**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:

\[
R_{eq} = \frac{3}{6} \Omega = 0.5 \Omega
\]

Now form the solution:

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

\[
= 4 + (7.5 - 4)e^{-\frac{t}{0.5}} = 4 + 3.5e^{-0.25t}V
\]

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.

\[
R_{eq} = \frac{2}{(2+6)} = 1.6\Omega
\]

By current division:

\[
v(t) = 6 + (0 - 6)e^{-\frac{t}{0.4}} = 6 - 6e^{-2.5t}V
\]

Problem 3 (a)

![Circuit Diagram]

For \( t < 0 \), under DC condition, inductor is short circuit.
By current division:

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

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

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

For $t < 0$,
\[ i(0) = \frac{20}{4 + 6} = 2A \]

For $t > 0$,
\[ i(\infty) = 9 \times \frac{3}{3 + 6}A = 3A, \]
With respect to inductor, $R_{eq} = 9 \Omega$, $\frac{R_{eq} L}{C} = 4.5s$
\[ i(t) = 3 + (2 - 3)e^{-4.5t} = 3 - e^{-4.5t}A \]

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:
\[ v_B = \frac{8}{8 + 4 + 8} \times 24 = 9.6V \]
\[ v_R = 1.2 \times 6 = 7.2V; \]
\[ v(0) = v_B - v_R = 9.6 - 7.2 = 2.4V \]

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,
\[ R_{eq} = 8 + 4 + 6 = 18 \Omega \]
\[ \frac{1}{R_{eq}C} = \frac{1}{18 \times 0.05} = 1.11 \]
\[ v(t) = 16.8 + (2.4 - 16.8)e^{-1.11t}V = 16.8 - 14.4e^{-1.11t}V \]
\[ v_R(t) = 6 \left( 1.2 + \frac{C}{L} \frac{dv}{dt} \right) = 6 \left( 1.2 + 0.05 \times (-14.4) \times (-1.11)e^{-1.11t} \right) = 7.2 + 0.8e^{-1.11t}V \]
Problem 5

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

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

$$v_x = 10V$$

$$i(0) = \frac{v_x}{6} = 1.667A$$

You may also find $i(0)$ 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,

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

With respect to inductor, $R_{eq} = 6 + 2||5\Omega = 10\Omega$

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

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

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

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

For $t < 0$, $20u(t) = 20V$, 

For $t > 0$, $20u(t) = 0V$, 

\[ i(0) = \frac{20}{4} = 5A \]

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

\[ i(t) = 0 + (5 - 0)e^{-6t}A = 5e^{-6t}A \]

\[ v(t) = L \frac{di}{dt} = 0.5 \times 5 \times (-6)e^{-6t}V \]

\[ v(t) = -15e^{-6t}u(t)V \]

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: \( i(0) = \frac{9}{6}A = 1.5A \), 
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, \( R_{eq} = 2 + 3 || 6 \Omega = 4 \Omega \), 
\[ \frac{R_{eq}}{L} = \frac{4}{2} = 2s \]

\[ i(t) = 0.75 + (1.5 - 0.75)e^{-2t} = 0.75 + 0.75e^{-2t}A \]

\[ v_0(t) = L \frac{di}{dt} + 2i = 2 \times (-2) \times 0.75e^{-2t} + 2(0.75 + 0.75e^{-2t})V = 1.5 - 1.5e^{-2t}V \]