{-\frac{t}{R_{eq}C}}$$

$$= 4 + (7.5 - 4)e^{-\frac{t}{3}} = 4 + 3.5e^{-0.25t}V$$

Find $i(t)$ from $v(t)$ by the property of capacitor:

$$i(t) = C \frac{dv}{dt} = 2 \times (-0.25) \times 3.5e^{-0.25t}A = -1.75e^{-0.25t}A$$
Problem 2

For $t < 0$, $i_s(t) = 5u(t) = 0$. No power supply, $v(0) = 0V$

For $t > 0$, $i_s(t) = 5u(t) = 5A$

![Circuit Diagram]

To find $v(\infty)$, consider the above circuit under DC condition.

The voltage across $5A = 5 \times 6 / (2+2) = 5 \times 2.4 = 12V$

By voltage division: $v(\infty) = \frac{2}{2+2} \times 12 = 6V$

To find $R_{eq}$ with respect to capacitor, turn off 5A with open circuit.

$$R_{eq} = \frac{2}{2+6} = 1.6 \Omega, \quad \frac{1}{R_{eq}C} = \frac{1}{1.6\times0.25} = 2.5$$

$$v(t) = 6 + (0 - 6)e^{-\frac{t}{1.2}} = 6 - 6e^{-2.5t}V$$

Problem 3 (a)

For $t < 0$, under DC condition, inductor is short circuit.

By current division:

$$i(0) = \frac{4}{4+6} \times 3 = 1.2A$$

For $t > 0$, $R_{eq}$ with respect to inductor is: $R_{eq} = 6 + 4||12 = 9\Omega$

At $t = \infty$, under DC condition, inductor is also short circuit.

Also by current division:

$$i(\infty) = \frac{4||12}{4||12 + 6} \times 3 = 1A$$

Form the solution: $i(t) = 1 + (1.2 - 1)e^{-3t} = 1 + 0.2e^{-3t}A$
Problem 3 (b)

\[ i(0) = \frac{20}{4 + 6} = 2A \]

\[ i(\infty) = 9 \times \frac{3}{3 + 6} = 3A, \]

With respect to inductor, \( R_{eq} = 9\Omega \), \( \frac{R_{eq}}{C} = 4.5s \)

\[ i(t) = 3 + (2 - 3)e^{-4.5t} = 3 - e^{-4.5t}A \]

Problem 4: For RC circuit, always find capacitor voltage first. Need \( v(0), v(\infty), R_{eq} \)

For \( t < 0 \), capacitor open, the right side loop and the left side loop are not related:

\[ v_B = \frac{8}{8 + 4 + 8} \times 24 = 9.6V \]

\[ v_R = 1.2 \times 6 = 7.2V; \]

\[ v(0) = v_B - v_R = 9.6 - 7.2 = 2.4V \]

\[ v_B(t) = 6 \left( 1.2 + C \frac{dv}{dt} \right) = 6(1.2 + 0.05 \times (-14.4) \times (-1.11)) = 7.2 + 4.8e^{-1.11t}V \]

\[ v(t) = 16.8 + (2.4 - 16.8)e^{-1.11t}V \]

\[ = 16.8 - 14.4e^{-1.11t}V \]

\[ = 16.8 - 14.4e^{-1.11t}V \]

For \( t > 0 \), \( 8\Omega \) and \( 4\Omega \) are in parallel:

At \( t = \infty \), capacitor open, no current through \( 8\Omega \), \( 4\Omega \), \( v(\infty) = 24 - 1.2 \times 6 = 16.8V \)

With respect to capacitor,

\[ R_{eq} = 8 + 4 \times 6 = 18 \Omega \]

\[ \frac{1}{R_{eq}C} = \frac{1}{18 \times 0.05} = 1.11 \]

\[ v(t) = 16.8 + (2.4 - 16.8)e^{-1.11t} = 7.2 + 4.8e^{-1.11t}V \]
Problem 5

To find $i_0$, consider circuit for $t<0$, Treat inductor as short, use nodal analysis:

$$i_0 = \frac{v_x}{20} + \frac{v_x}{6}$$

For RL circuit, always find inductor current first

To find $i(t)$, consider circuit for $t<0$.

Treat inductor as short, use nodal analysis:

$$KCL at V_x: \quad 3 + \frac{10-v_x}{5} = \frac{v_x}{12} + \frac{v_x}{20} + \frac{v_x}{6}$$

$$v_x = 10V$$

$$i(x) = \frac{v_x}{6} = 1.667\ A$$

You may also find $i(x)$ by using source transformation.

$$i(t) = 0.8 + (1.667 - 0.8)e^{-20t}A = 0.8 + 0.867e^{-20t}A$$

$$v(t) = L \frac{di}{dt} = 0.5 \times 0.867 \times (-20)e^{-20t}V = -8.67e^{-20t}V$$

Problem 6

Find inductor current first.

For $t<0$, $v_x = 9u(t) = 0$.

No power supply, $i(0) = 0A$

At $t = \infty$, also treat inductor as short,

$$i(\infty) = \frac{10}{5+20} \times \frac{20}{20 + 6} = 0.8A,$$

With respect to inductor, $R_{eq} = 6 + 20||5\Omega = 10\Omega$

$$\frac{R_{eq}}{L} = \frac{10}{0.5} = 20\Omega$$

$$i(t) = 0.75 - 0.75e^{-6t}A$$

$$v_0(t) = L \frac{di}{dt} = 1.2 \times (-0.75) \times (-6)e^{-6t}V$$

$$v_0(t) = 5.4e^{-6t}u(t)V$$
**Problem 7**

For \( t < 0 \), \( 20 \ u(t) = 20 \text{V} \),

\[
\begin{align*}
\text{For } t < 0, & \quad \text{both } 2\Omega \text{ and } 3\Omega \text{ are short circuited: } i(0) = \frac{20}{4} = 5 \text{A} \\
\text{For } t > 0, & \quad \text{both } 2\Omega \text{ and } 3\Omega \text{ are short circuited: } i(\infty) = 0 \text{A} \\
\end{align*}
\]

With respect to inductor: \( R_{eq} = 4||12\Omega = 3\Omega \), \( \frac{R_{eq}}{L} = \frac{3}{0.5} = 6s \)

\[
\begin{align*}
i(t) &= 0 + (5 - 0)e^{-6t}A = 5e^{-6t}A \\
v(t) &= L \frac{di}{dt} = 0.5 \times 5 \times (-6)e^{-6t}V \\
v(t) &= -15e^{-6t}u(t)V
\end{align*}
\]

**Problem 8:** Find inductor current first. Need \( i(0), i(\infty), R_{eq} \)

For \( t < 0 \), both \( 2\Omega \) and \( 3\Omega \) are short circuited: \( i(0) = \frac{2}{3}A = 1.5A \),

At \( t = \infty \), inductor is short circuit, \( 2\Omega \) and \( 3\Omega \) are in parallel,

\[
i(\infty) = \frac{9}{6 + 3} \times \frac{3}{2 + 3}A = 0.75A, \]

For \( t > 0 \), with respect to inductor, \( R_{eq} = 2 + 3||6\Omega = 4\Omega \),

\[
\begin{align*}
i(t) &= 0.75 + (1.5 - 0.75)e^{-2t} = 0.75 + 0.75e^{-2t} \text{A} \\
v_0(t) &= L \frac{di}{dt} + 2i = 2 \times (-2) \times 0.75e^{-2t} + 2(0.75 + 0.75e^{-2t})V = 1.5 - 1.5e^{-2t}V
\end{align*}
\]