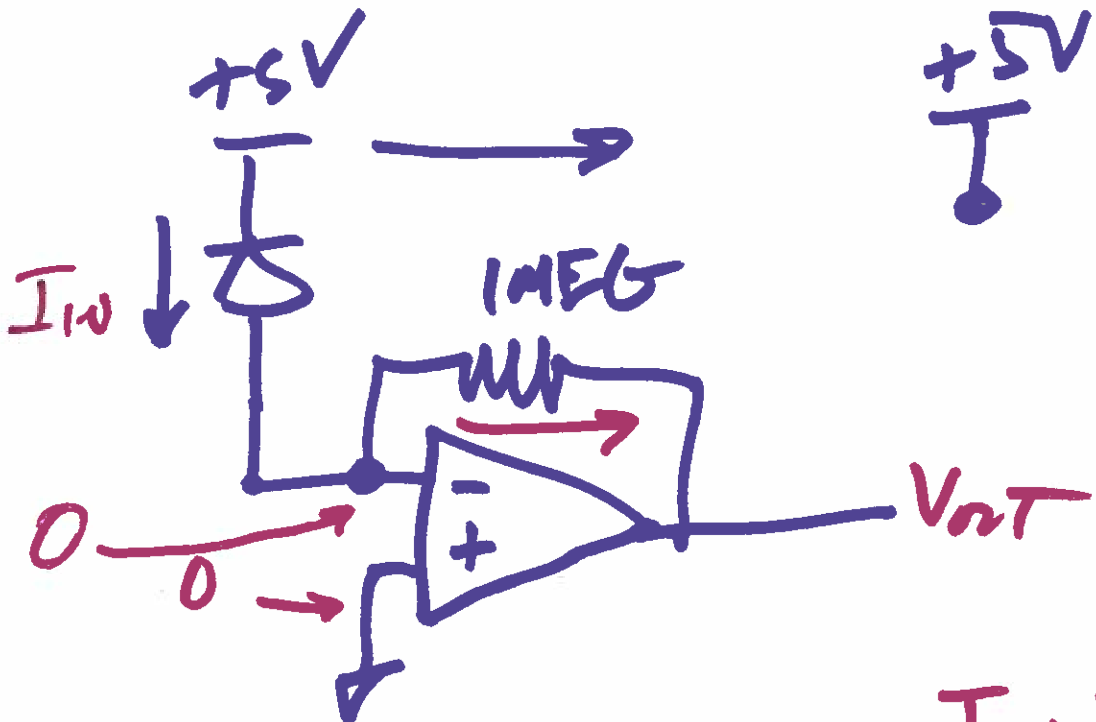
EE 220 Circuits I

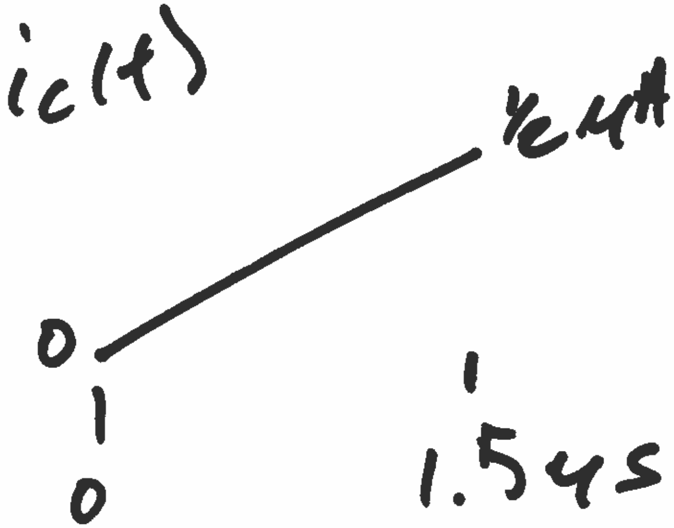
Oct. 21, 2019

Lecture 15



$$I_{in} = \frac{0 - V_{out}}{1MEG}$$

$$V_{OUT} = -I_{in} \cdot 1MEG$$



$$i_c(t) = \frac{0.5\,\mu A}{1.5\,\mu s} \cdot t = \frac{1}{3}t$$

$$\frac{1}{10p} = \frac{1}{10 \times 10^{-12}} = \frac{1}{10^{-11}} = 10^{11}$$

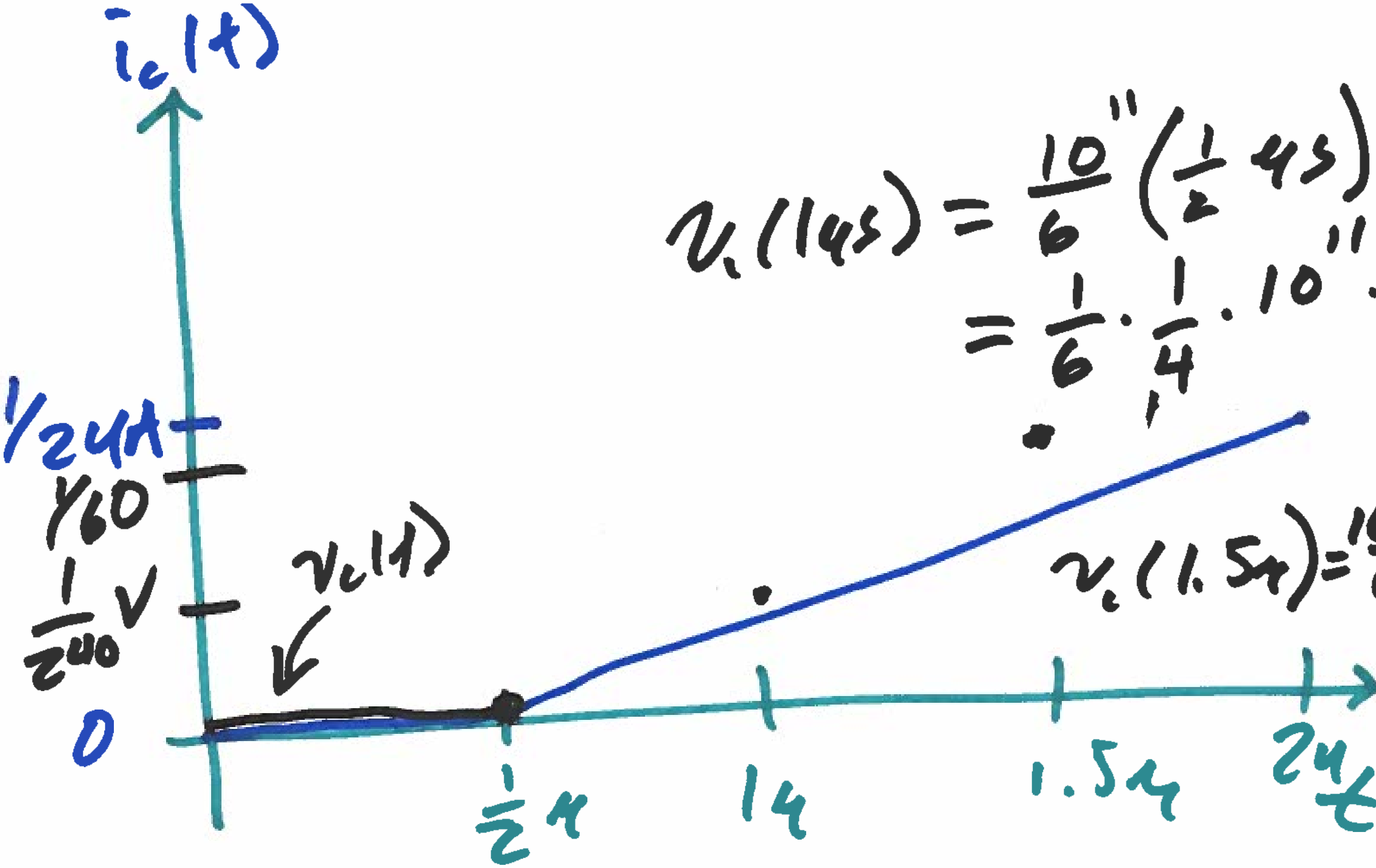
$$v_c(t) = \frac{1}{C}\int_0^t i_c(t) \cdot dt = 10^{11}\int_0^t \frac{1}{3}t \cdot dt = 10^{11}\frac{1}{6}t^2$$

$100G = 10^{11}$

$100 \cdot 10^{9}$

$0.1 \cdot 10^{12} = 0.1T$

2)

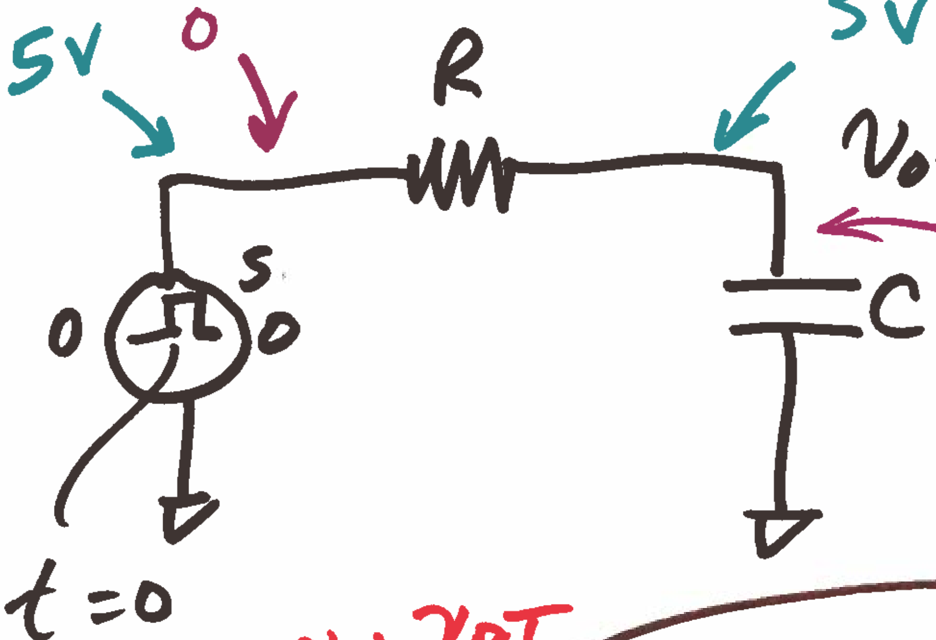


$$v_c(1\mu s) = \frac{10^{11}}{6}\left(\frac{1}{2}\mu s\right)^2 = \frac{1}{6}\cdot\frac{1}{4}\cdot 10^{11}\cdot 10^{-12} = \frac{1}{240}$$

$$v_c(1.5\mu) = \frac{10^{11}}{6}(1\,\mu s)^2 = \frac{10^{11}\cdot 10^{-12}}{6} = \frac{1}{60}$$

$$v_C(t) = \frac{10^{11}}{6}t^2 \quad 0 < t < 1.5\mu$$

$$v_c(t) = \frac{10^{11}}{6}\left(t - \tfrac{1}{2}\mu s\right)^2 \quad \tfrac{1}{2}\mu \le t \le 2.0\mu$$

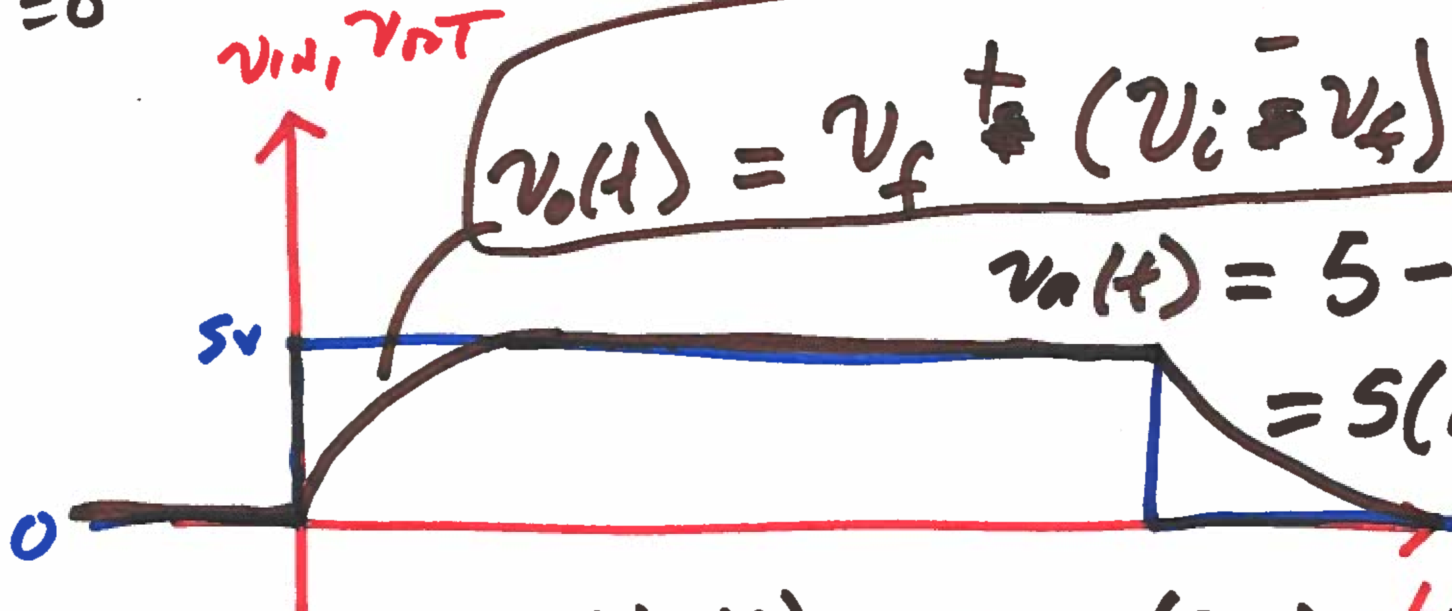


$v_o(0^-) = 0$

$t < 0$

$t >> 0$

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

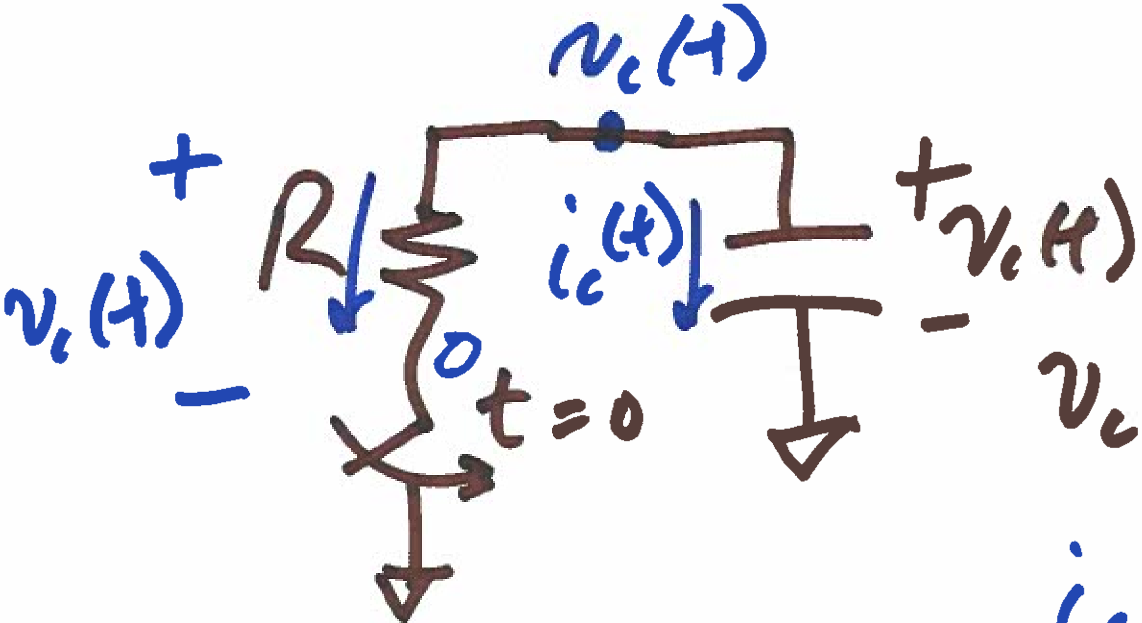


$$v_o(t) = 5 - 0 - 5e^{-t/RC}$$

$$= 5(1 - e^{-t/RC})$$

$$v_o(t) = 0 + (5-0)e^{-t/RC}$$

$$= 5e^{-t/RC}$$



$$v_c(0) = 5V$$

$$i_c(t) = C\frac{dv_c(t)}{dt}$$

$$\frac{v_c(t)}{R} + C\frac{dv_c(t)}{dt} = 0$$

$$\frac{v_c(t)}{R} = -C\frac{dv_c(t)}{dt}$$

$$\int_0^t \frac{dt}{-RC} = \int_{V_c(0^-)}^{v_c(t)} \frac{dv_c(t)}{v_c(t)}$$

$$\frac{t}{-RC} = \ln x \Big|_{V_c(0^-)}^{v_c(t)}$$

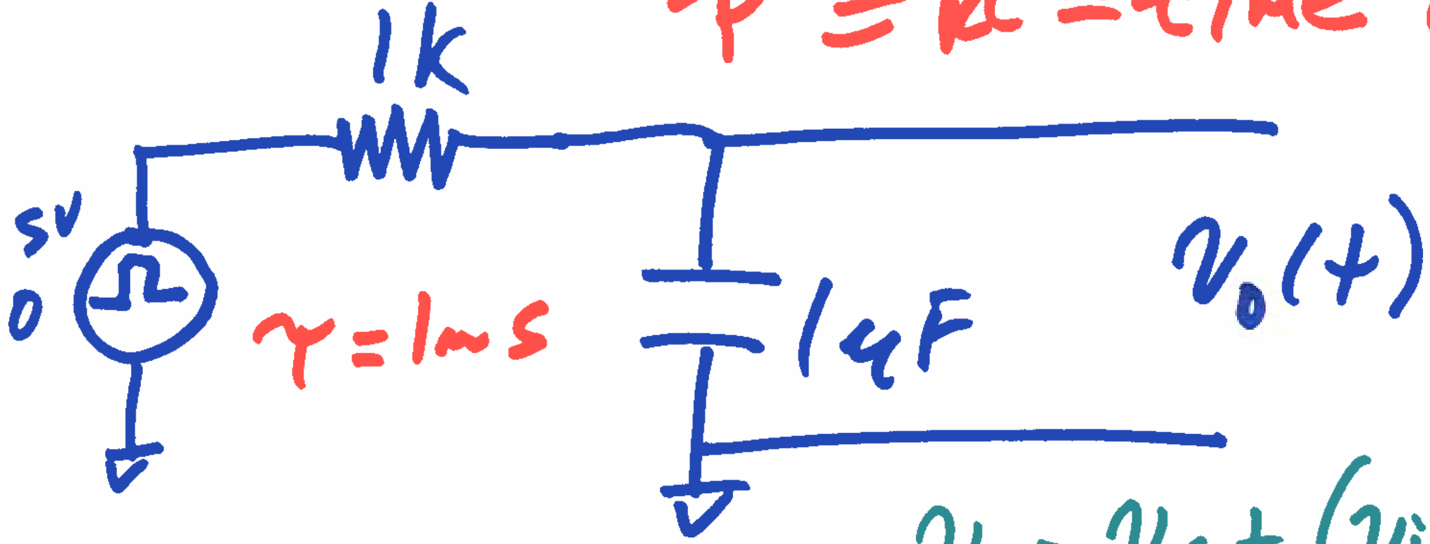
$V_c(0^-) \rightarrow v_i$

$$-\frac{t}{RC} = \ln \frac{v_c(t)}{v_i}$$

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

b)

$\tau = RC = $ time constant



$\tau = 1ms$

$$v_0 = v_f + (v_i - v_f)e^{-t/RC}$$

INPUT $0 \to 5$

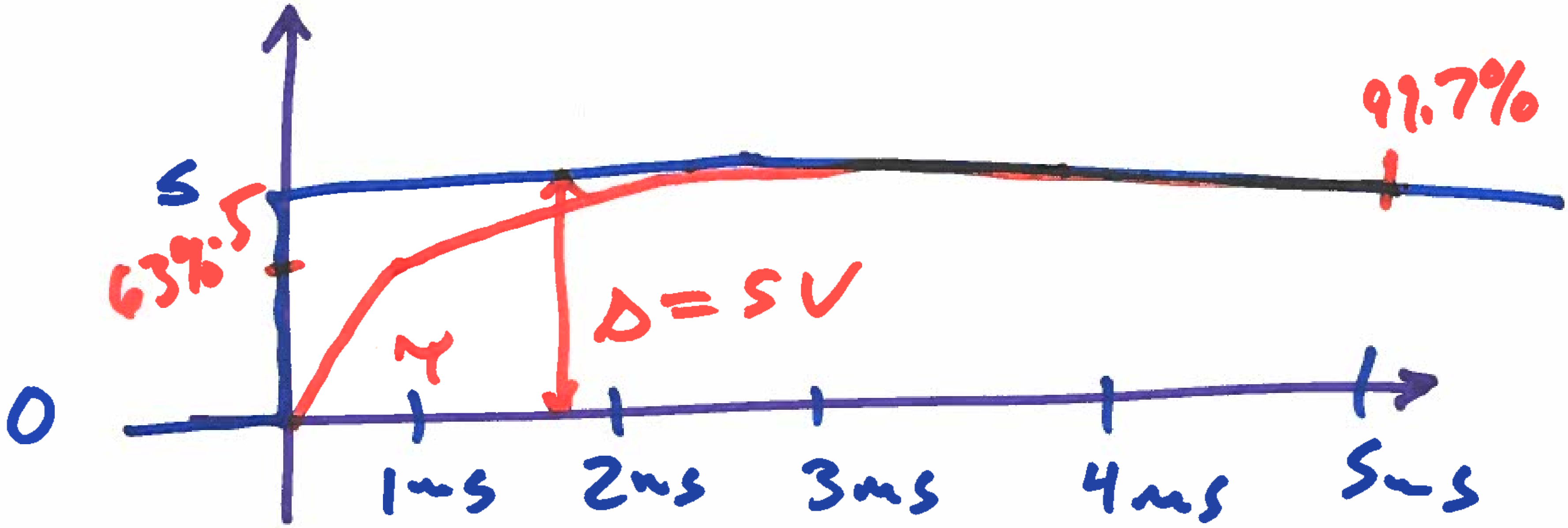
$$v_i = 0, \quad v_f = 5V$$

$$v_0(t) = 5 + (0-5)e^{-t/1ms}$$

$$v_0(t) = 5(1 - e^{-t/1ms})$$

INPUT $5 \to 0$ $\quad v_i = 5, \quad v_f = 0$

$$v_0(t) = 5e^{-t/1ms}$$



memorize
63% of transition
5V

1τ

$t = 1ms$

$v_o(t) = 5\left(1 - \frac{1}{e}\right)$

$5(1 - .37)$

$5 \cdot 63\%$

5τ is settled

$\frac{1}{e^5} \approx 0$

99.7%

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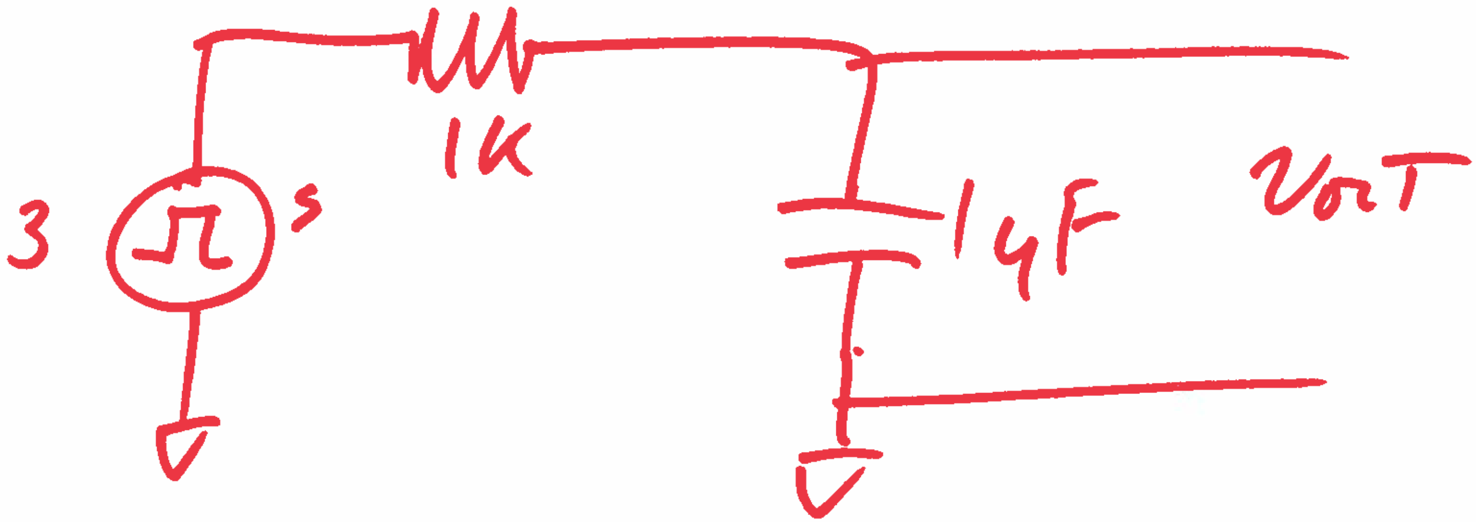

INPUT $3 \rightarrow 5$ $\quad v_i = 3,\ v_f = 5$

$$v_o(t) = 5 + (3-5)e^{-t/1ms}$$

$$v_o(t) = 5 + (-2V)e^{-t/1ms}$$

$5-3$

$v_i = 5$

$v_f = 3$

$v_o(t) =$

$3 + (5-3)e^{-t/RC}$

8)