Announcement : (1) No tutorial tmrw

(2) Quiz 2 on Nov 20, 4pm

Pattern : 4 MCQ + 2 "Essay" (Scan & Upload)

Sequential mode

Upload answer for each "essay" qn

Time on eduserver includes upload

Syllabus: Graph Theory & Network Topology

2pm - 4pm

* 4pm - 6pm

Essay - Free?

Time?

Mark Dist?

Bode - Plots

Example: $Z(s) = \dfrac{5\times 10^4 s}{s^2 + 505 s + 2500}$

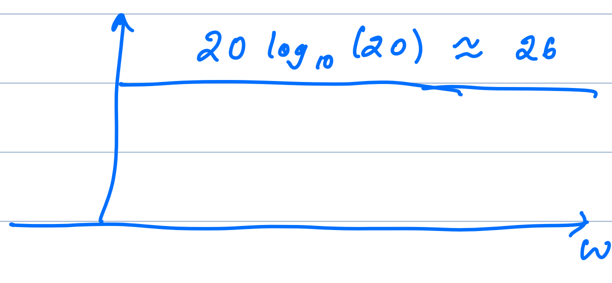
$= \dfrac{5\times 10^4 s}{(s+500)(s+5)}$

$(1+s\tau)$

$= \dfrac{5 \cancel{\times 10^4} s \quad 20}{\cancel{500}\left(1+\frac{s}{500}\right)\cancel{5}\left(1+s/5\right)}$

$= \dfrac{20 \cdot s}{\left(1+\frac{s}{500}\right)\left(1+\frac{s}{5}\right)}$

Bode plot of $Z(s)$ = Sum of Bode plot of each of these "component"



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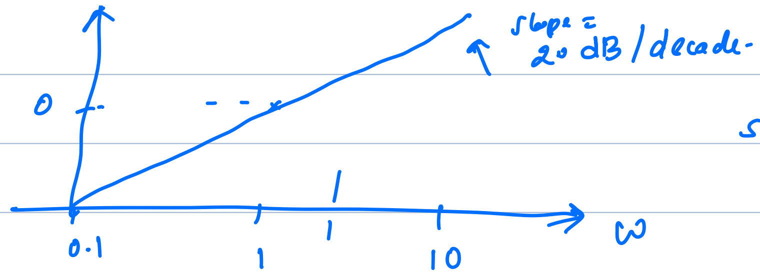
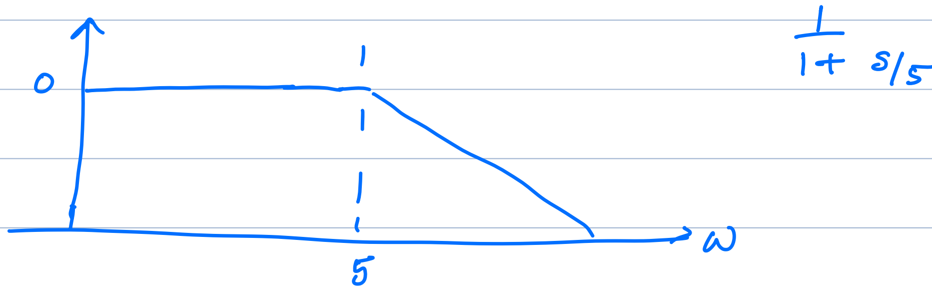
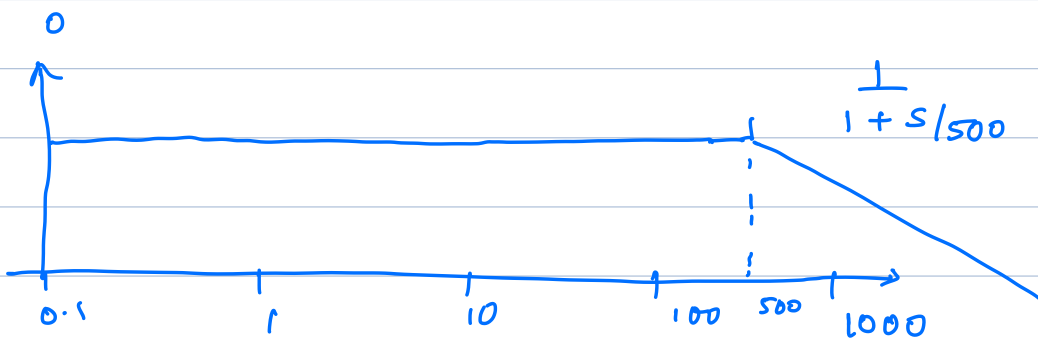
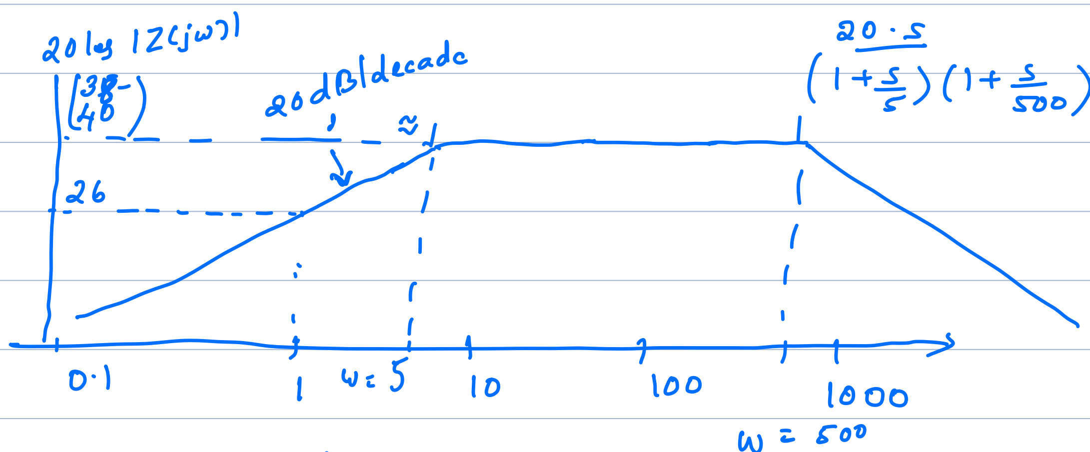






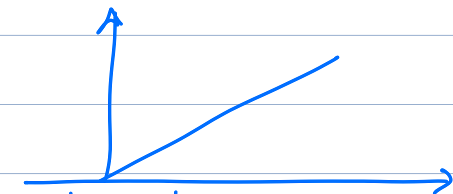


Exercise: Phase response!

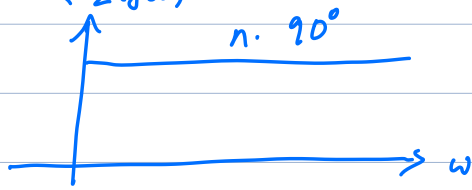
Case 6: Repeated poles & zeros

$$Z(s) = s^n$$

$$20 \log |Z(j\omega)| = 20n \log(\omega)$$

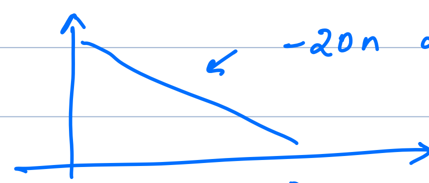


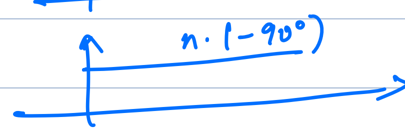
$\angle Z(j\omega)$



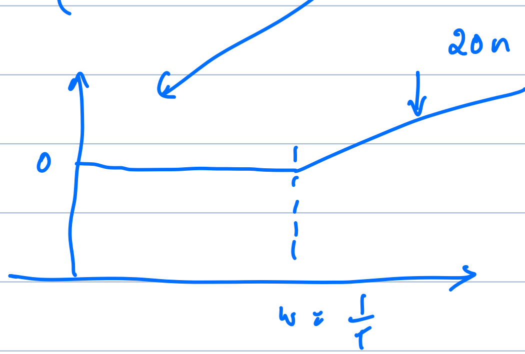
$$Z(j\omega) = (j\omega)^n$$

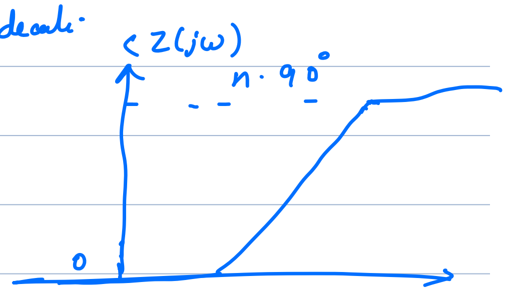
$$Z(s) = \frac{1}{s^n}$$





Case 7: $Z(s) = \dfrac{1}{(1+sT)^n}$ $Z(s) = (1+sT)^n$





Case 8: 2nd order system (Complex conjugate poles)

$$Z(s) = \frac{1}{s^2 + 2\zeta\omega_n \cdot s + \omega_n^2}$$

xeta

$$s = -2\zeta\omega_n \pm \sqrt{4\zeta^2\omega_n^2 - 4\cdot\omega_n^2}$$

$$= \frac{\quad}{2}$$

$$= \omega_n \left(-\zeta \pm \sqrt{\zeta^2 - 1}\right) \qquad \zeta > 1$$

$0 < \zeta < 1$

$$= \omega_n \left(-\zeta \pm j\sqrt{1-\zeta^2}\right)$$

$$Z(s) = \frac{1}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

$$= \frac{1}{\underbrace{\omega_n^2}\,\left(\underbrace{(1/\omega_n)^2 s^2 + 2(\zeta/\omega_n)s + 1}\right)}$$

$$\hat{Z}(s) = \frac{1}{\left(\frac{1}{\omega_n}\right)^2 s^2 + 2(\zeta/\omega_n)s + 1}$$

$$\hat{Z}(j\omega) = \frac{1}{1 - \frac{\omega^3}{\omega_n^2} + j \cdot 2\frac{\zeta\omega}{\omega_n}}$$

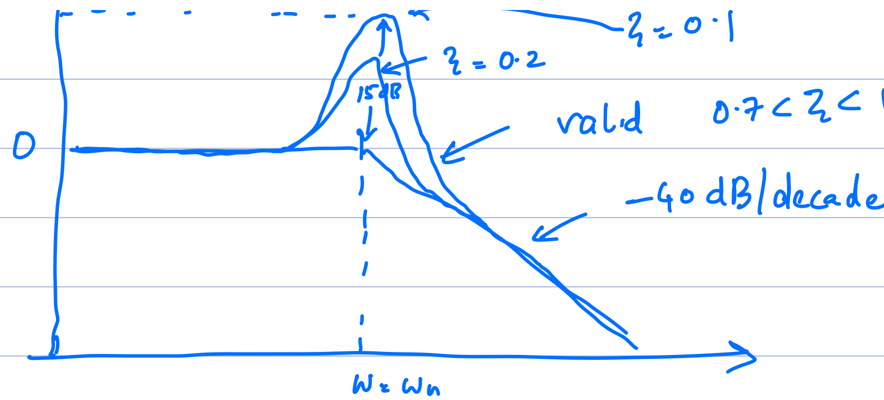
$$20\log|\hat{Z}(j\omega)| = -20\log\left[\Big(\underbrace{1 - \frac{\omega^2}{\omega_n^2}}_{\left(\frac{\omega}{\omega_n}\right)^4}\Big)^2 + \underbrace{\left(\frac{2\zeta\omega}{\omega_n}\right)^2}_{(\omega/\omega_n)^2}\right]^{\frac{1}{2}}$$

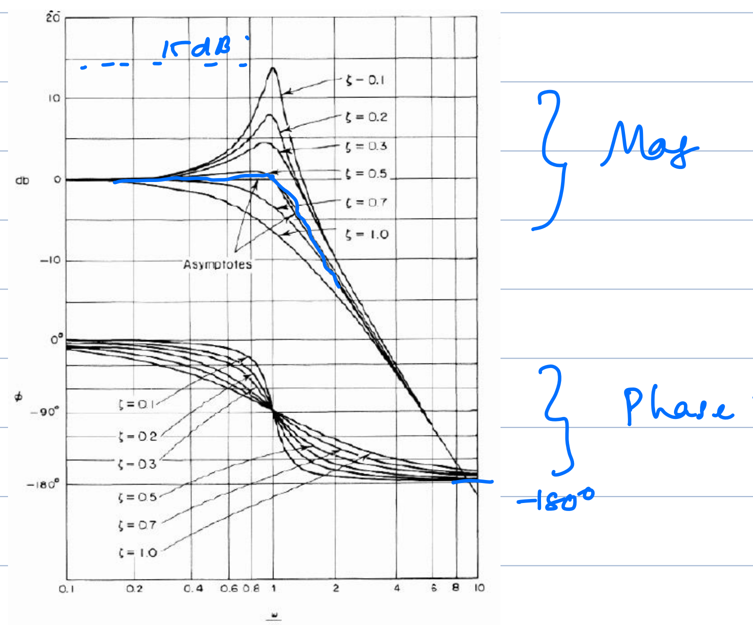
$$\approx \left(\frac{\omega}{\omega_n}\right)^4$$

$\omega << \omega_n$ $\qquad 20\log|\hat{Z}(j\omega)| = 0$

$\omega >> \omega_n$ $\qquad 20\log|\hat{Z}(j\omega)| = -20\log(\omega/\omega_n)^2$

$$= -40\log(\omega/\omega_n)$$

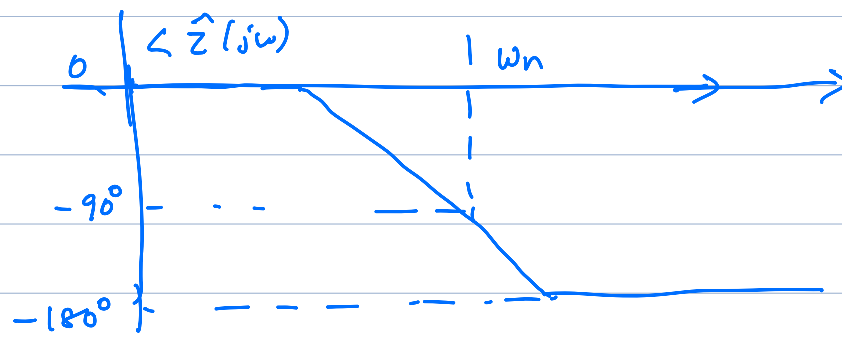




$$\angle \hat{Z}(j\omega) = -\tan^{-1}\frac{2\zeta(\omega/\omega_n)}{1-(\omega/\omega_n)^2} \qquad \omega = \omega_n$$

$\omega \ll \omega_n \qquad \angle \hat{Z}(j\omega) = 0$

$\omega \gg \omega_n \qquad \angle \hat{Z}(j\omega) = -180^\circ$



" Hayt " , " Control systems "