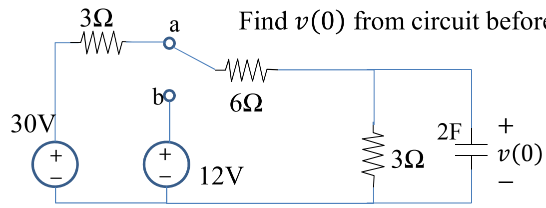
Problem 1: No matter what is asked, for RC circuit, always find capacitor voltage first. Need $v(0), v(\infty)$ and R_{eq} with respect to capacitor.

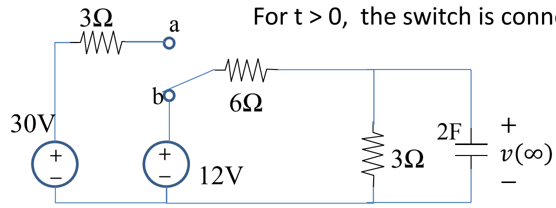
Find $v(0)$ from circuit before switch, i.e., t < 0



Treat capacitor as open circuit.
By voltage division:

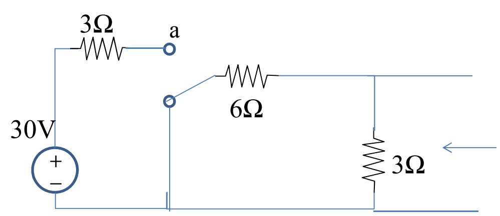
$$v(0) = 30 \times \frac{3}{3+6+3} = 7.5V$$

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:

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

Now form the solution: $\frac{1}{R_{eq}C} = \frac{1}{2\times 2} = \frac{1}{4}$

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

$$= 4 + (7.5 - 4)e^{-\frac{1}{4}t} = 4 + 3.5\,e^{-0.25t}V$$

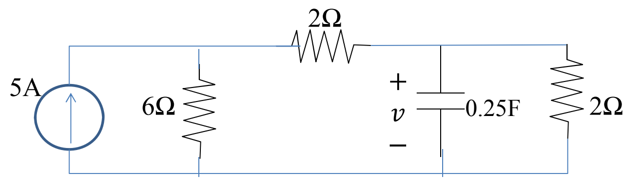
Find $i(t)$ from $v(t)$ by the property of capacitor:

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

Problem 2

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

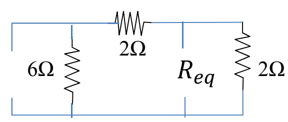
For t > 0 , $i_s(t) = 5u(t) = 5A$



To find $v(\infty)$, consider the above circuit under DC condition.
The voltage across 5A = 5 × 6 // (2+2) =5× 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.

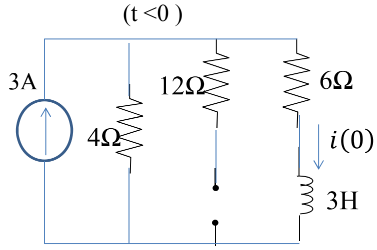
R_{eq} = 2// (2+6)= 1.6Ω , $\frac{1}{R_{eq} \times C} = \frac{1}{1.6 \times 0.25} = 2.5$



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

Problem 3 (a)

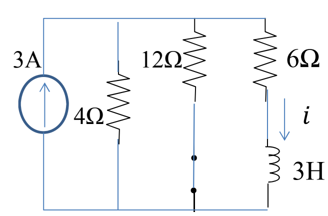
(t <0)



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

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

(t > 0)



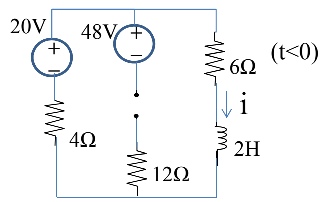
At $t = \infty$, under DC condition, inductor is also short circuit.
Also by current division:

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

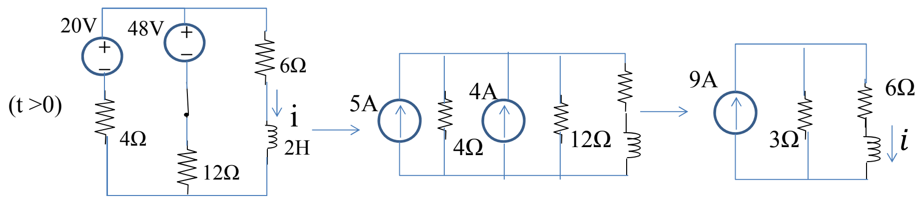
For t > 0, R_{eq} with respect to inductor is: $R_{eq} = 6 + 4||12 = 9\Omega$

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

Problem 3 (b)



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



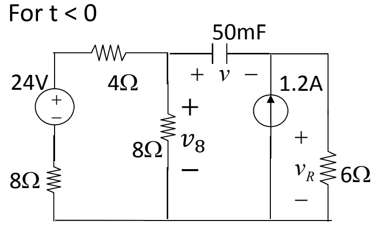
$$i(\infty) = 9 \times \frac{3}{3+6} A = 3A,$$

With respect to inductor, $R_{eq} = 9\Omega$, $\frac{R_{eq}}{L} = 4.5s$

$$i(t) = 3 + (2-3)e^{-4.5t} = 3 - e^{-4.5t} A$$

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

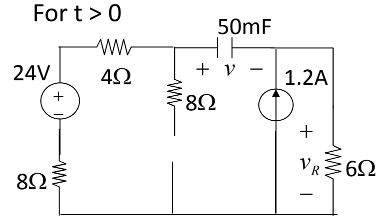
For t < 0



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

$$v_8 = \frac{8}{8+4+8} \times 24 = 9.6V$$
$$v_R = 1.2 \times 6 = 7.2V;$$
$$v(0) = v_8 - v_R = 9.6 - 7.2 = 2.4V$$

For t > 0



At $t = \infty$, capacitor open,
No current through 8Ω, 4Ω,

$$v(\infty) = 24 - 1.2 \times 6 = 16.8V$$

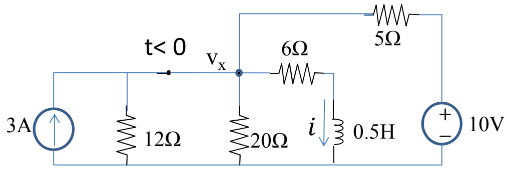
With respect to capacitor,

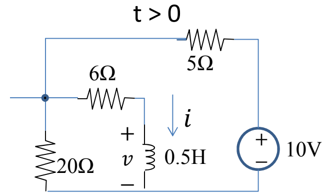
$$R_{eq} = 8 + 4 + 6 = 18\,\Omega$$
$$\frac{1}{R_{eq}C} = \frac{1}{18 \times 0.05} = 1.11$$

$$v(t) = 16.8 + (2.4 - 16.8)e^{-1.11t}V$$
$$= 16.8 - 14.4e^{-1.11t}V$$

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

Problem 5





For RL circuit, always find inductor current first

To find $i(0)$, consider circuit for t<0,
Treat inductor as short, use nodal analysis:
KCL at V_x, $3 + \frac{10-v_x}{5} = \frac{v_x}{12} + \frac{v_x}{20} + \frac{v_x}{6}$

v_x=10V

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

You may also find $i(0)$ by using source transformation.

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,

$R_{eq} = 6 + 20||5\Omega = 10\Omega$

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

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

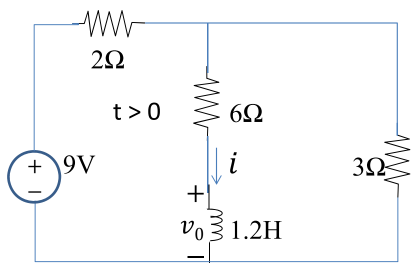
$$v(t) = L\frac{di}{dt} = 0.5 \times 0.867 \times (-20)e^{-20t}\text{V} = -8.67e^{-20t}V$$

Problem 6

Find inductor current first.

For t < 0, V_s= 9 u(t) = 0,
No power supply,

$i(0) = 0A$



At $t = \infty$, $i(\infty) = \frac{9}{2+6||3} \times \frac{3}{3+6}A = 0.75A$,

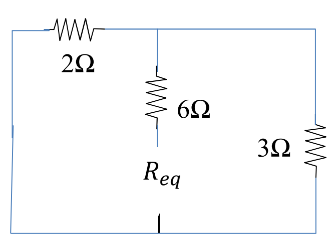
With respect to inductor, $R_{eq} = 6 + 2||3\Omega = 7.2\Omega$

$\frac{R_{eq}}{L} = \frac{7.2}{1.2} = 6s$

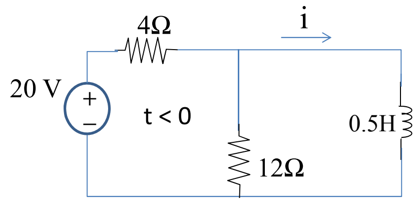
. $i(t) = 0.75 - 0.75e^{-6t}A$

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

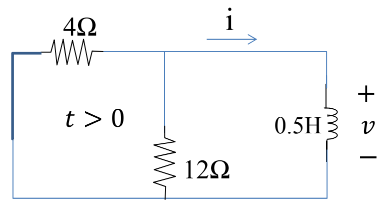
. $v_0(t) = 5.4e^{-6t}u(t)V$



Problem 7 For t < 0, 20 u(-t) =20V,



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



For t > 0, 20 u(-t) = 0V,
. $i(\infty) = 0A$

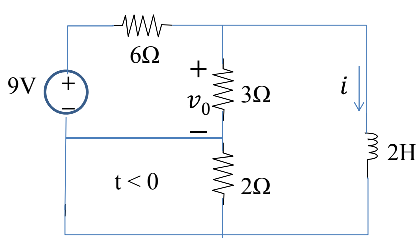
With respect to inductor: $R_{eq} = 4||12\Omega = 3\Omega$, $\frac{R_{eq}}{L} = \frac{3}{0.5} = 6s$

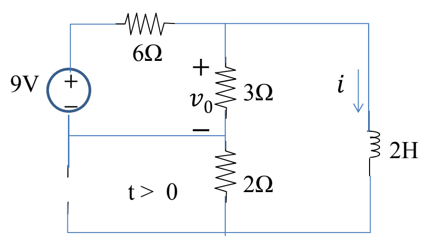
$$i(t) = 0 + (5-0)e^{-6t}A = 5e^{-6t}A$$

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

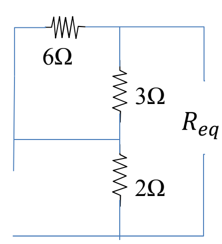
$$v(t) = -15e^{-6t}u(t)V$$

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





For t<0, both 2Ω *and* 3Ω are short circuited: $i(0) = \frac{9}{6}A = 1.5A$,
At $t = \infty$, inductor is short circuit, 2Ω and 3Ω are in parallel,
$i(\infty) = \frac{9}{6+3||2} \times \frac{3}{2+3}A = 0.75A$,
For t > 0, with respect to inductor, $R_{eq} = 2 + 3||6\ \Omega = 4\Omega$,
. $\frac{R_{eq}}{L} = \frac{4}{2} = 2s$



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

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