Lec 13.

$A\sin(\omega t) \rightarrow \boxed{} \rightarrow A'\sin(\omega t+\phi)$

ω influences A'/A and ω influences ϕ } Bode plot.

Understand how 0's and poles change the $\underbrace{\text{Bode plot}}$.

$|G|$ magnitude / amplitude (dB) $= 20\log_{10}|G| = G_{DB}$
$\angle G$ phase

$G(s)$: $s=\sigma+j\omega \rightarrow \sigma=0 \rightarrow G(\omega)$

write $G(\omega)$ as: $K_o \dfrac{(j\omega\tau_1+1)(j\omega\tau_2+1)\cdots}{(j\omega\tau_a+1)(j\omega\tau_b+1)\cdots} \rightarrow |G|_{dB} = 20\log_{10}K_o + 20\log_{10}(j\omega\tau_1+1) + 20\log_{10}(j\omega\tau_2+1) - 20\log_{10}(j\omega\tau_a+1) - 20\log_{10}(j\omega\tau_b+1)\ldots$

3 types of terms:

1) $K_o(j\omega)^n \quad n\in\mathbb{Z}$

2) $(j\omega\tau+1)^{\pm1}$ ← 1 = zero, -1 = pole.

3) $\left[\left(\dfrac{j\omega}{\omega_n}\right)^2 + 2\zeta\dfrac{j\omega}{\omega_n}+1\right]^{\pm1}$ ← complex conj poles/zeros.

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1) $\log_{10}|1| = \underbrace{20\log_{10}|K_o|}_{b} + \underbrace{20n}_{m}\underbrace{\log_{10}\omega}_{x}$ ← mag

phase → $\angle j^n = 0$.

$n=2$	$\phi=180$
$n=1$	90
$n=0$	$+0$
$n=-1$	-90
$n=-2$	-180

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2) $(j\omega\tau+1)^1$ ← zero.

2 cases:

$\omega\tau \ll 1 \rightarrow 1$

$\omega\tau \gg 1 \rightarrow j\omega\tau$

$\angle j\omega\tau+1 \approx 0$

$\angle j\omega\tau+1 \approx 90°$

$\omega = \frac{1}{\tau}$ = break point
↓
plug in
$j\omega\tau+1 = j+1$.
$|j+1| = 1.4 \rightarrow 3\text{dB}$
$\angle j+1 = \pi/4$

$\angle \frac{j\omega+1}{j+1} = ↗$

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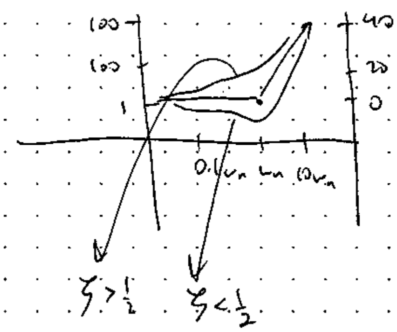
3) $\frac{\omega}{\omega_n} \ll 1$ #3 → 1 phase = 0

$\frac{\omega}{\omega_n} \gg 1$ #3 → $\left(\frac{j\omega}{\omega_n}\right)^2$ phase = 180



$\omega = \omega_n$ phase = 90°