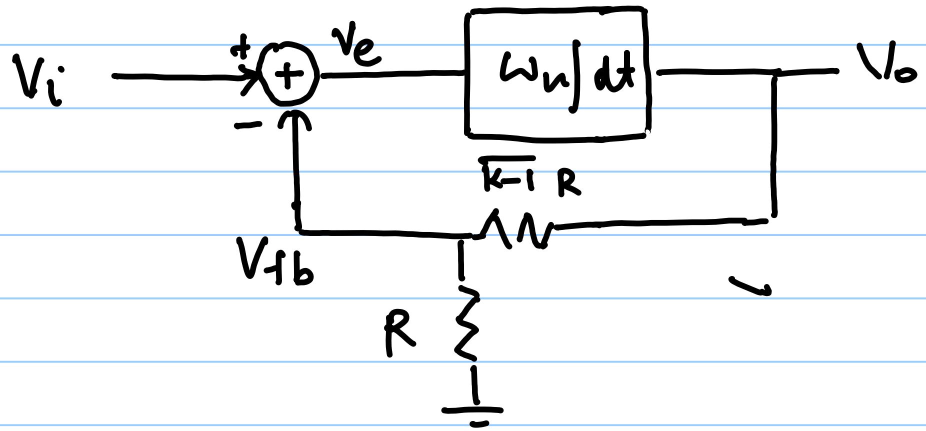
Lecture # 05

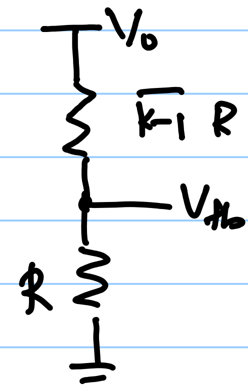
Note Title 09-02-2021



$$V_e = V_i - V_{fb}$$

$$V_{fb} = \frac{1}{K} V_o$$

$$V_o = \omega_n \int V_e \cdot dt$$



$$V_{fb} = \frac{R}{R + \overline{K-1}R} V_o$$

$$= \frac{1}{K} V_o$$

$$V_o = \omega_n \int \left(V_i - \frac{V_o}{K}\right) dt \quad -(1)$$

$$\frac{dV_o}{dt} = \omega_n \left(V_i - \frac{V_o}{K} \right)$$

$$\frac{dV_o}{dt} + \omega_n \frac{V_o}{K} = \omega_n V_i$$

$$V_o = e^{-\omega_n t/K} \int \omega_n . \underset{\sim}{V_i}\, e^{\omega_n t/K}\, dt + Q e^{-\omega_n t/K}$$

$V_i = 0; \ t < 0$
$= V_i(0); \ t \geq 0$

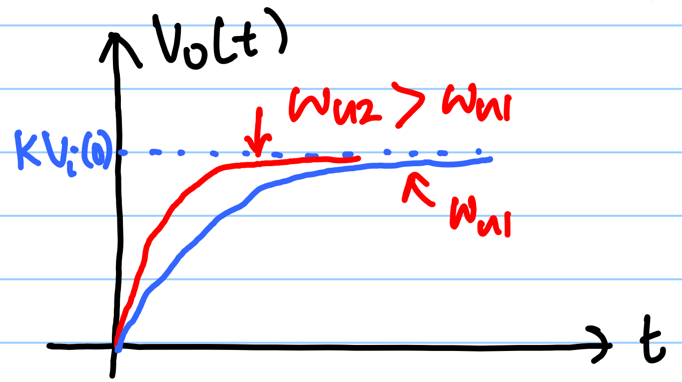
$$V_o = e^{-\omega_n t/K} \int \underset{\sim}{\omega_n} V_i(0) . e^{\omega_n t/K} dt + Q e^{-\omega_n t/K}$$

$$V_o = V_i(0) . \frac{\cancel{\omega_n}}{\cancel{\omega_n}/K} + Q e^{-\omega_n t/K}.$$

$$V_o(t) = K V_i(0) + Q e^{-\omega_n t/K}$$

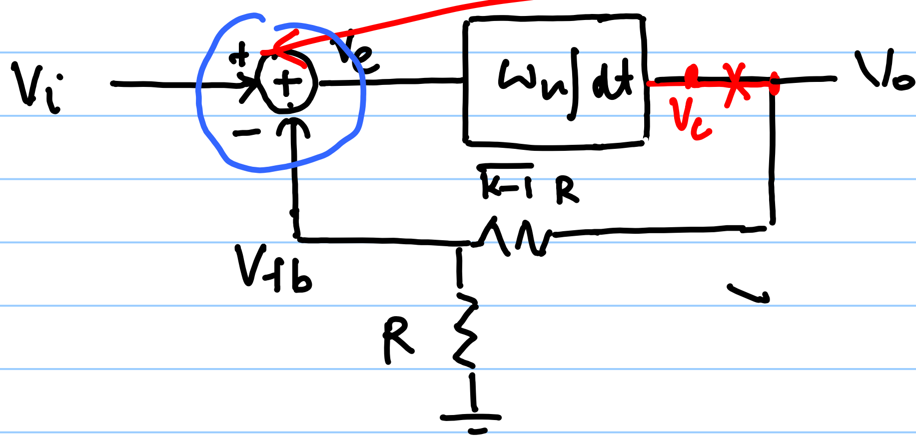
at $t = 0$, $V_o(t) = 0 \Rightarrow 0 = K V_i(0) + Q \Rightarrow Q = -K V_i(0)$

$$V_o(t) = K V_i(0) \left(1 - e^{-\omega_n t/K}\right) \checkmark$$

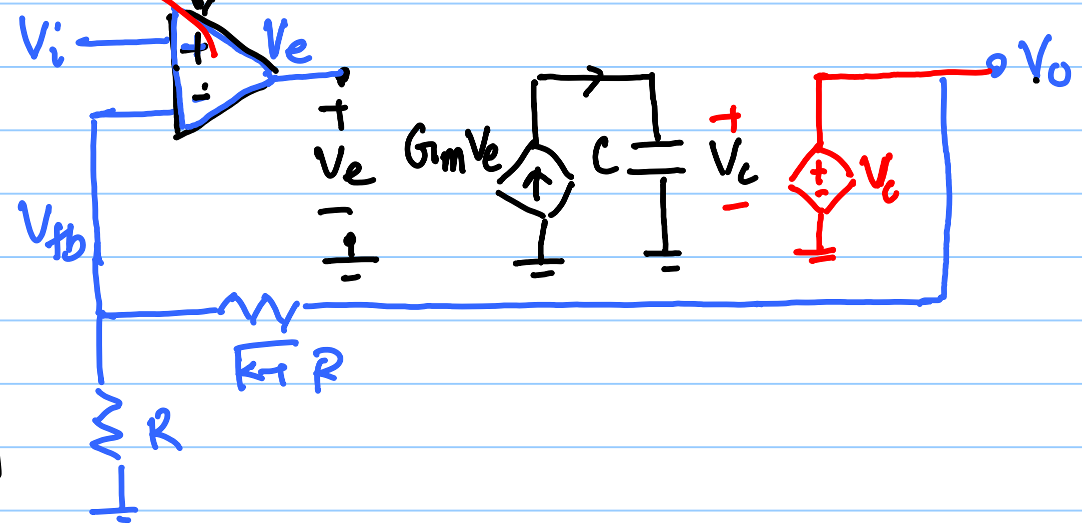


$$\frac{dV_o(t)}{dt} = K V_i(0) \frac{\omega_n}{K} \cdot e^{-\omega_n t/K}$$

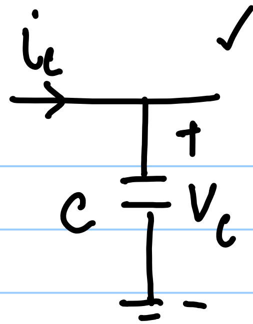
$$= \omega_n V_i(0)\, e^{-\omega_n t/K}$$



$(V_e = V_i - V_{fb})$



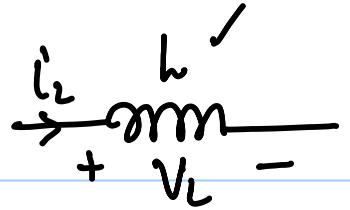
$V_o = \omega_n \int V_e \, dt \checkmark$



$$i_c = C\frac{dV_c}{dt}$$

$$V_c = \frac{1}{C}\int i_c \cdot dt$$

$$i_c \propto V_e$$



$$V_L = L\frac{di_L}{dt}$$

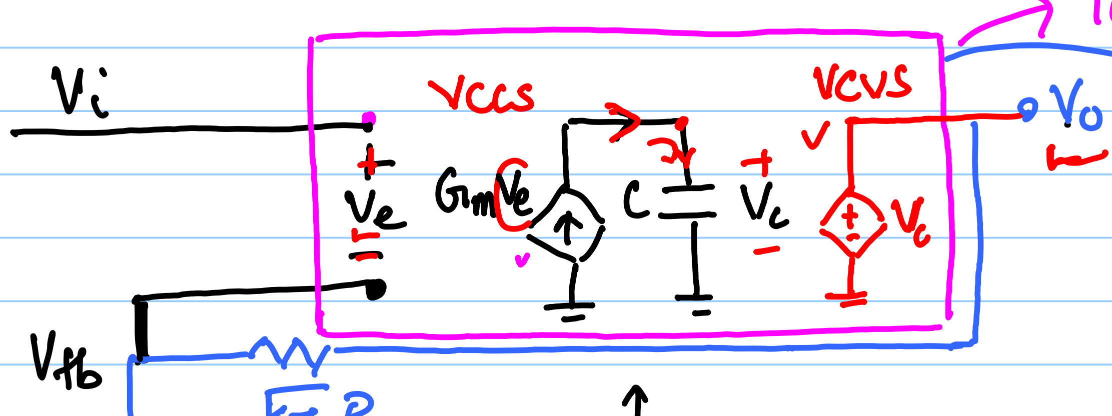
$$i_L = \frac{1}{L}\int V_L dt$$

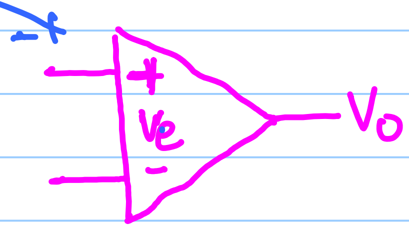
$$V_c(t) = \frac{1}{C}\int G_m V_e \, dt$$

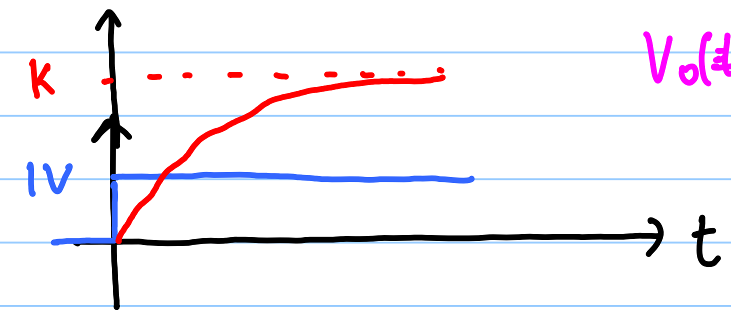
$$V_c(t) = \frac{G_m}{C}\int V_e \cdot dt$$

$$V_o(t) = V_c(t)$$

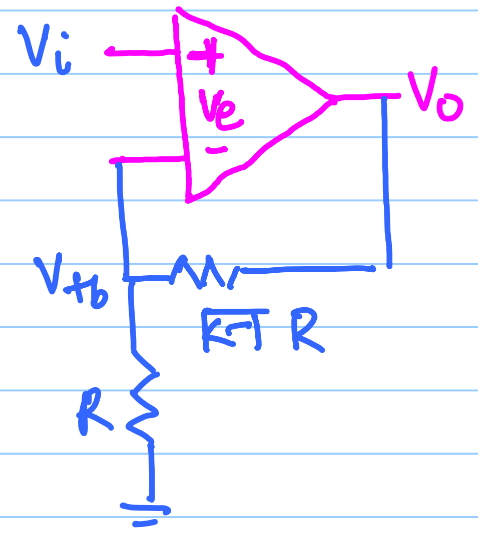
$$V_o(t) = \frac{G_m}{C}\int V_e \, dt$$







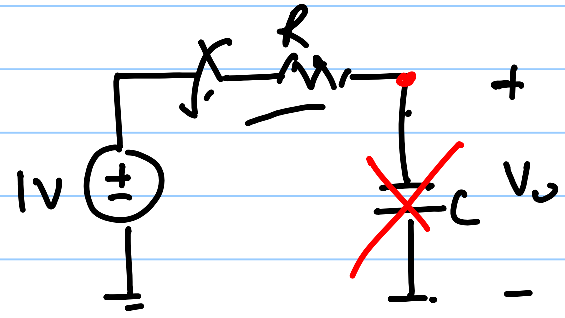
$$V_o(t) = \int \frac{G_m}{C} V_e \cdot dt$$



$$V_o(t) = \frac{G_m}{C}\int V_e \, dt$$

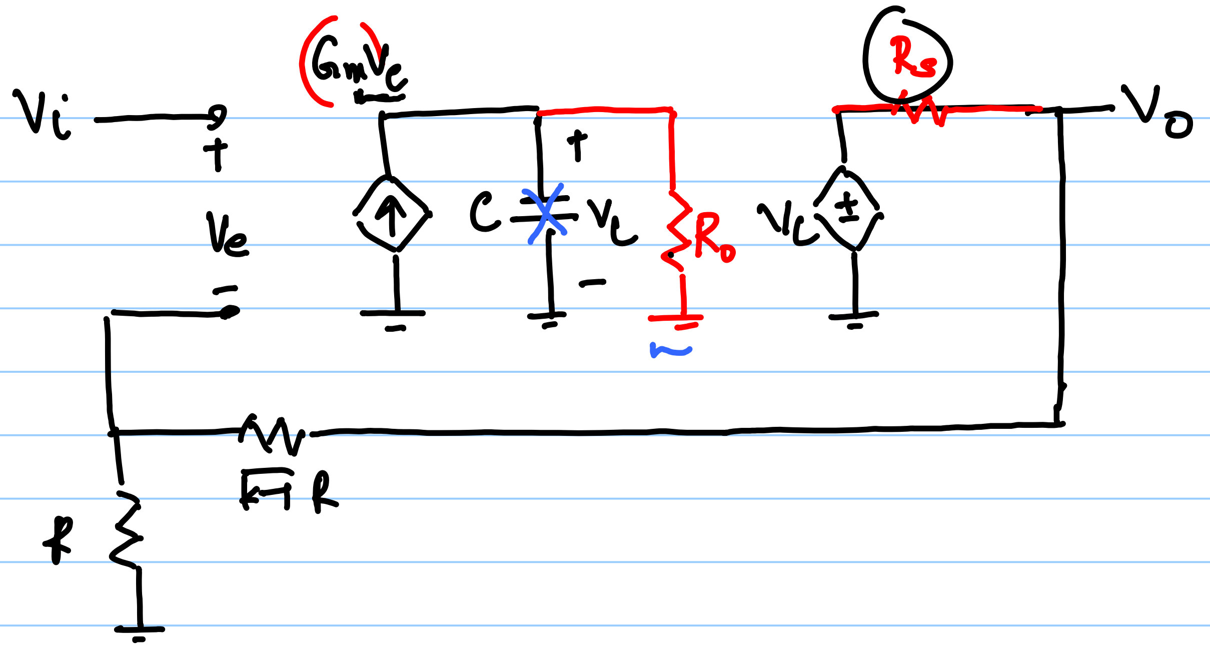
$$V_o(t) = \frac{G_m}{C}\int \left(V_i - \frac{V_o}{K}\right) dt$$

at $t \to \infty$, $C \to$ open circuit



Voltage in steady state

$\underset{t\to\infty}{\mathrm{lt}} \; V_o(t)$:



Ideally,

$R_s \to 0$

$R_L \to \infty$

1) What is V_o in steady state ✓

2) What is V_e in steady state.

#1 R_o is finite, $R_s = 0$

$$V_c = G_m V_e \cdot R_o = G_m R_o \left(V_i - \frac{V_o}{K} \right) = V_o$$

$$V_o = \frac{V_i}{\left(\frac{1}{G_m R_o} + \frac{1}{K} \right)} = \frac{K V_i}{1 + \frac{K}{G_m R_o}} \quad \frac{K}{G_m R_o} \to 0$$

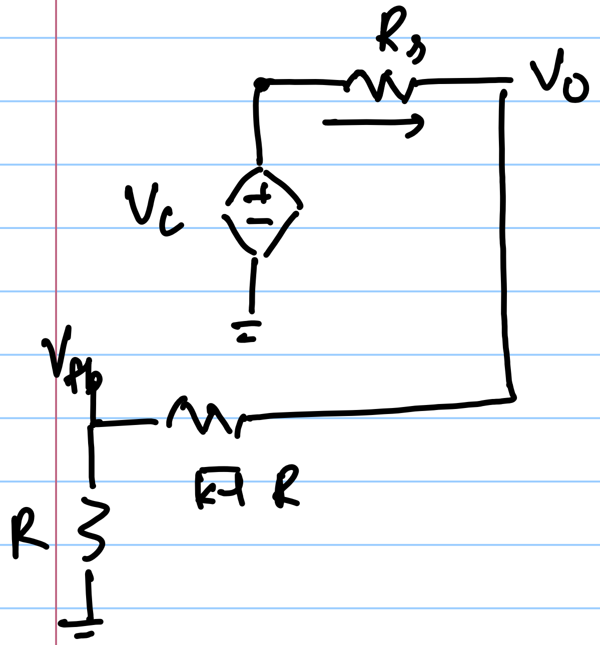
$$V_e = V_i - \frac{V_o}{K}$$

$$V_o = V_i - \frac{V_i}{1 + \frac{K}{G_m R_o}}$$

$$V_e = V_i \frac{1}{1 + \frac{G_m R_o}{K}} \to 0 \quad G_m R_o \to \infty$$

$$V_o < K V_i$$

#2 $R_L \to \infty$, R_s is finite



$V_i^- = V_{fb}$

$V_i^- = V_c \cdot \frac{R}{R+(K-1)R+R_s} = \frac{\cancel{R}}{KR+\cancel{R_s}} \quad \frac{\cancel{KR+R_s}}{K\cancel{R}} V_o$

$V_o = \frac{KR}{KR+R_s} \cdot V_c$ $\quad V_i = \frac{V_o}{K}$