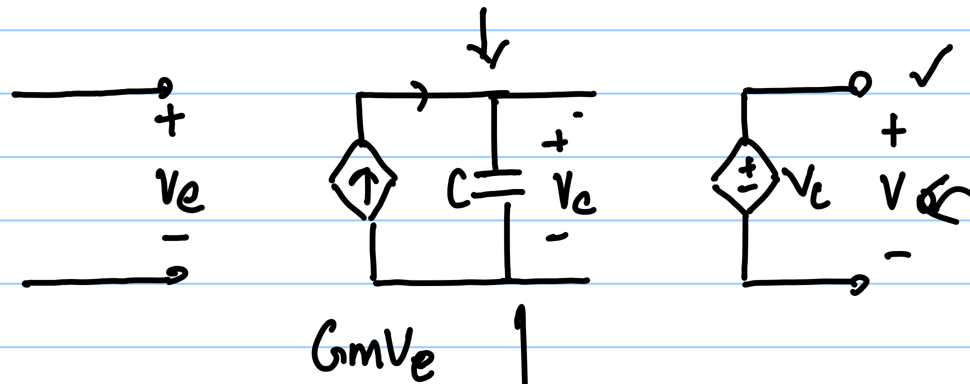
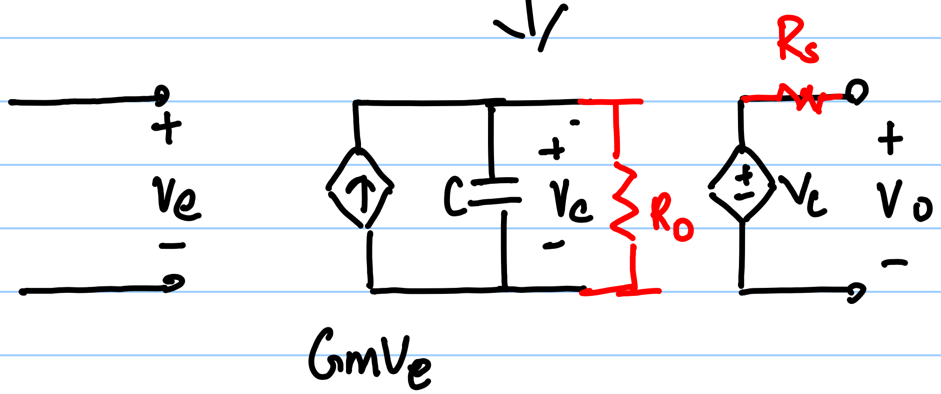
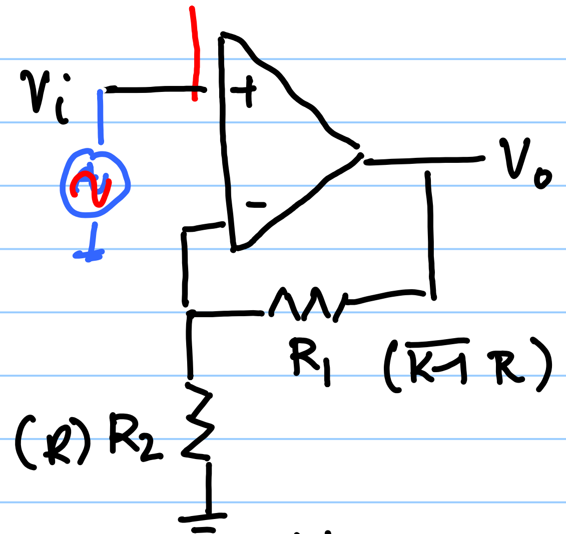
Note Title 10-02-2021

Lecture # 06

Ideal Operational Amp. (Opamp)

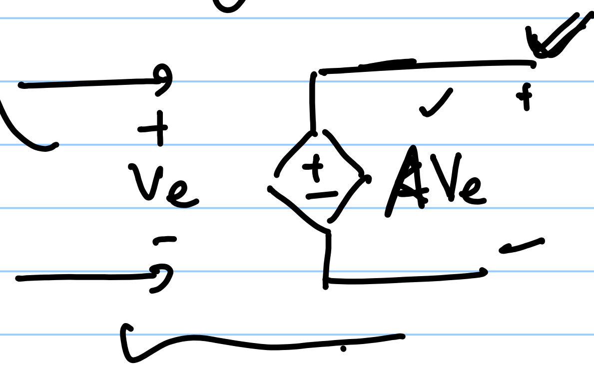






$$\frac{V_o}{V_i} = K$$

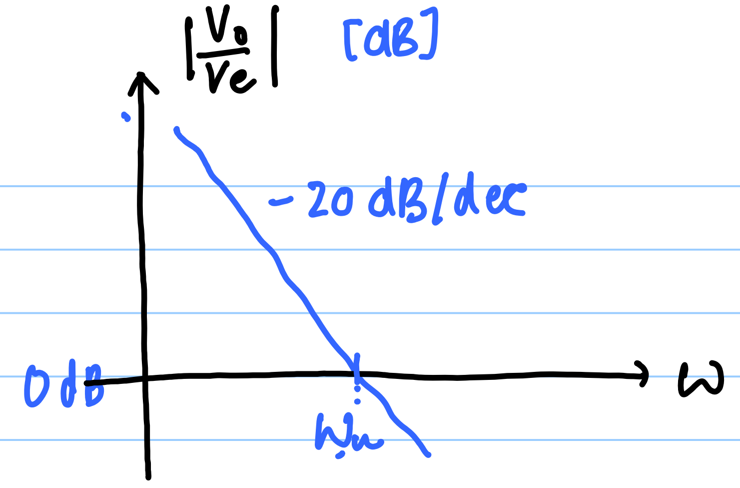
$$V_c = \frac{1}{C} \int G_m V_e \, dt$$



$$V_c(s) = G_m \cdot V_e(s) \times \frac{1}{sC}$$

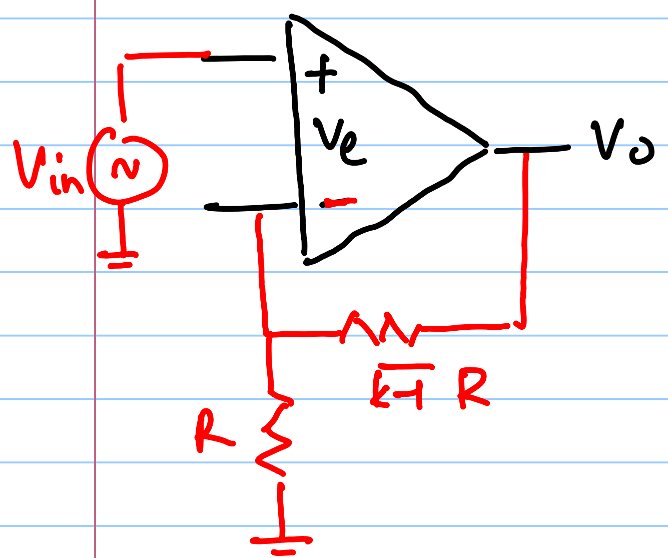
$$V_o(s) = \frac{G_m / C}{s} \cdot V_e(s)$$

$$H(s) = \frac{V_o(s)}{V_e(s)} = \frac{(G_m/C)}{s}$$



$$20\log_{10}|H(\omega)|$$

$$\omega_n = \frac{G_m}{C}$$



$$\frac{V_o(s)}{V_e(s)} = \frac{\omega_n}{s} \checkmark \; ; \quad \omega_n = \frac{G_m}{C}$$

$$V_e(s) = V_{in}(s) - \frac{1}{K} V_o(s)$$

$$V_o(s) = \frac{\omega_n}{s} V_e(s) = \frac{\omega_n}{s}\left(V_{in}(s) - \frac{V_o(s)}{K}\right)$$

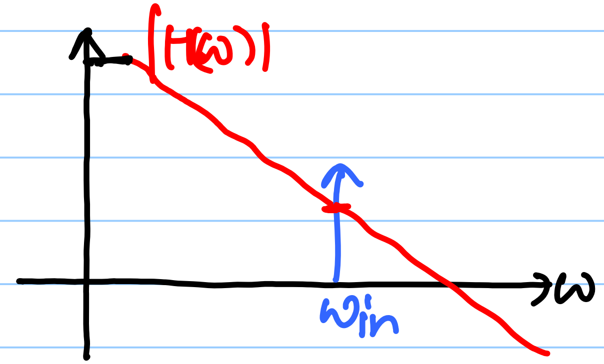
$$V_o(s)\left(\frac{s}{\omega_n} + \frac{1}{K}\right) = V_{in}(s)$$

$$H(s) = \frac{V_o(s)}{V_{in}(s)} = \frac{1}{\frac{s}{\omega_a} + \frac{1}{K}} = \frac{K}{1 + \frac{s}{(\omega_n/K)}}$$

$$v_{in}(t) = a \sin(\omega_{in} t) \longrightarrow v_o(t)$$

$$v_o(t) = |H(\omega_{in})| \, a \sin(\omega_{in} t + \phi)$$

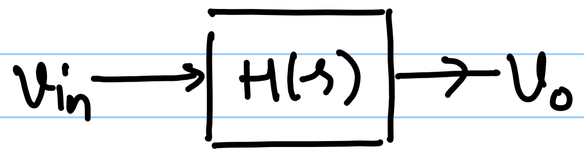
$$= a \, |H(\omega_{in})| \, \sin(\omega_{in} t + \phi)$$



$$|H(j\omega_{in})| = \frac{K}{\left| 1 + j \frac{\omega_{in}}{\omega_n/K} \right|} = \frac{K}{\sqrt{1 + \left(\frac{\omega_{in}}{\omega_n/K}\right)^2}}$$

$$\phi = -\tan^{-1}\left(\frac{\omega_{in}}{\omega_n/K}\right)$$

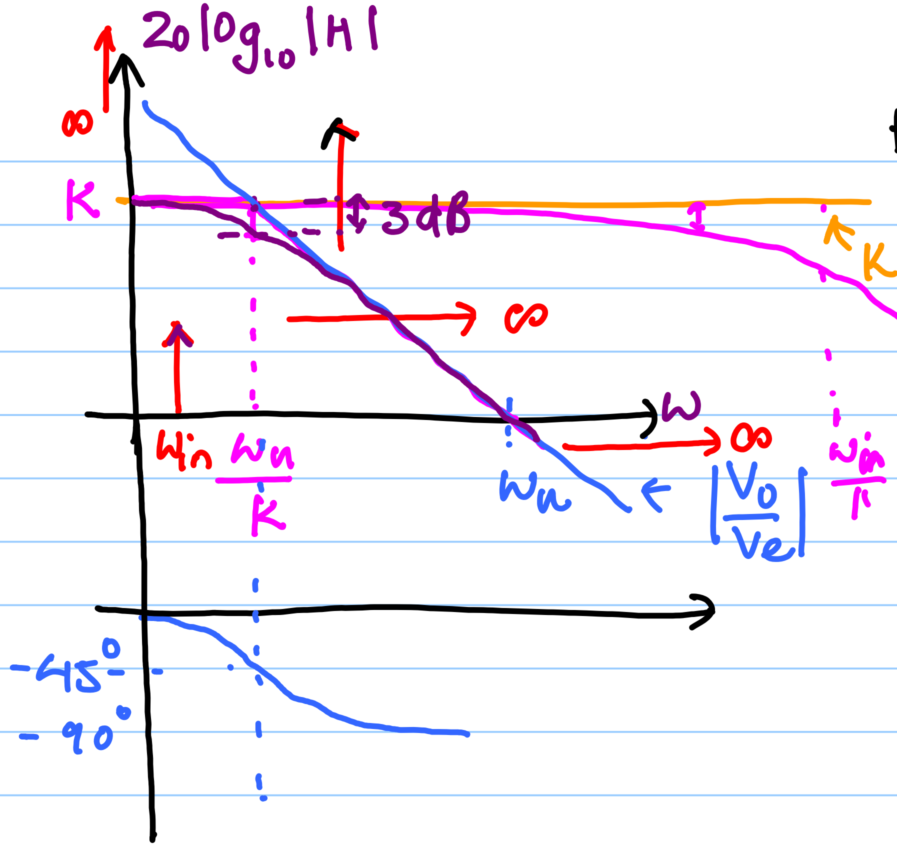
$$\measuredangle H(j\omega_{in}) = -\tan^{-1}\left(\frac{\omega_{in}}{\omega_n/K}\right)$$



$$V_o(s) = H(s) \cdot V_{in}(s)$$

$$\omega_{in} \ll \frac{\omega_n}{K} \Rightarrow |H(j\omega_{in})| \approx K$$

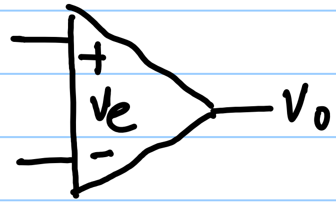
$$\measuredangle H(j\omega_{in}) \approx 0$$



$$H(s) = \frac{K}{1+\frac{s}{(\omega_n/K)}} \checkmark \rightarrow \frac{K}{\frac{\omega_n'}{\omega_n/K}} = \phi \Rightarrow \omega_n' = \omega_n$$

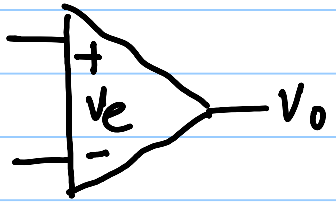
$$\frac{V_o(s)}{V_e(s)} = \frac{\omega_n}{s}$$

$$\frac{V_o}{V_e} = \frac{\omega_n \to \infty}{s}$$



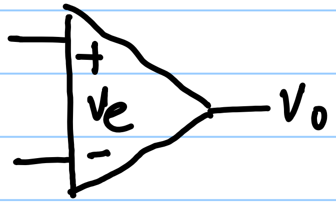
$$\frac{V_o}{V_e} = G \quad ; G \to \infty$$

#1



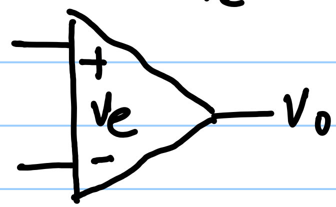
$$\frac{V_o}{V_e} = G \to \infty$$

#2



$$\frac{V_o}{V_e} = G \text{ (large)}$$

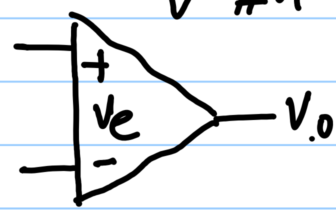
#3



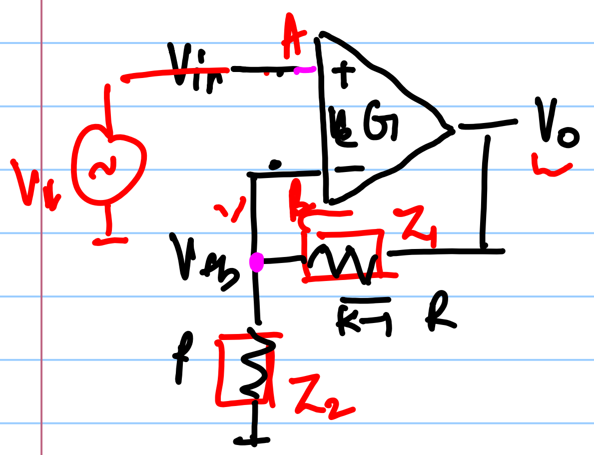
$$\frac{V_o}{V_e} = \frac{\omega_n}{s}$$

#3

#4 ✓ #4



$$\frac{V_o}{V_e} = \frac{A_{DC}}{1+s/\omega_p} \checkmark$$



$$a\left(V_{in}-\frac{V_o}{k}\right) = V_o$$

$$V_{in} = V_o\left(\frac{1}{k}+\frac{1}{a}\right)$$

$$\frac{V_o}{V_{in}} = \frac{K}{1+\frac{K}{a}}$$

$$V_e = V_{in} - \frac{V_o}{K} = \frac{V_o}{a}$$

$$= \frac{V_{in}\,(K/a)}{1+K/a}$$

$$= \frac{V_{in}}{1+a/K}$$

#1: $\underline{a\to\infty}$

$$\frac{V_o}{V_{in}} = K,\quad V_e = 0 = V_{in}-V_{fb}$$

$\Rightarrow \underline{V_{fb} = V_{in}} \rightarrow$ Virtually Short.

$$V_{fb} = \frac{Z_2}{Z_1+Z_2}V_o = V_{in} \quad \checkmark$$

#3: $\underline{a = \frac{\omega_n}{s}}$; $\frac{V_o}{V_{in}} = \frac{K}{1+\frac{s}{\omega_n/K}} \xrightarrow{s=0} K$ $\quad V_e = \frac{V_{in}}{1+\frac{\omega_n}{K\cdot s}} \rightarrow 0$