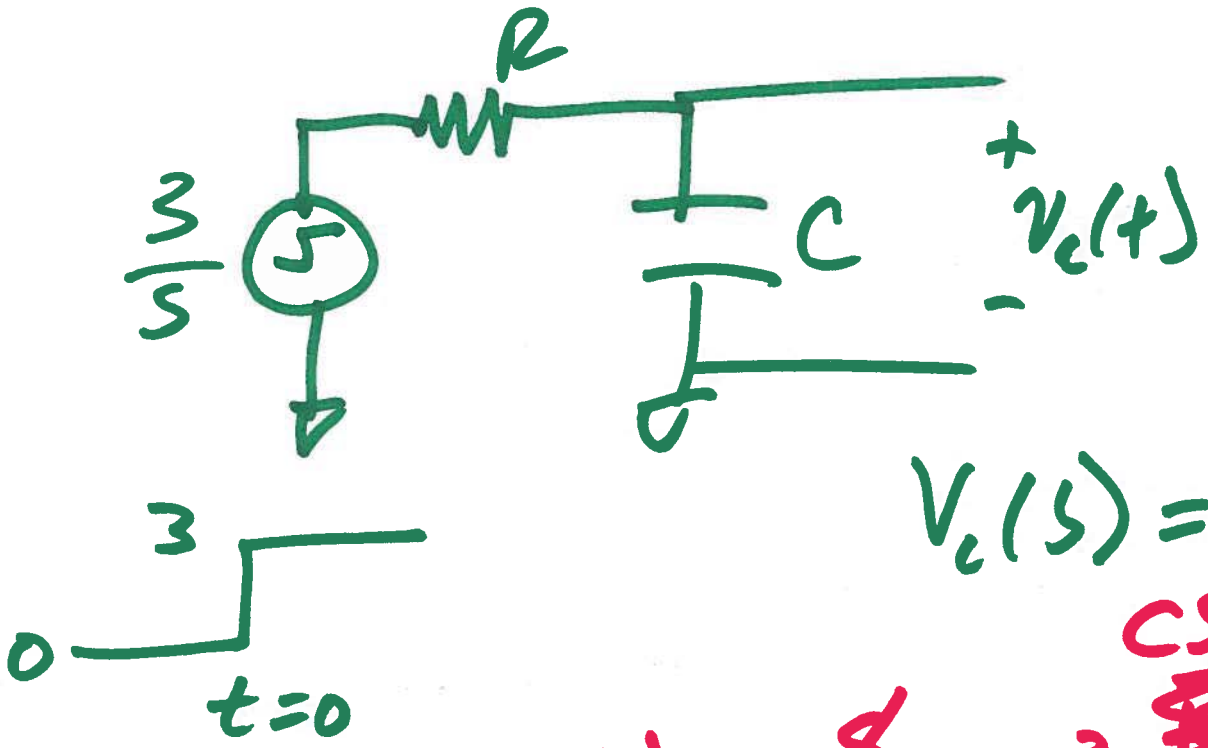
EE 221 Circuits II

April 17, 2019

Lecture 20

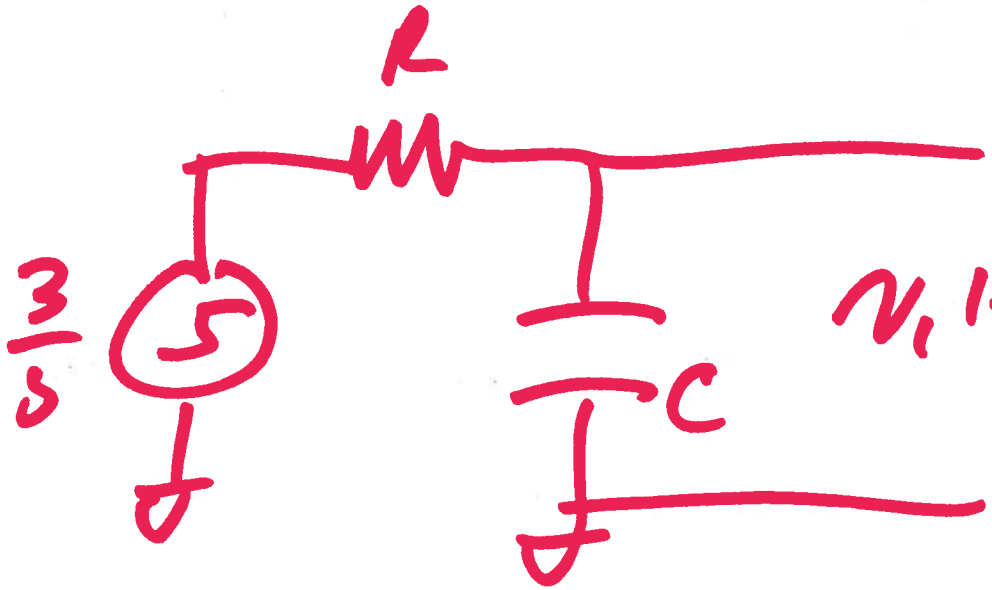


$$V_c(s) = \frac{CS\frac{1}{sC}}{CS\left(\frac{1}{sC}+R\right)} \cdot \frac{3}{s}$$

$$\frac{1}{1+sRC} \cdot \frac{3}{s}$$

$$\frac{\frac{1}{RC}}{\frac{1}{RC}+s} \cdot \frac{3}{s}$$

$$V_c(s) = \frac{\frac{1}{RC}}{s+\frac{1}{RC}} \cdot \frac{3}{s} \rightarrow 3 \cdot \frac{1}{s+\frac{1}{RC}}$$



$$V_1(s) = \frac{\frac{s}{R}\frac{1}{sC}}{\frac{s}{R}\left(\frac{1}{sC}+R\right)} \cdot \frac{3}{s}$$

$$= \frac{\frac{1}{RC}}{\frac{1}{RC}+s} \cdot \frac{3}{s}$$

$$= \frac{A}{s} + \frac{B}{s+\frac{1}{RC}}$$

2)

$$\not{s}\left(\frac{\frac{1}{RC}}{\frac{1}{RC}+s}\cdot\frac{3}{\not{s}}\right)=\frac{A}{\not{s}}\not{s}+\frac{B}{s+\frac{1}{RC}}\not{s}$$

$$A=\frac{\frac{1}{RC}\cdot 3}{\frac{1}{RC}+0}=\boxed{3=A}$$

$$\frac{1}{RC}+s\left(\frac{\frac{1}{RC}}{\not{\frac{1}{RC}}+s}\cdot\frac{3}{s}\right)=\left(\frac{A}{s}\cdot\frac{1}{RC}+s+\frac{B}{\not{s}+\frac{1}{RC}}\not{s}\right)\frac{1}{RC}+s$$

$$B=\frac{\frac{1}{RC}\cdot 3}{-\frac{1}{RC}}\Rightarrow\boxed{B=-3}$$

3)

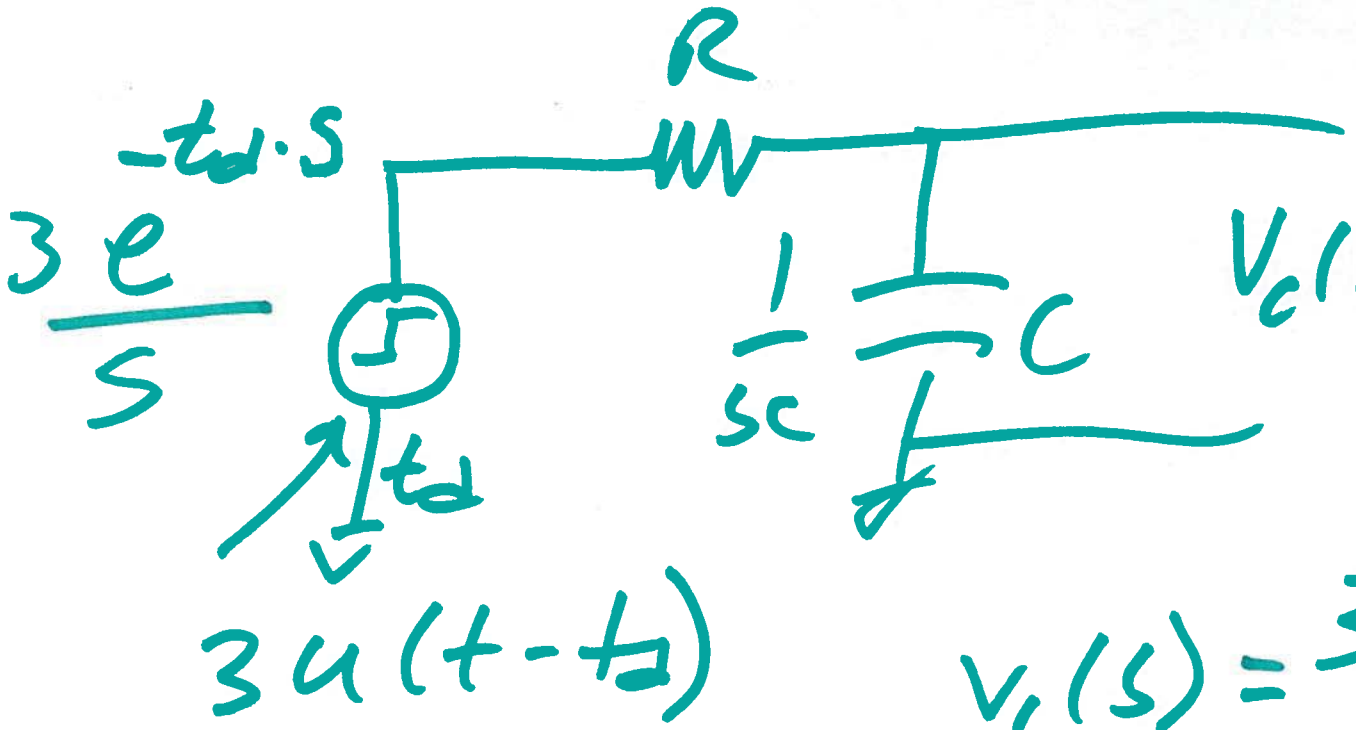
$$V_c(s) = \frac{3}{s} + \frac{-3}{s + \frac{1}{RC}}$$

$$\frac{1}{s} \rightarrow u(t), \quad \frac{1}{s + \frac{1}{RC}} \rightarrow e^{-t/RC} u(t)$$

$$v_c(t) = 3u(t) - 3e^{-t/RC} u(t)$$

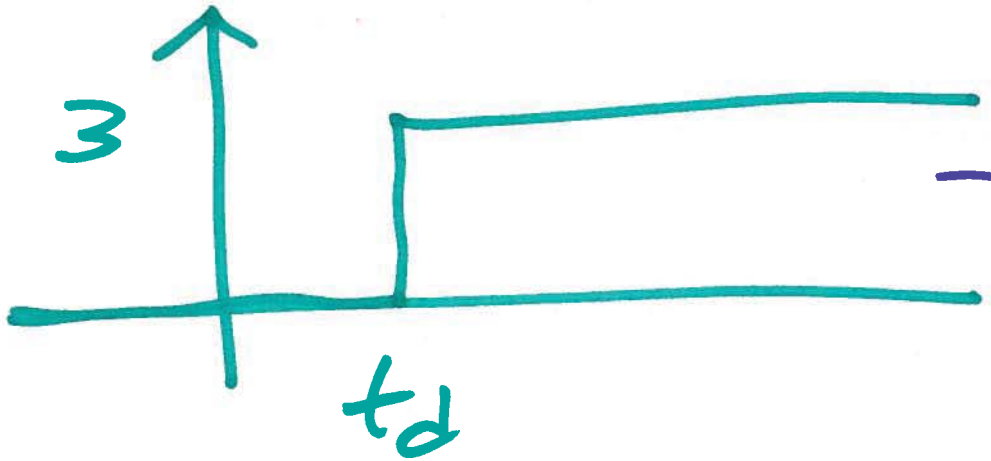
$$v_c(t) = 3\left(1 - e^{-t/RC}\right) u(t)$$

for $t \geq 0$



$$V_c(s) = \frac{\frac{1}{sC}}{R + \frac{1}{sC}} \frac{3e^{-t_d \cdot s}}{s}$$

$$V_c(s) = \frac{3\frac{1}{RC} \cdot e^{-t_d \cdot s}}{\left(s + \frac{1}{RC}\right) s}$$



$$\rightarrow v_f + (v_i - v_f)e^{-\frac{t-t_d}{RC}}$$

$v_f = 3$, $v_i = 0$

$t > t_d$

$$V_1(s) = \left(\frac{\frac{3}{RC} e^{-t_d \cdot s}}{\left(s + \frac{1}{RC}\right) s} \right)_{s+\frac{1}{RC}} = \left(\frac{A}{s} + \frac{B}{s+\frac{1}{RC}} \right)_{s+\frac{1}{RC}}$$

$$s = -\frac{1}{RC}$$

$$A = 3$$

$$B = \frac{\frac{3}{RC}}{-\frac{1}{RC}} \cdot e^{-t_d\left(-\frac{1}{RC}\right)}$$

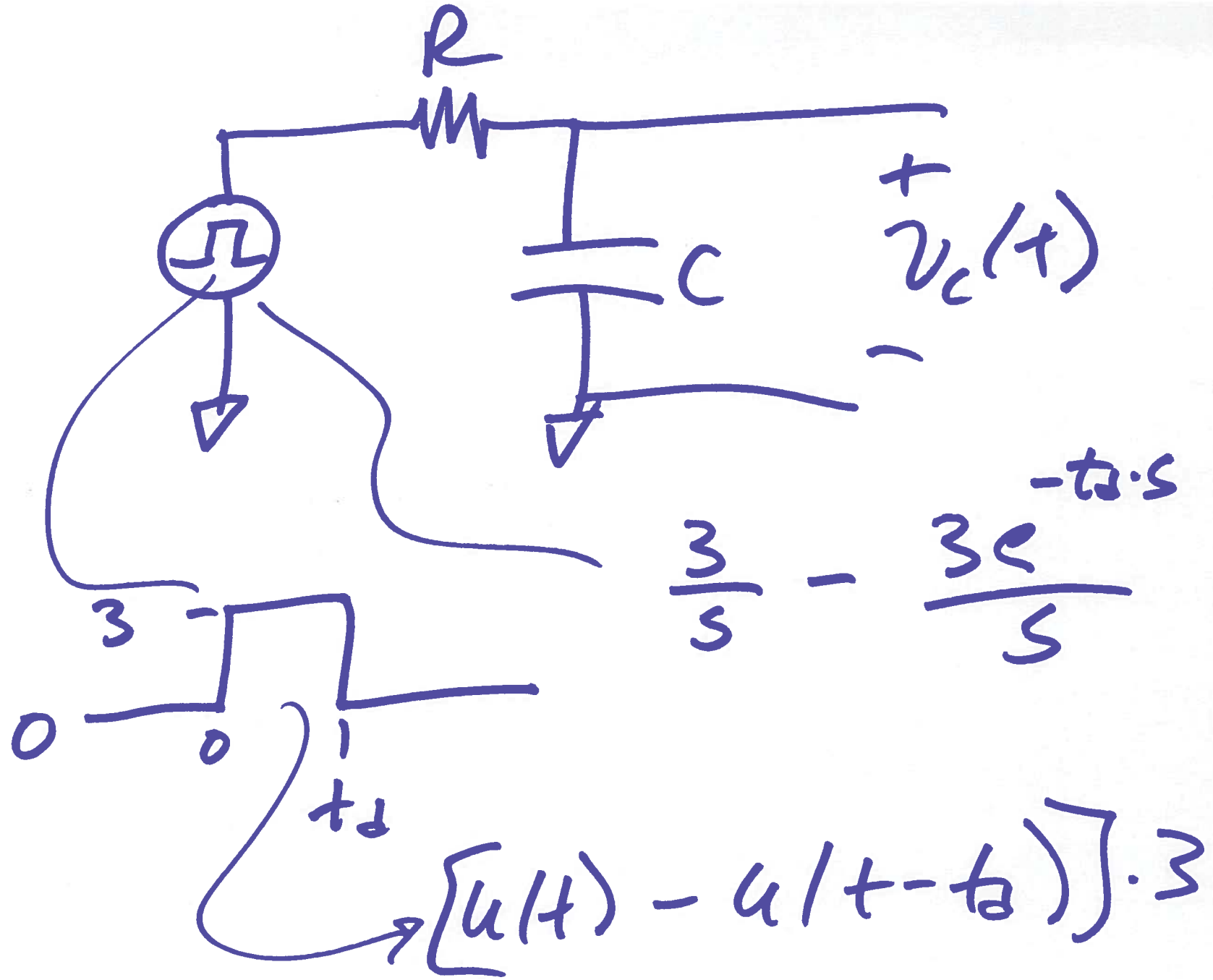
$$B = -3\, e^{t_d/RC}$$

$$V_1(s) = \frac{3}{s} + \frac{-3e^{t_d/RC}}{s + \frac{1}{RC}}$$

$$\frac{3}{s} \rightarrow 3u(t)_{t_d} \qquad \frac{-3e^{t_d/RC}}{s+\frac{1}{RC}} \rightarrow -3e^{-\frac{t}{RC}} e^{t_d/RC} u(t+t_d)$$

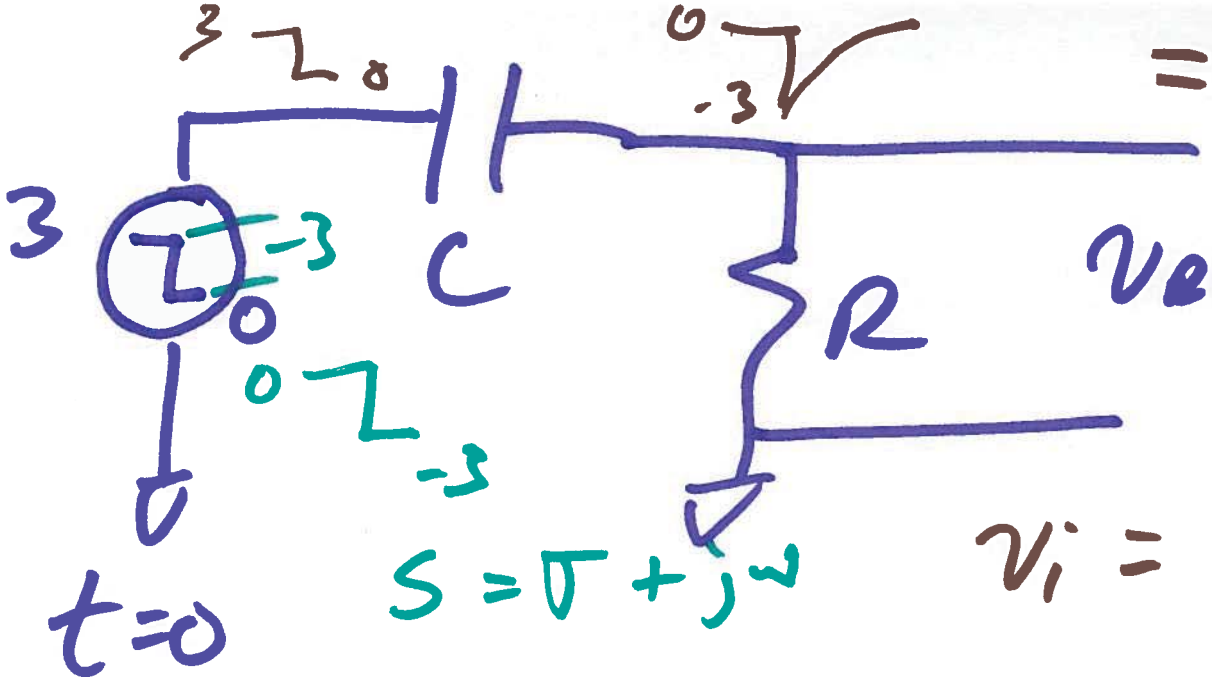
$$-3e^{-(t-t_d)/RC} \cdot u(t)_{t_d}$$

$$v_1(t) = 3u(t)_{t_d} - 3e^{-(t-t_d)/RC} u(t)_{t_d}$$



$$\frac{3}{s} - \frac{3e^{-t_d \cdot s}}{s}$$

$$[u(t) - u(t - t_d)] \cdot 3$$



$= v_f + (v_i - v_f)e^{-t/RC}$

$v_R(t) = -3e^{-t/RC}$ $t>0$

$v_i = -3$, $v_f = 0$

$$V_R(s) = \frac{R}{R+\frac{1}{sC}} \cdot \frac{-3}{s} = \frac{s}{s+\frac{1}{RC}} \cdot \frac{-3}{s}$$

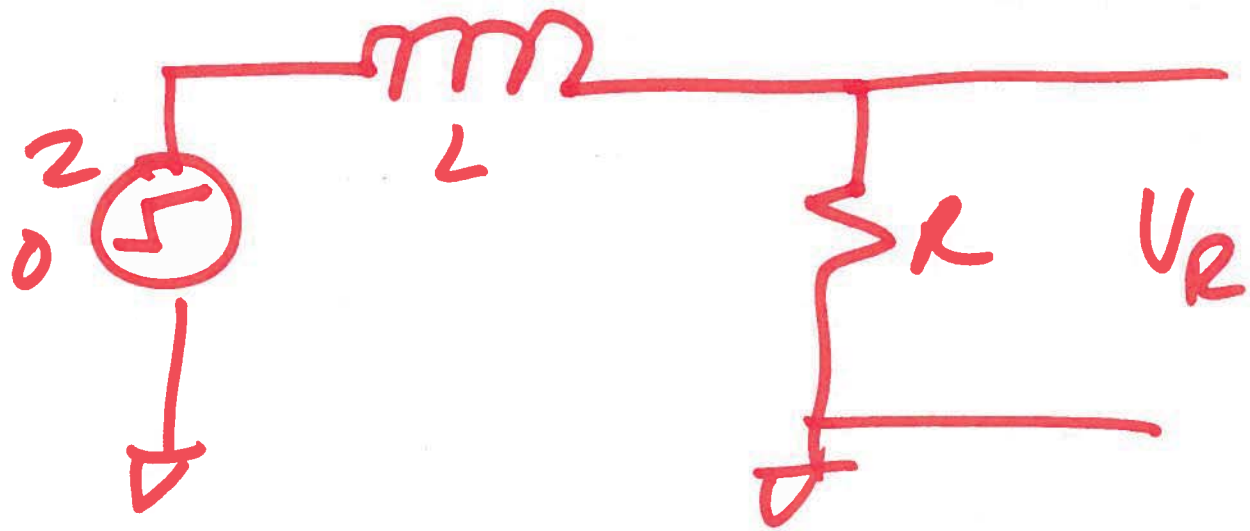
$$V_R(s) = \frac{-3}{s+\frac{1}{RC}}$$

$$= -3e^{-t/RC} \cdot u(t)$$

$\frac{1}{\frac{1}{a}} = a$

$\frac{1}{a/b} = \frac{b}{a}$ $\frac{a}{b} \times \frac{cd}{fg}$

$$b = \frac{afg}{cd}$$



$2(1-e^{-t/\tau_R})$

$-t/\tau$

$V_R(t)$ $2-2e$

$-t/\tau$

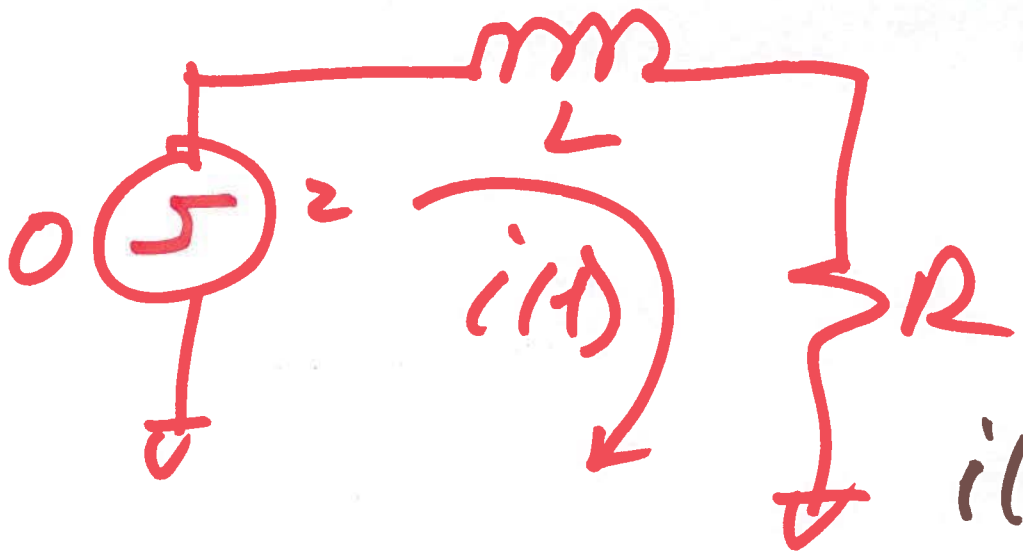
$$V_R(s) = \frac{R}{R+sL} \cdot \frac{2}{s} = \frac{2}{s} \cdot \frac{R/L}{s+\frac{R}{L}}$$

$$\frac{2}{s} \cdot \frac{\frac{R}{L}}{s+\frac{R}{L}} = \frac{A}{s} + \frac{B}{s+\frac{R}{L}}$$

$$A = 2, \quad B = \frac{2 \cdot \frac{R}{L}}{-R/L} = -2$$

$$V_R(t) = \frac{2}{s} + \frac{-2}{s+R/L} \rightarrow 2u(t) - 2e \cdot u$$

$-t/\tau$



$$\frac{\frac{2}{R}}{s} + \frac{-\frac{2}{R}}{s + R/L}$$

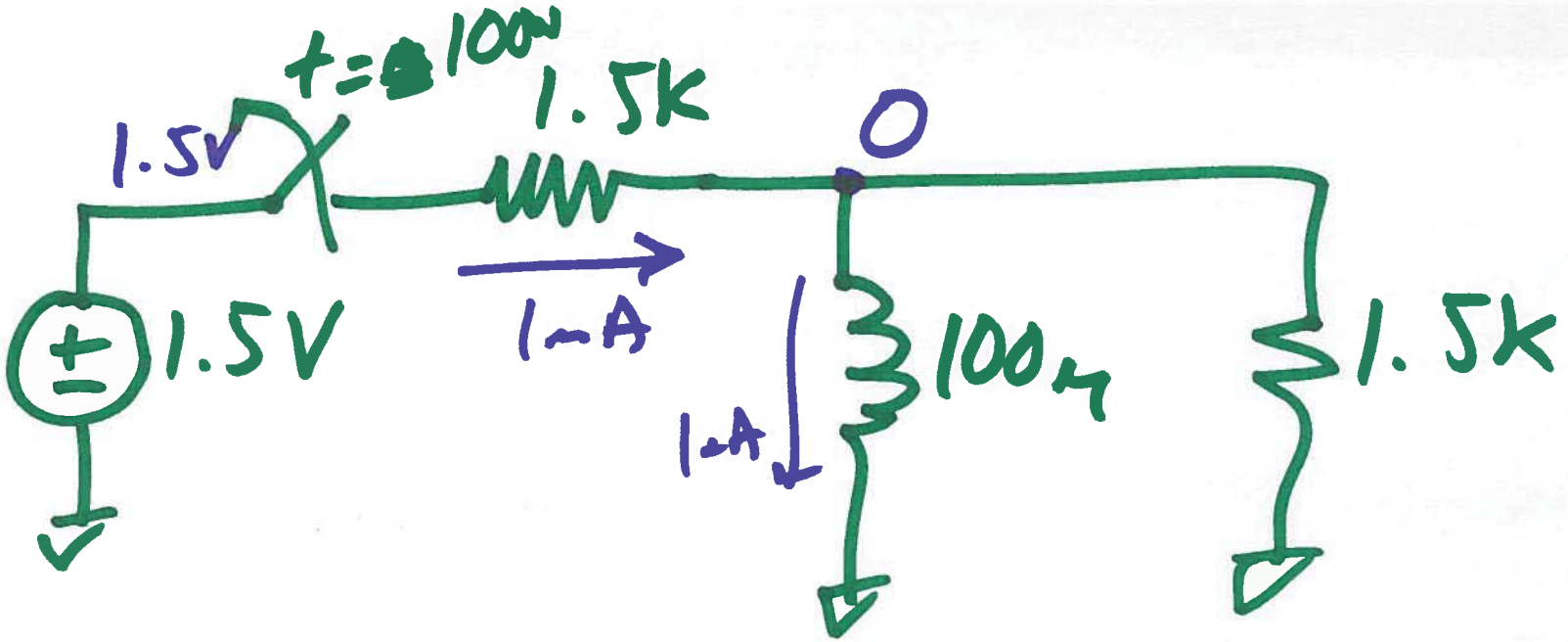
$$i(t) = \frac{2}{R}u(t) - \frac{2}{R}e^{-t/L/R}u(t)$$

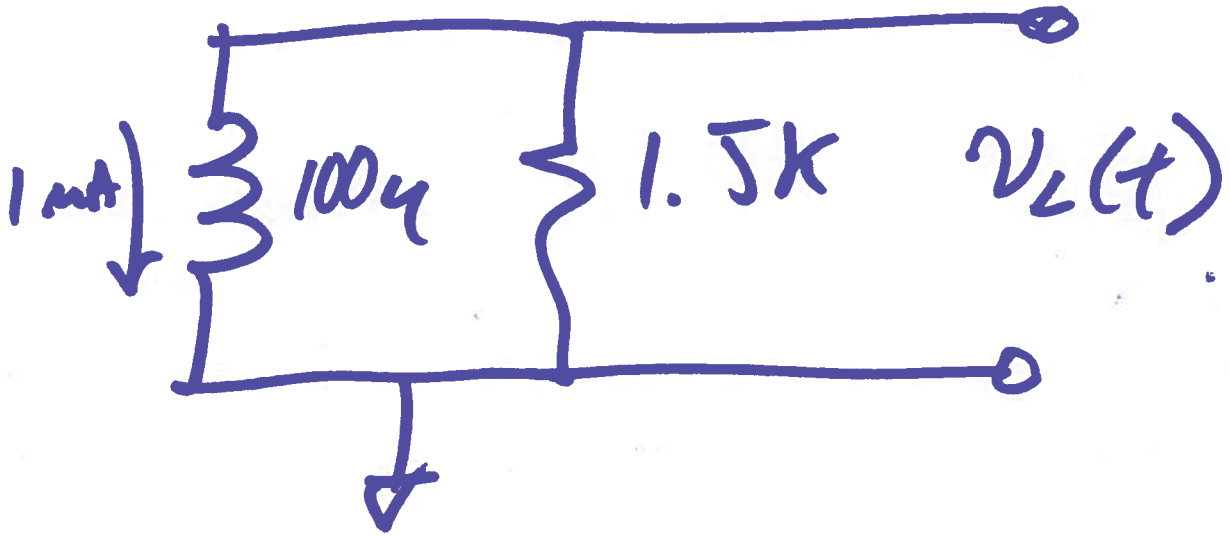
$$I(s) = \frac{\frac{2}{s}}{sL + R} = \frac{2}{R}\left(1 - e^{-t/L/R}\right)$$

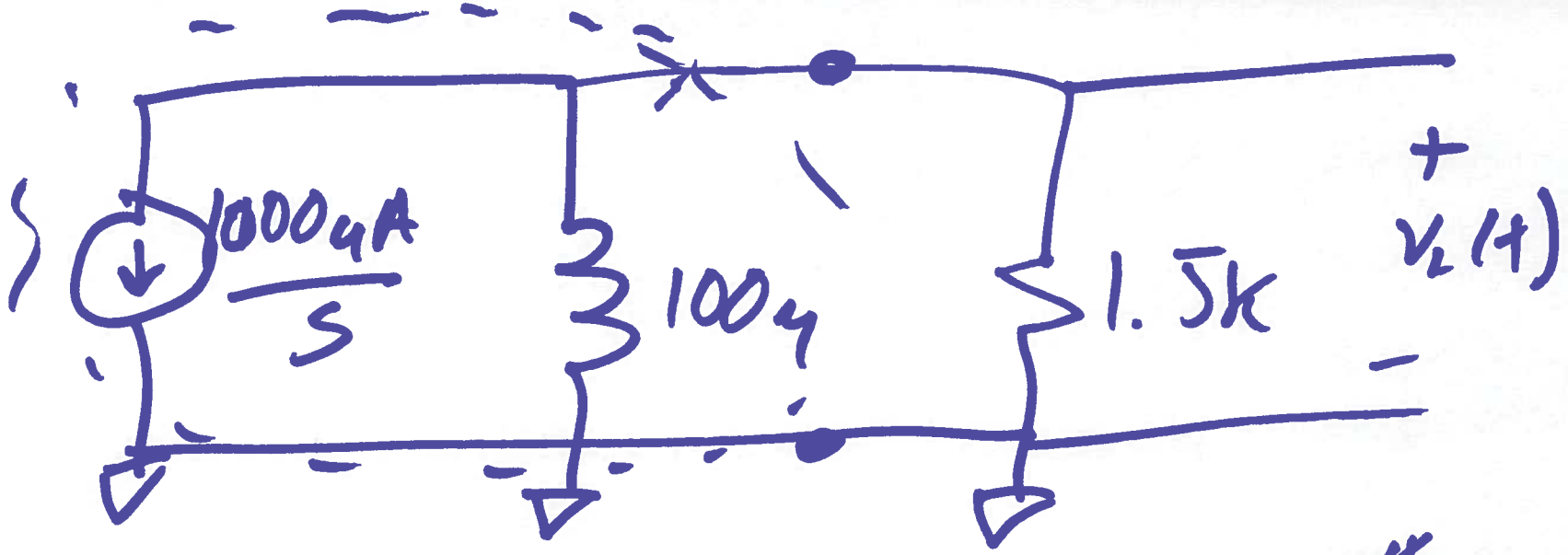
$$= \frac{2}{s(sL+R)} = \frac{2/L}{s\left(s + \frac{R}{L}\right)} = \frac{A}{s} + \frac{B}{s + \frac{R}{L}}$$

$$A = \frac{2}{R}, \quad B = \frac{2/L}{-\frac{R}{L}} = \frac{-2}{R}$$

11)


t=0
1.5V
1.5k
0
1.5V
1mA
100Ω
1.5k
1mA


1mA
100Ω
1.5k
$v_L(t)$



$$V_L(s) = \frac{-10mA}{s} \cdot \frac{1.5k \cdot s \cdot 10^{-4}}{1.5k + s \cdot 10^{-4}}$$

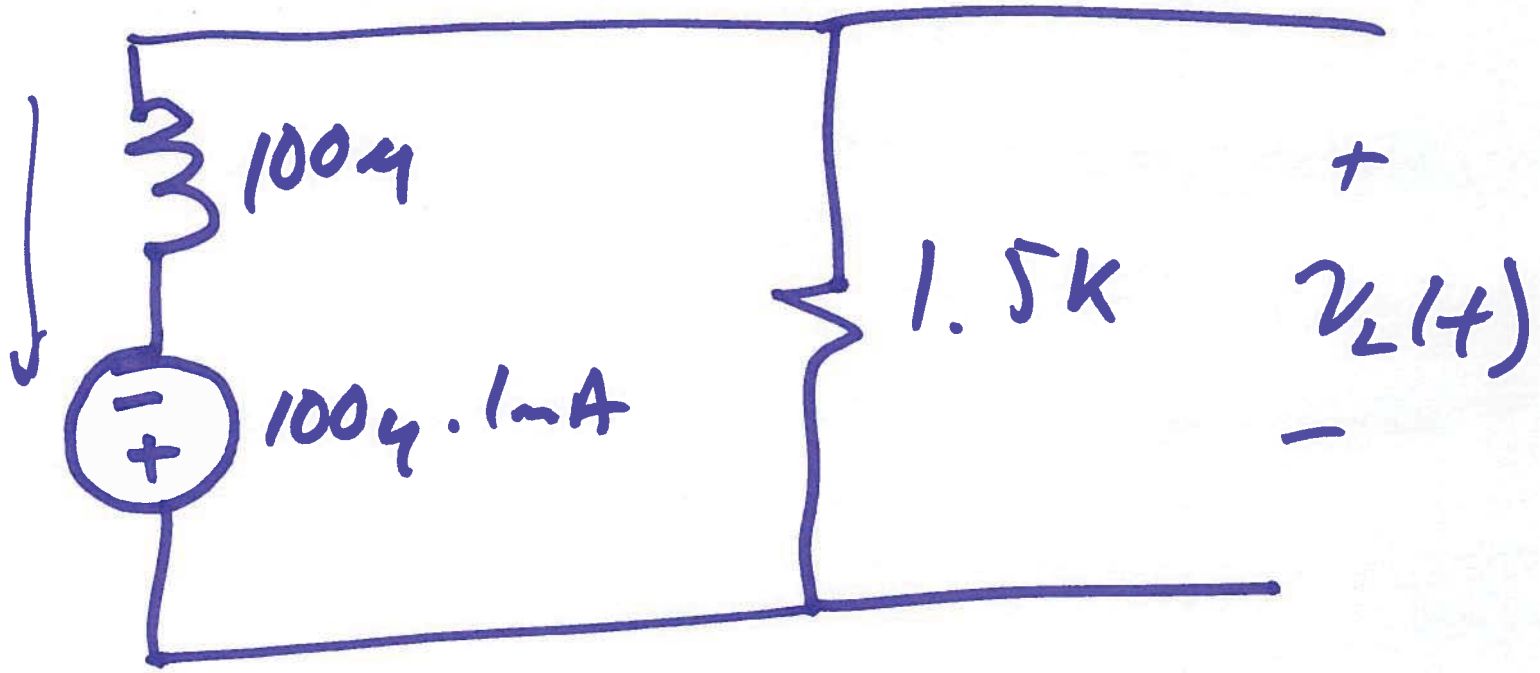
$$\frac{L}{R} = \frac{100\mu}{1.5k} = 66ns$$

$$\frac{1.5k}{10^{-4}} + s \cdot 10^{-4} \cdot 100M$$

$$15\,10^6 = \frac{1}{\frac{L}{R}}$$

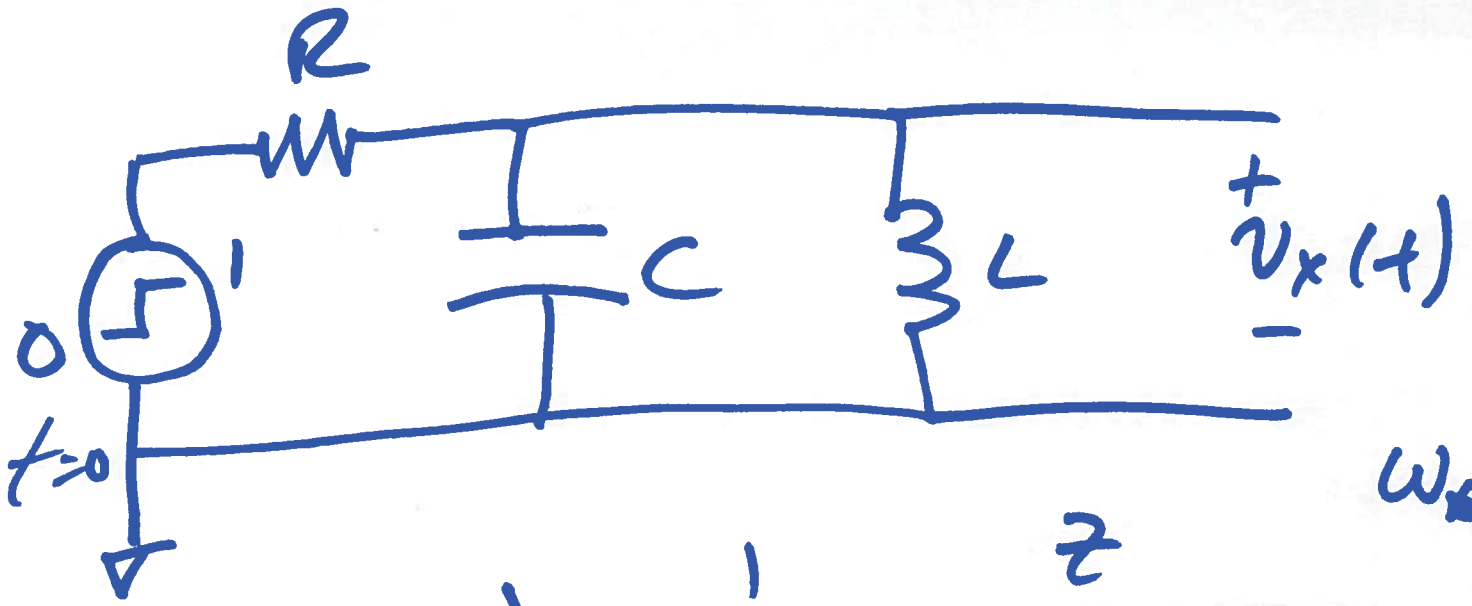
$$V_L(s) = \frac{-1mA \cdot 1.5k}{s + 15 \cdot 10^6}$$

$$\rightarrow -1.5V e^{-\frac{t}{\frac{1}{15 \cdot 10^6}}}$$



$$V_L(s) = -100\mu \cdot 1mA \cdot \frac{1.5K}{1.5K + s \cdot 100\mu}$$

$$= \frac{-1.5V}{s + \frac{1.5K}{100\mu}} \rightarrow -1.5\, e^{-t/\tau}$$



$$V_x(s) = \frac{1}{s} \cdot \frac{Z}{Z+R}$$

$$Z = \frac{sL \cdot \frac{1}{sC}}{sL + \frac{1}{sC}} = \frac{sL}{s^2LC+1}$$

$$V_x(s) = \frac{1}{s} \frac{\frac{s/L}{s^2+\frac{1}{LC}}}{s/L/s^2+\frac{1}{LC} + R}$$

$$\omega_{res} = \frac{1}{\sqrt{LC}}$$

$$f_{res} = \frac{1}{2\pi\sqrt{LC}}$$

$$V_x(s) = \frac{1}{s} \cdot \frac{\frac{s}{6}}{\frac{s}{C} + s^2 R + \frac{R}{LC}}$$

$$= \frac{1}{s + s^2 RC + \frac{R}{L}}$$

$$s_1, s_2 = \frac{-\frac{1}{RC} \pm \sqrt{\left(\frac{1}{RC}\right)^2 - \frac{4}{LC}}}{2}$$

$$= \frac{\frac{1}{RC}}{s^2 + s \cdot \frac{1}{RC} + \frac{1}{LC}}$$

$$= \frac{\frac{1}{RC}}{(s - s_1)(s - s_2)}$$