# EENG307: Bode Plots for Second Order Systems and Additional Terms[1]

## Lecture 26

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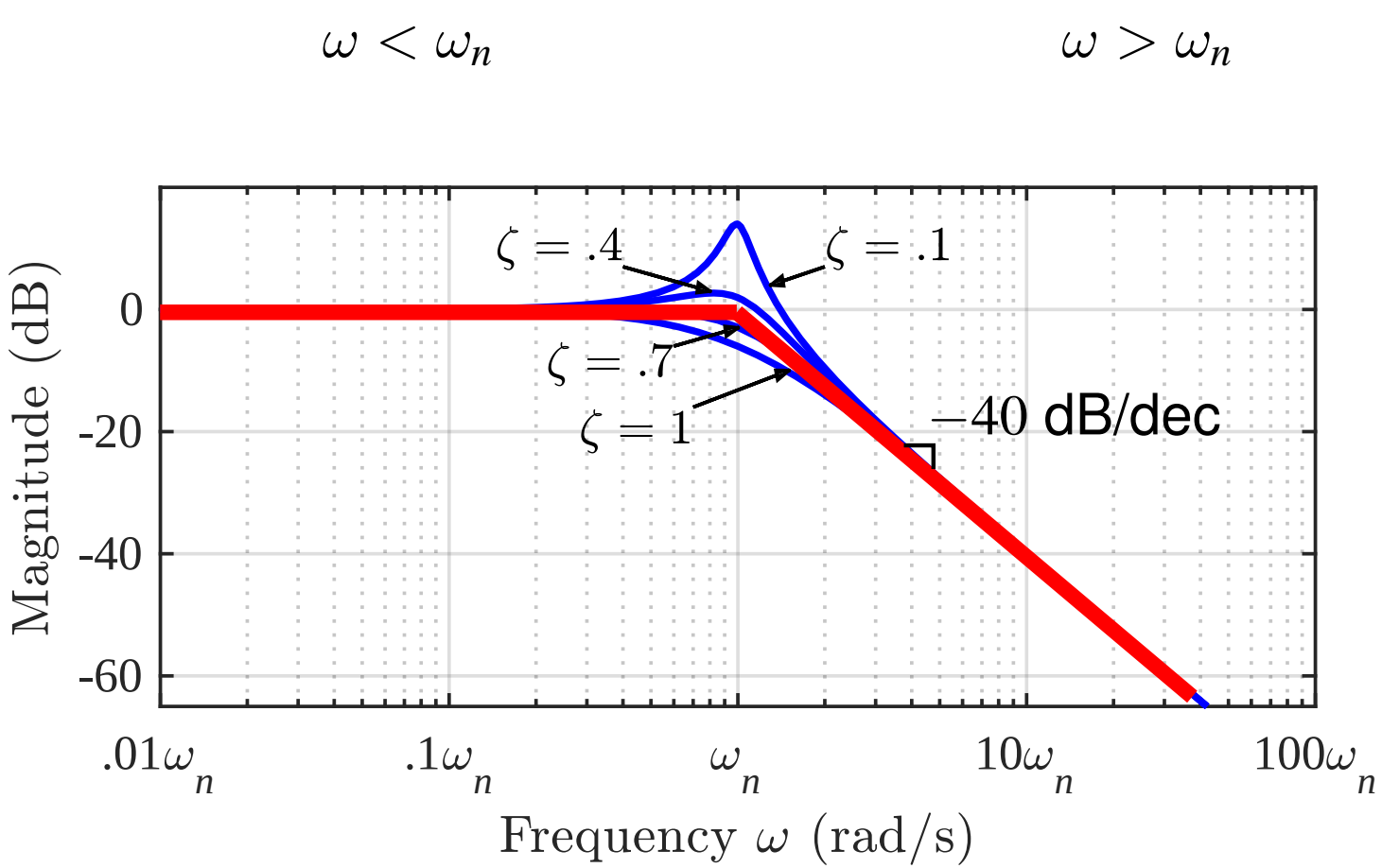
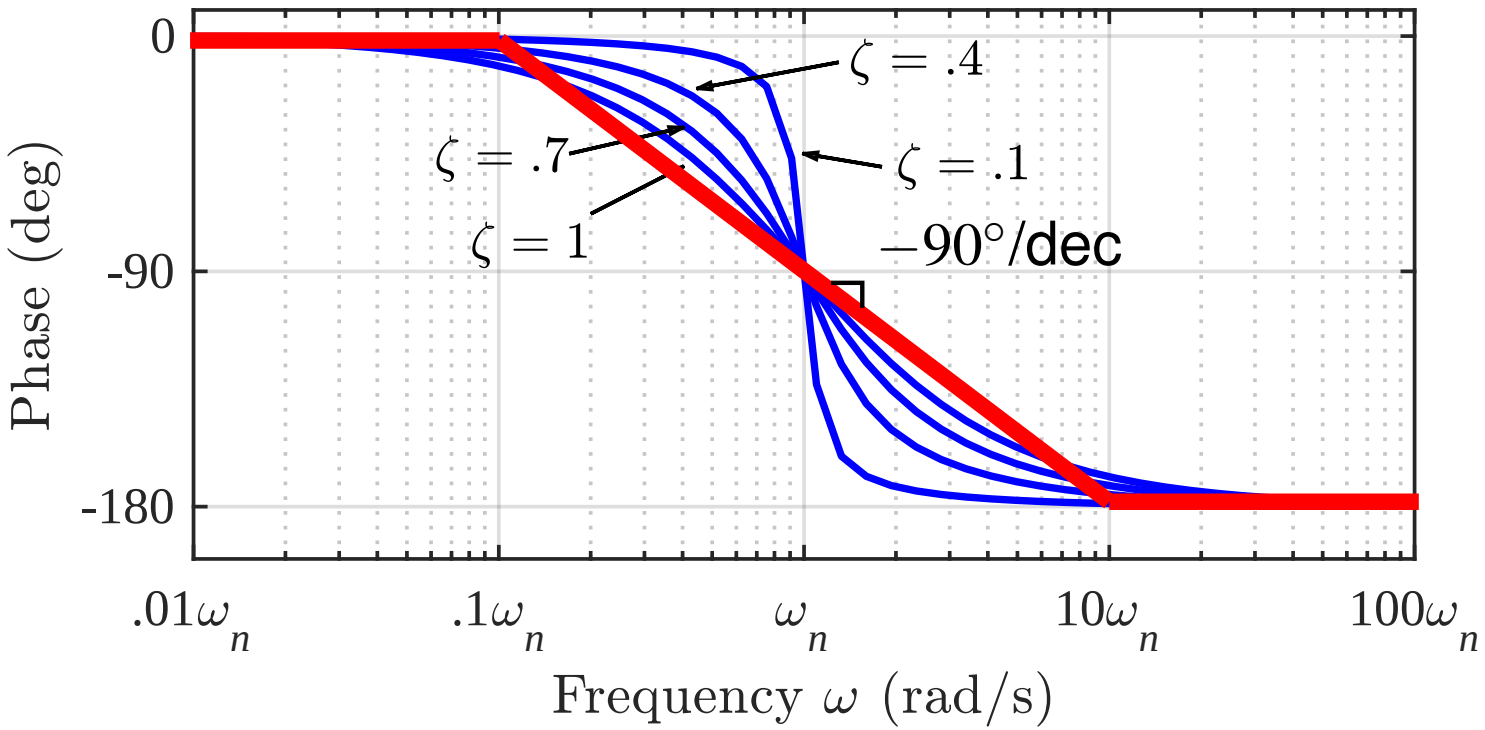
# Magnitude Response for Second Order System with Linear Approximation

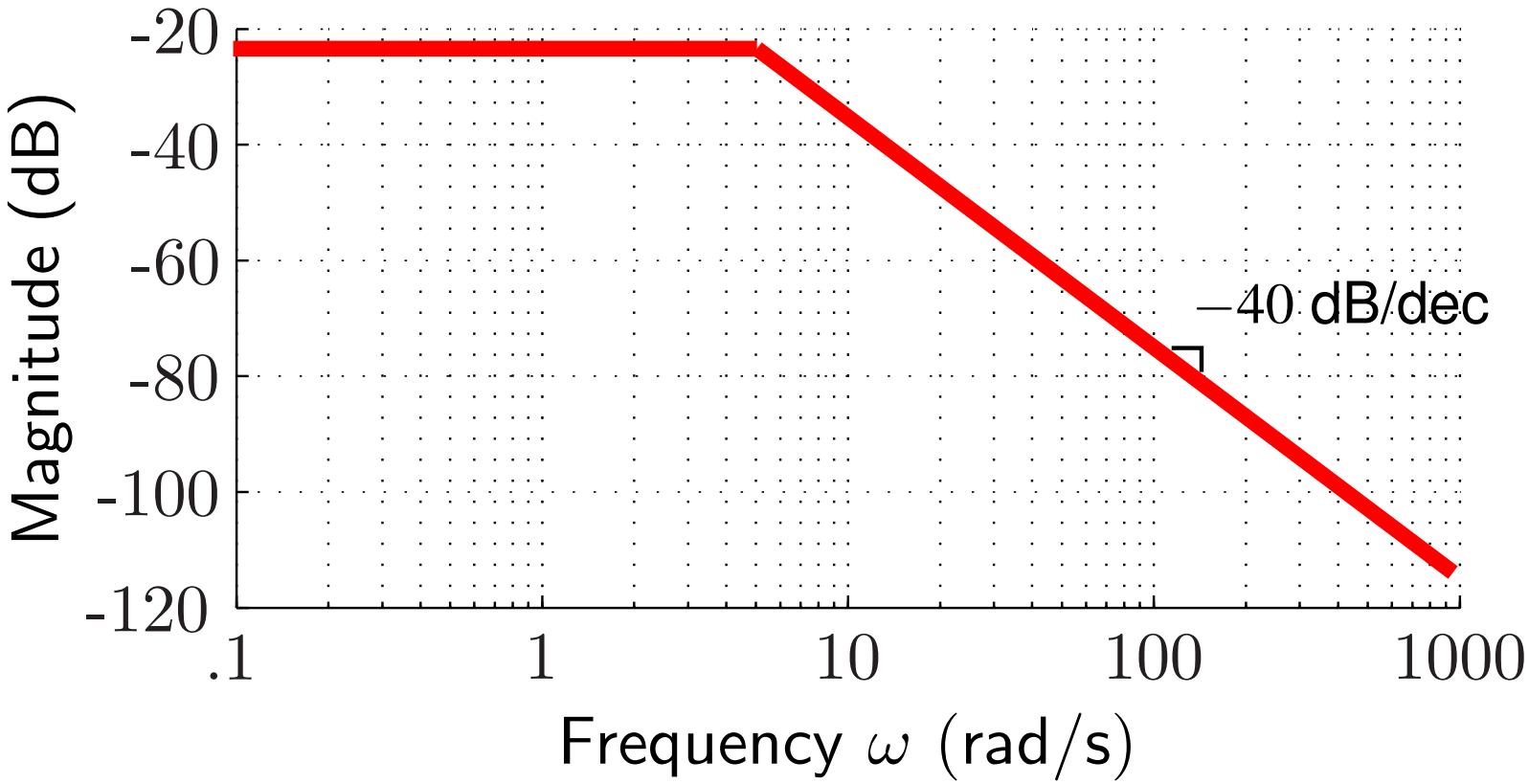


# Phase Response for Second Order System with Linear Approximation

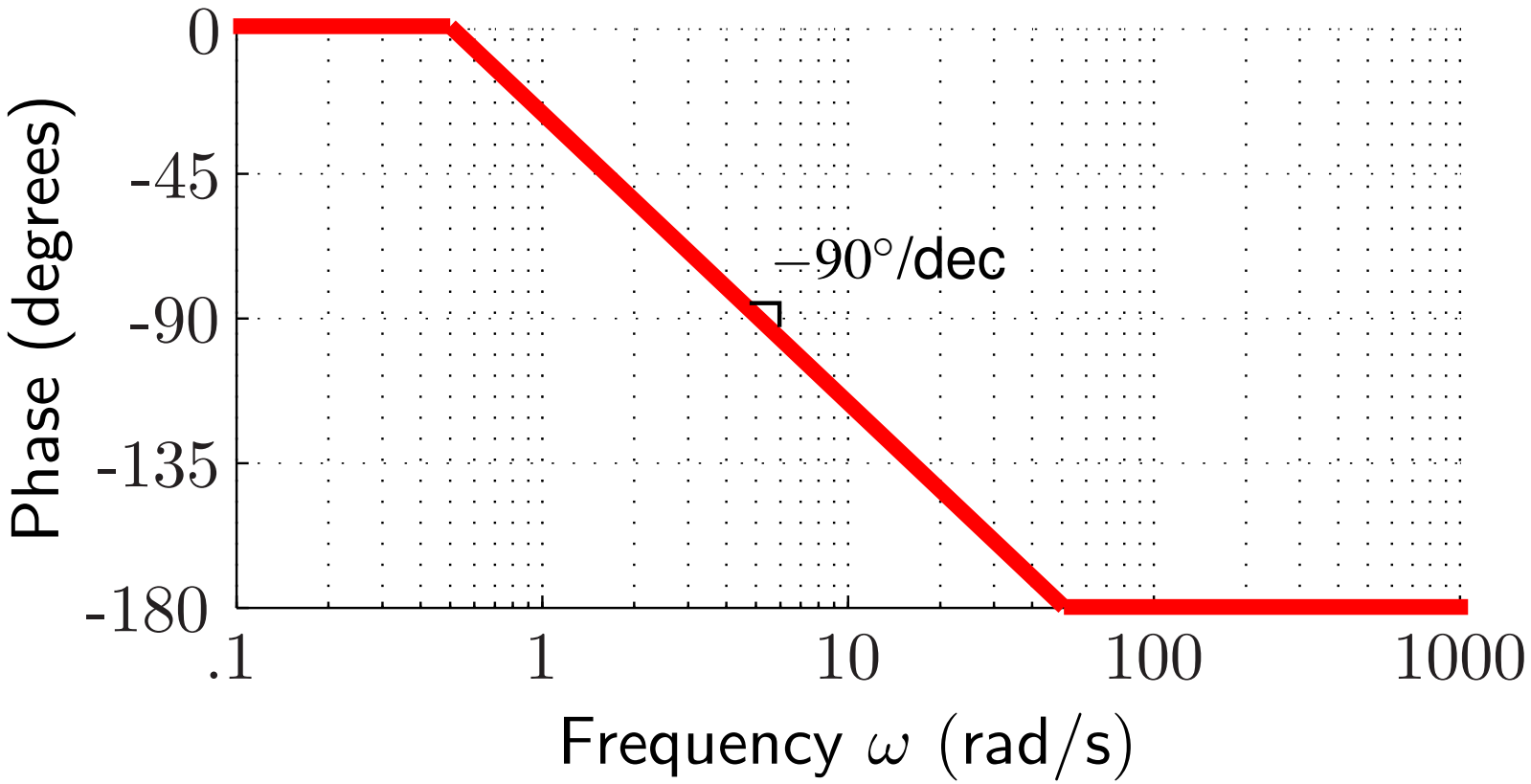
$\omega < \frac{\omega_n}{10}$ $\qquad$ $\frac{\omega_n}{10} < \omega < 10\omega_n$ $\qquad$ $\omega > 10\omega_n$



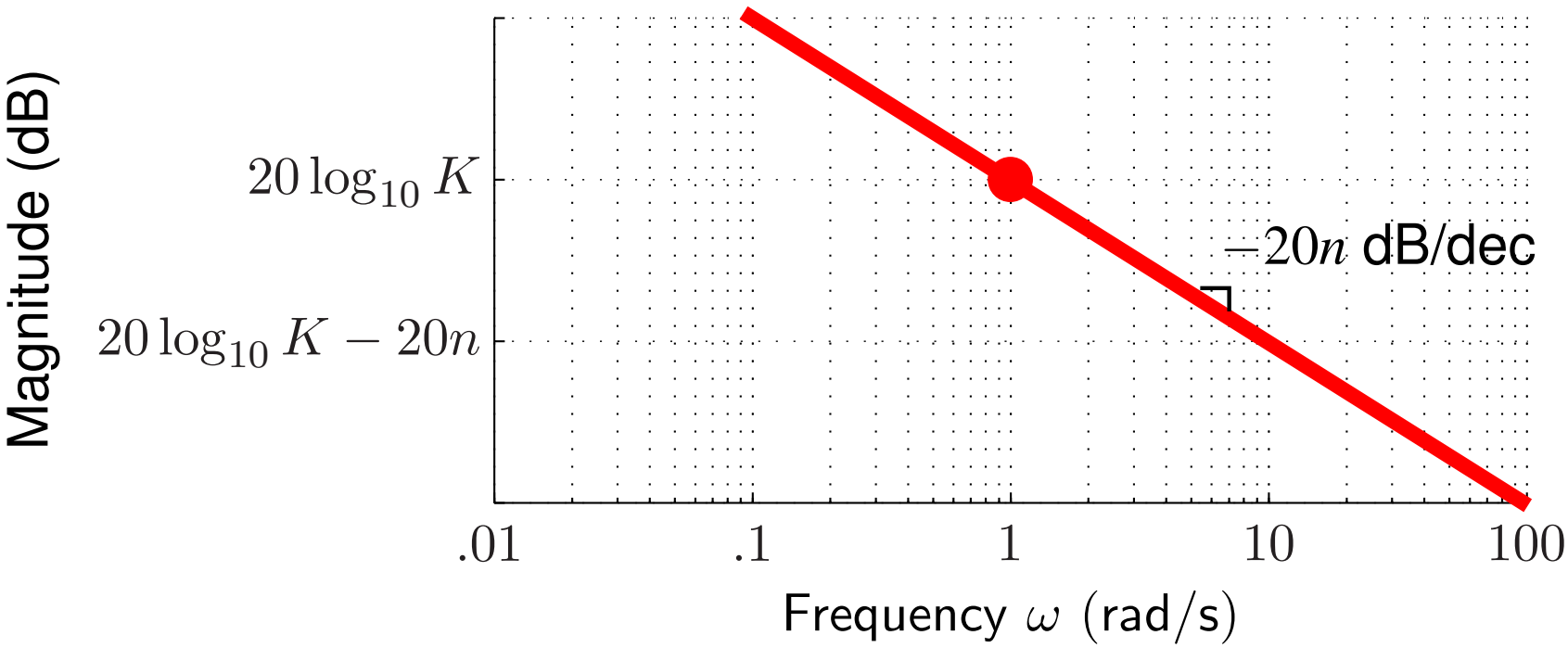
# Magnitude Response



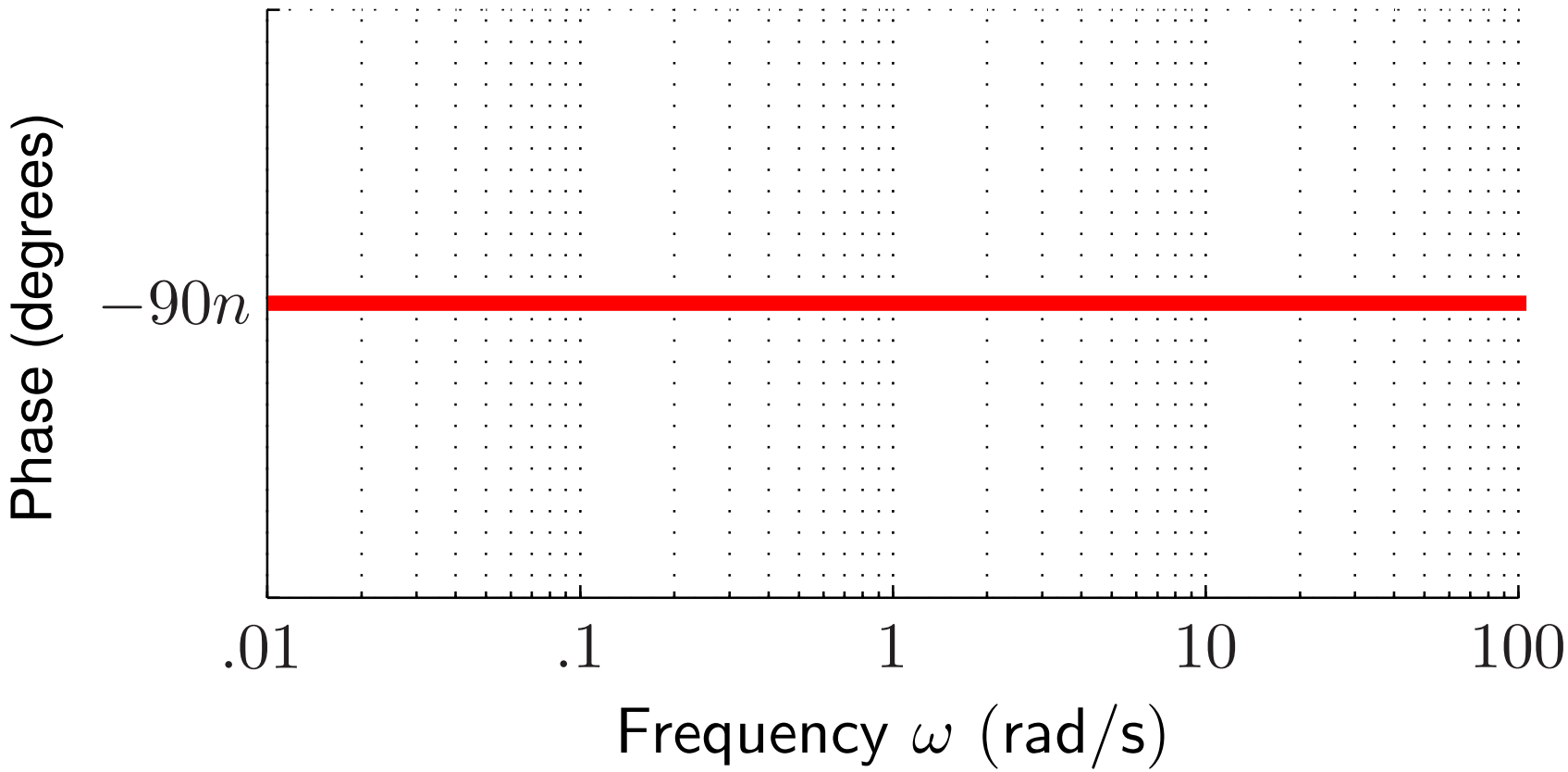
# Phase Response



# Multiple Integrator Magnitude Response

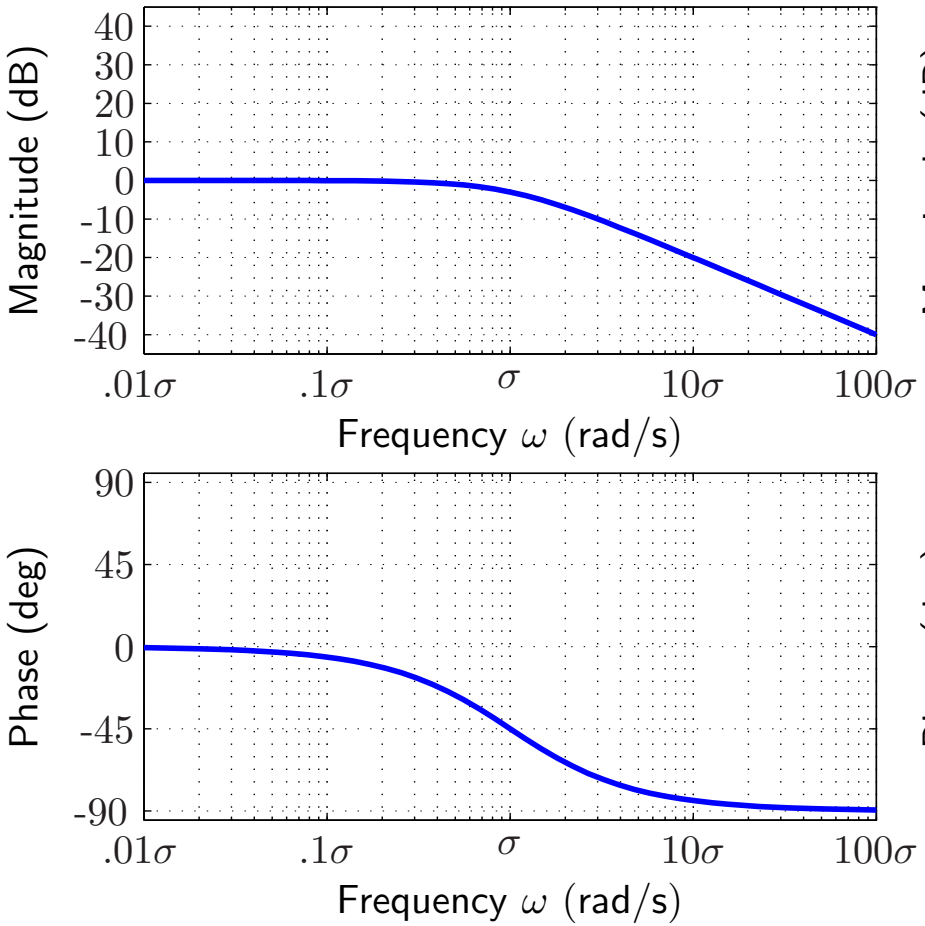


# Multiple Integrator Phase Response

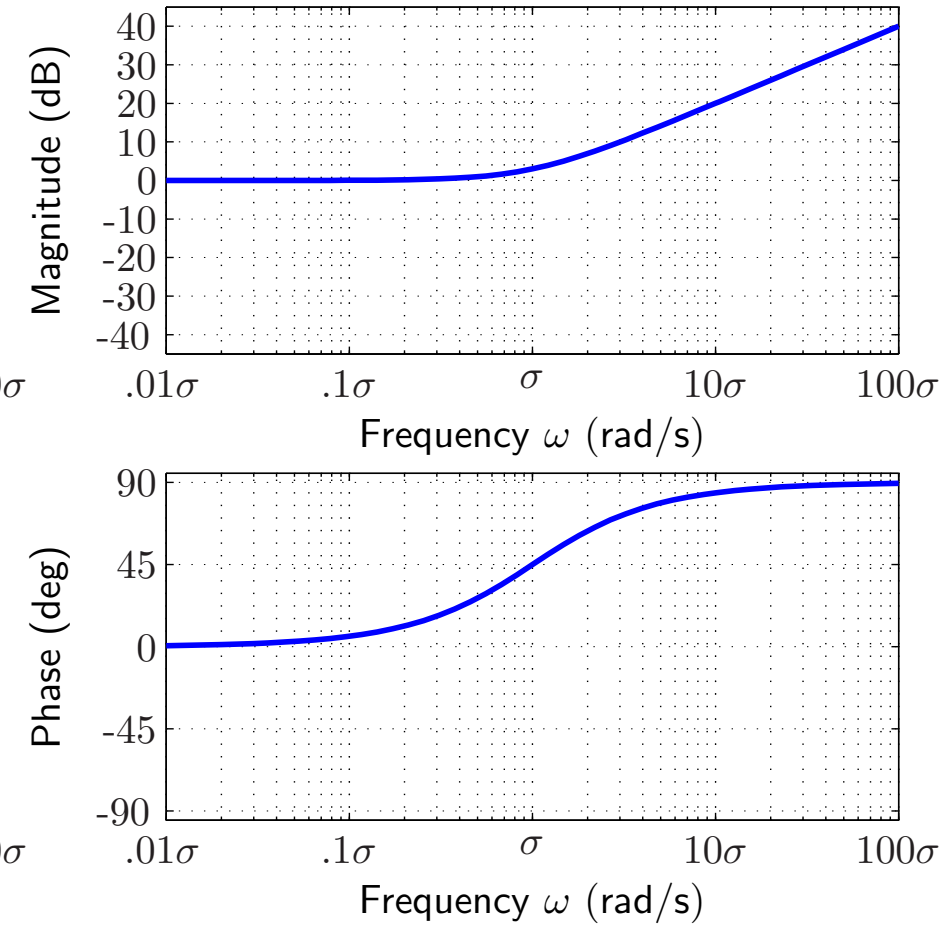


# Comparison of single pole and single zero systems

$$G(s) = \frac{\sigma}{s+\sigma}$$



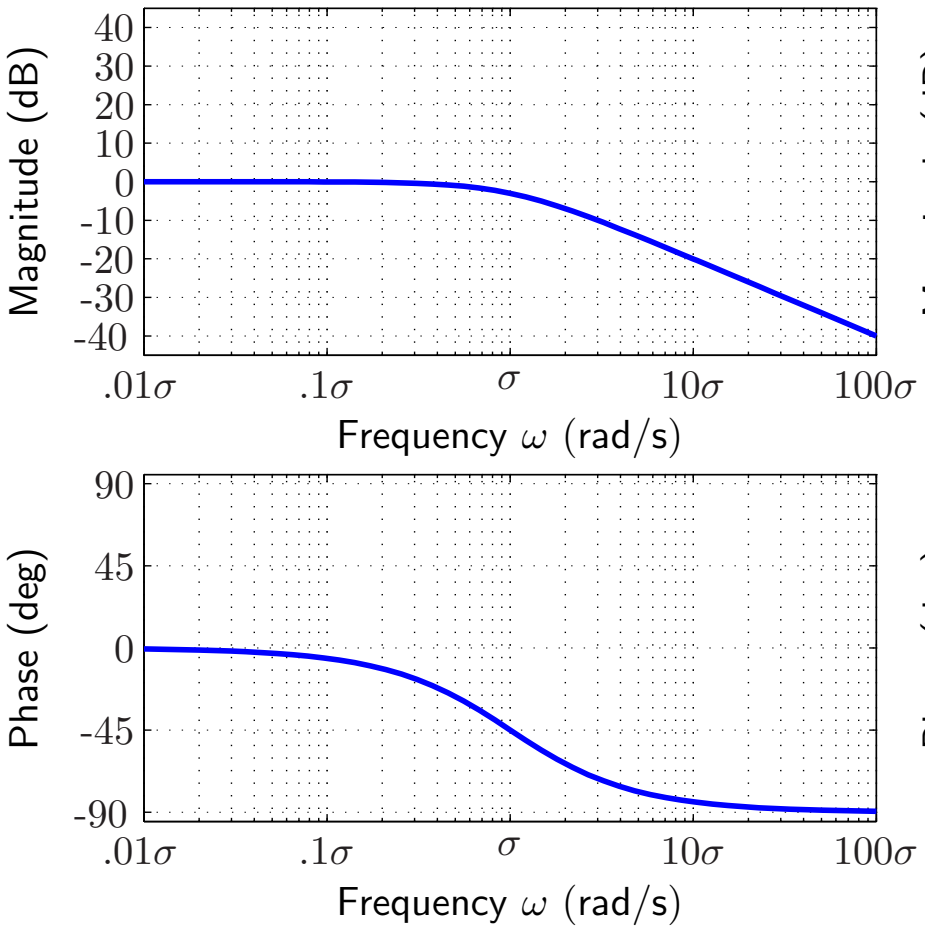

$$G(s) = \frac{s+\sigma}{\sigma}$$



# Comparison of LHP and RHP pole systems

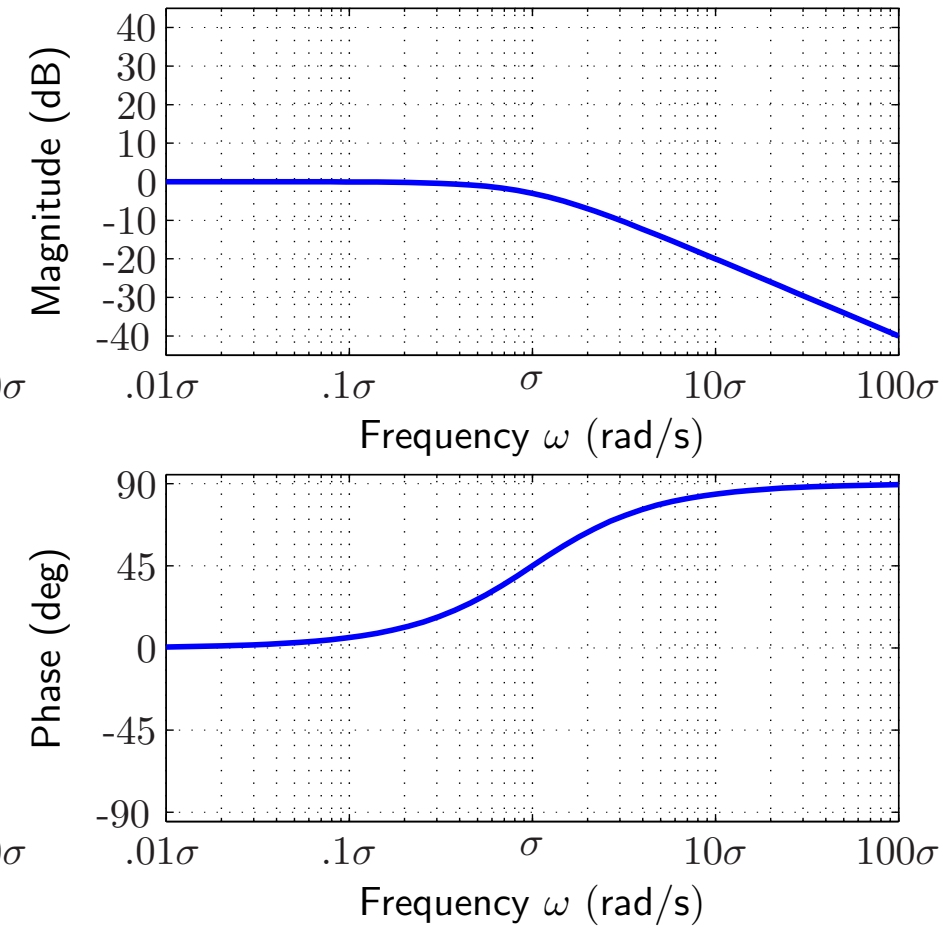
## LHP Pole

$$G(s) = \frac{\sigma}{s+\sigma}$$




## RHP Pole

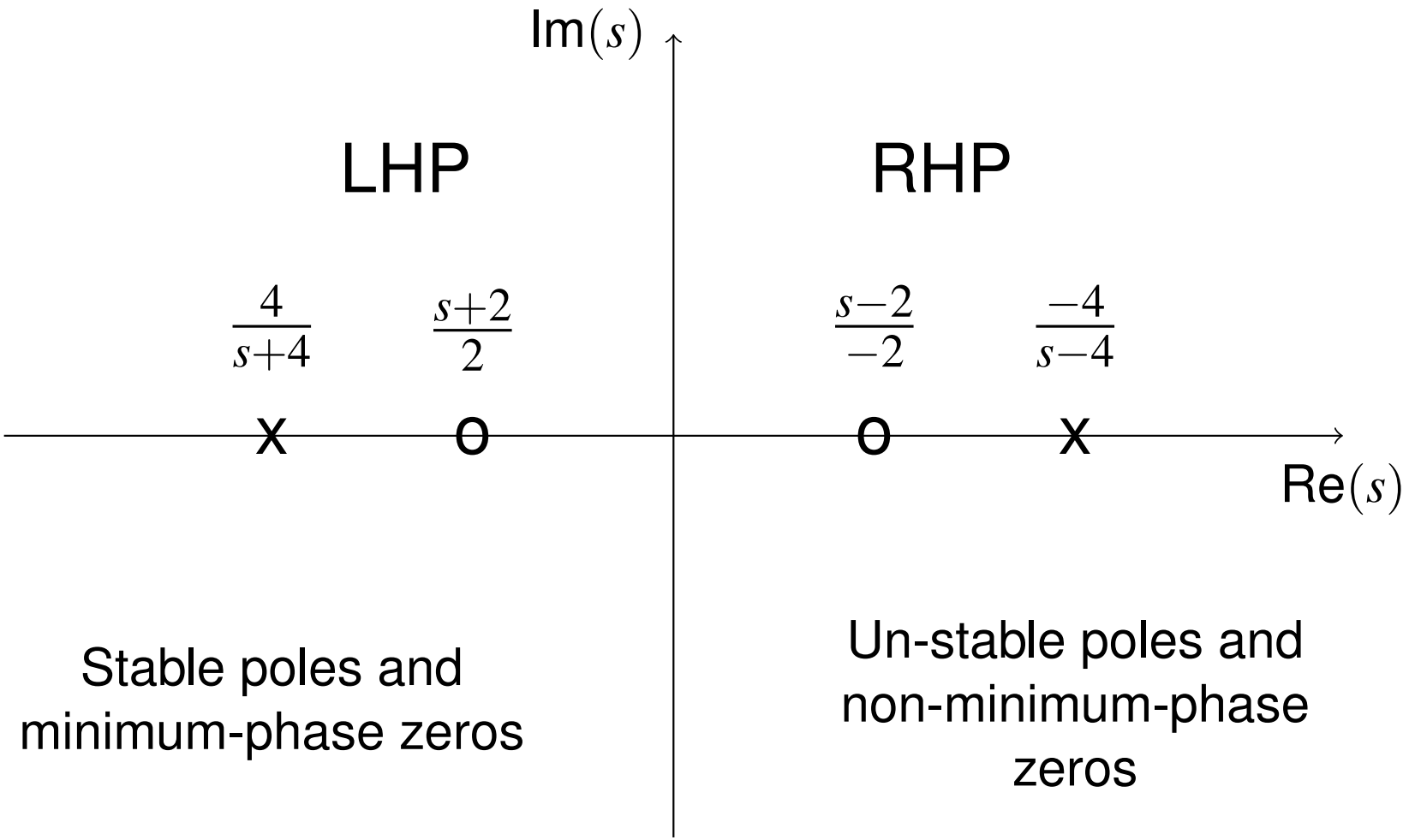
$$G(s) = \frac{-\sigma}{s-\sigma}$$



1. Are the magnitude plots the same or different? Does this answer make sense given that all we have changed in the transfer function is the sign?
2. Are the phase plots the same or different? Does this answer make sense given that all we have changed in the transfer function is the sign?

| Item (Pole/Zero?) | Location | How Many? | Slope of Magnitude | Slope of Phase |
|---|---|---|---|---|
| Zero | LHP | 1 | 20 dB/dec | 45°/dec |
| | RHP | 1 | 20 dB/dec | -45°/dec |
| | LHP | 2 | 40 dB/dec | 90°/dec |
| | RHP | 2 | 40 dB/dec | -90°/dec |
| | $s = 0$ (derivative) | $n$ | $20n$ dB/dec | 0°/dec at $90n$° |
| Pole | LHP | 1 | -20 dB/dec | -45°/dec |
| | RHP | 1 | -20 dB/dec | 45°/dec |
| | LHP | 2 | -40 dB/dec | -90°/dec |
| | RHP | 2 | -40 dB/dec | 90°/dec |
| | $s = 0$ (integrator) | $n$ | $-20n$ dB/dec | 0°/dec at -$90n$° |

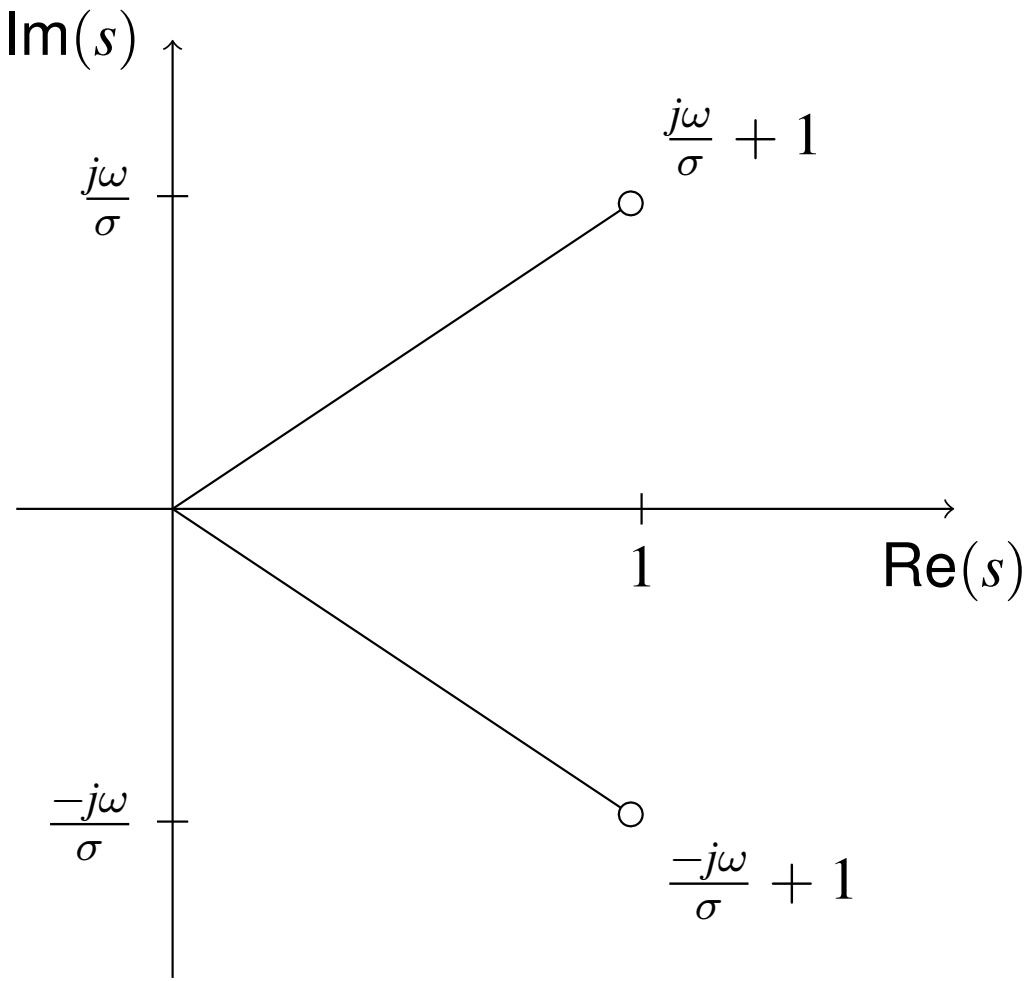
# Right half plane poles and zeros




Stable poles and minimum-phase zeros

Un-stable poles and non-minimum-phase zeros

# Comparison of terms in LHP and RHP




Same magnitude, but opposite phase