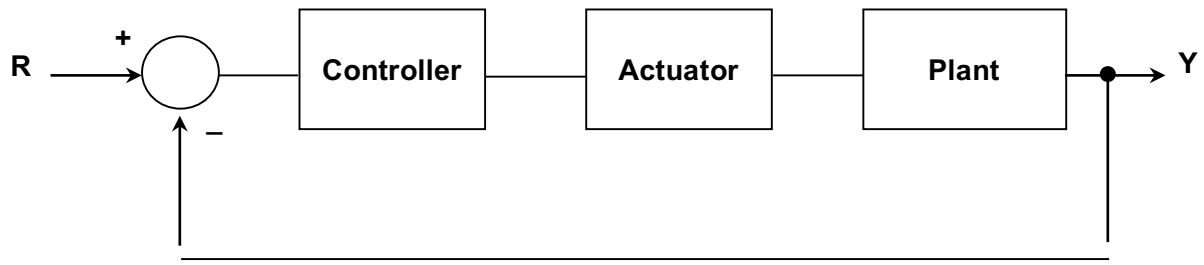
Problem 1 [100 pts]



Consider the closed-loop system above that consists of a Controller, Actuator, and a Plant. The Bode Amplitude and Phase responses of the Actuator and Plant are provided on the next two pages.

a.) Using the appropriate Bode response plots, construct a zero-pole-gain representation of the transfer function for the Actuator dynamics. [6pts]

b.) Using the appropriate Bode response plots, construct a zero-pole-gain representation of the transfer function for the Plant dynamics. [4pts]

c.) What are the Natural Frequency and Damping Ratio of the Plant? [4pts]

d.) Construct a zero-pole-gain representation of the transfer function for the combined Actuator*Plant system dynamics. [6pts]

e.) Using your result from (d), determine the Bode Gain at $\omega = 0$ rad/s (or the DC gain) of the combined Actuator*Plant system, and express your result in both dB and decimal units. [4pts]

f.) What is the relative degree of the open-loop Actuator*Plant system? Is it strictly proper? [4pts]

g.) Sketch the Bode Amplitude Response Curve for the combined Actuator*Plant system on the graph provided. Include any and all appropriate gains, breakpoints, asymptotes, attenuation rates, and resonance peaks. [20pts]

h.) Sketch the Bode Phase Response Curve for the combined Actuator*Plant system on the graph provided. [20pts]

i.) From your sketches, determine the Gain and Phase Crossovers, and the Gain and Phase Margins. Mark and label them on your sketches. [8pts]

GC= PC= GM = PM =

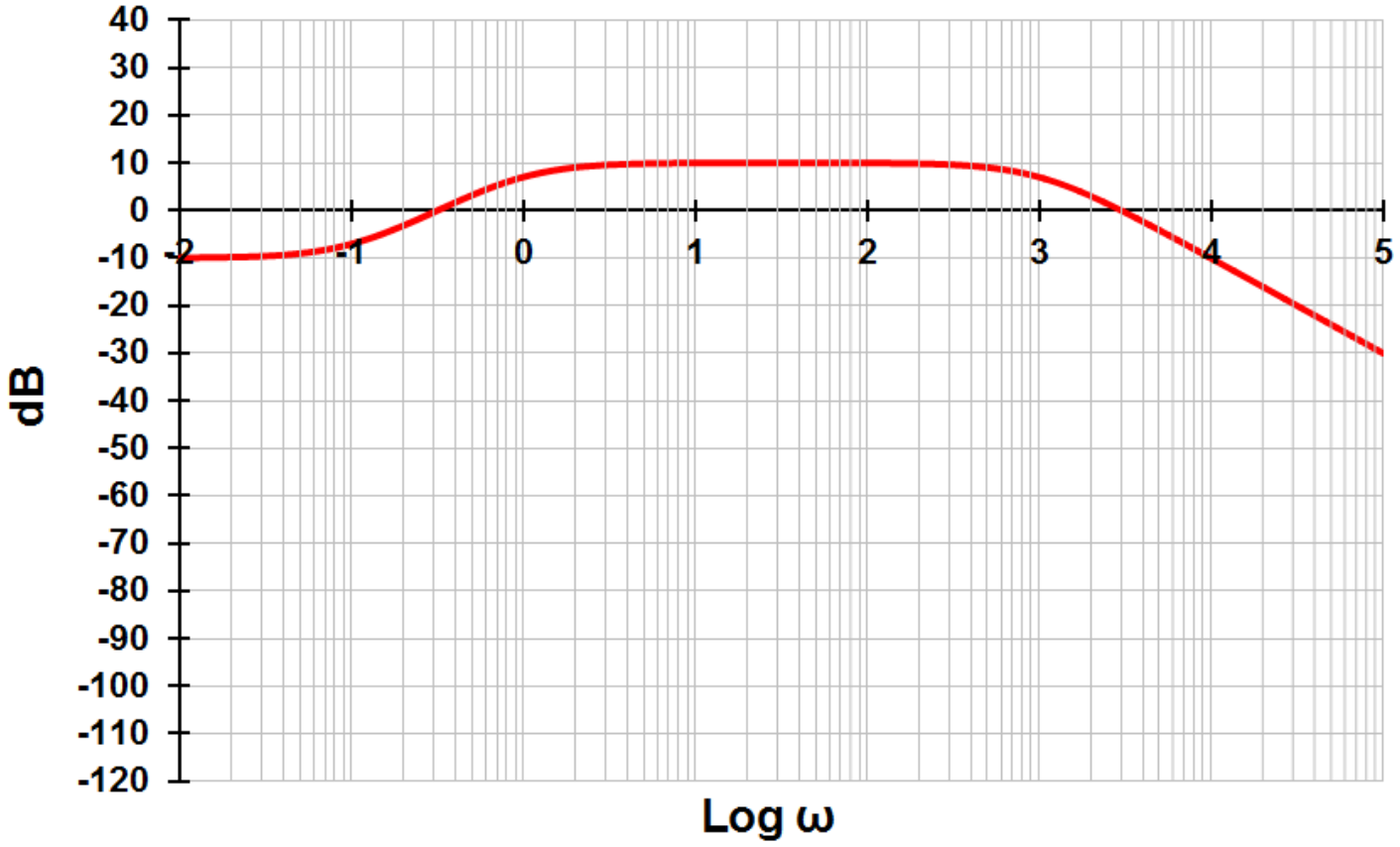
j.) Assuming that the Controller is just a unity gain, discuss the relative stability of the combined Actuator*Plant. Does it follow recommended design practice? [4pts]

k.) Discuss stability of the combined Actuator*Plant if the unity Controller gain is increased by a factor of 10 [4pts].

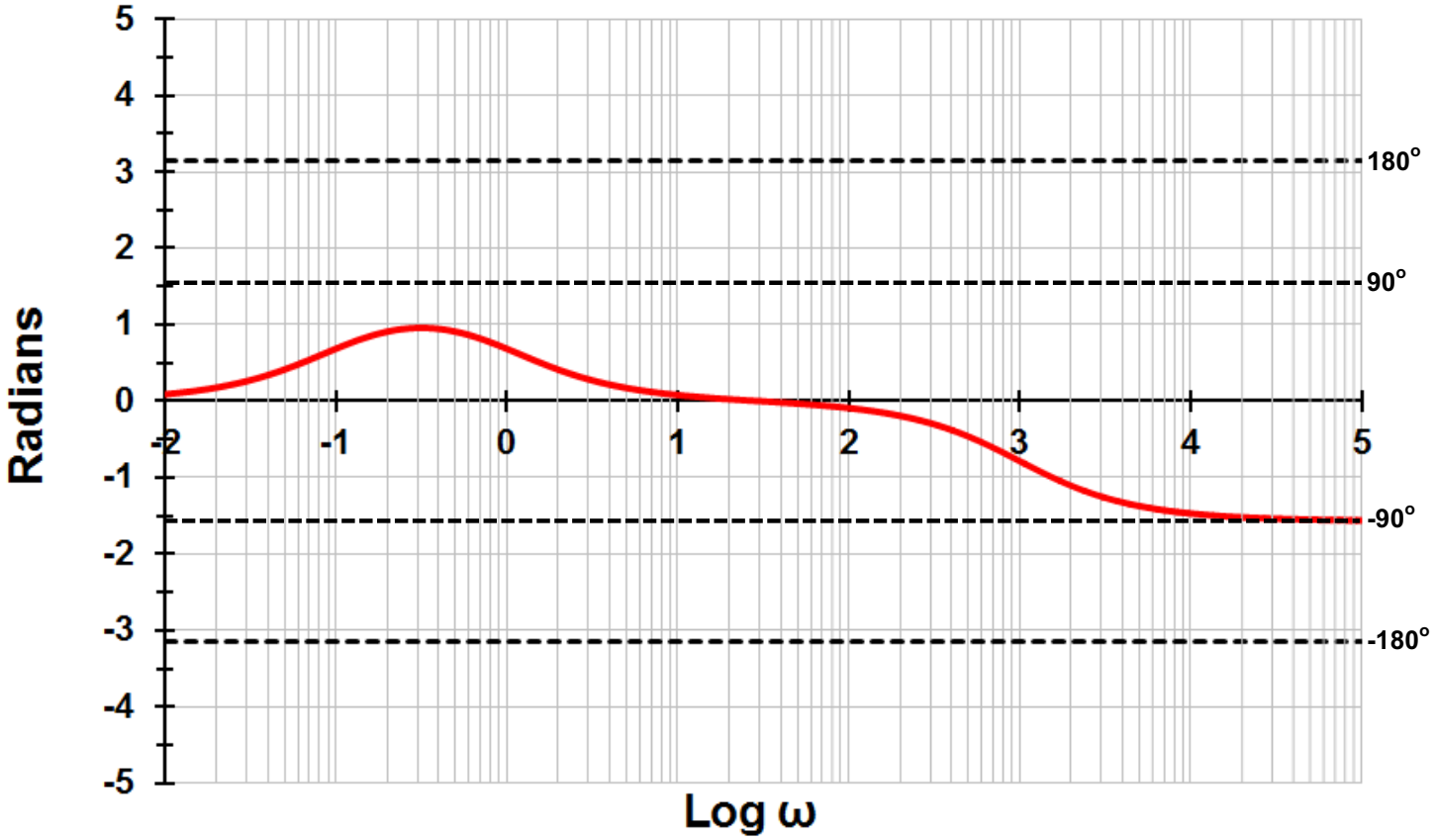
l.) Design a new controller to create a total system that:
Is flat in the passband,
Has unity gain in the passband,
Has a cutoff frequency of 100 rad/sec,
Has a stable controller. [12pts]

m.) Describe the nature of your controller [4pts]

ACTUATOR



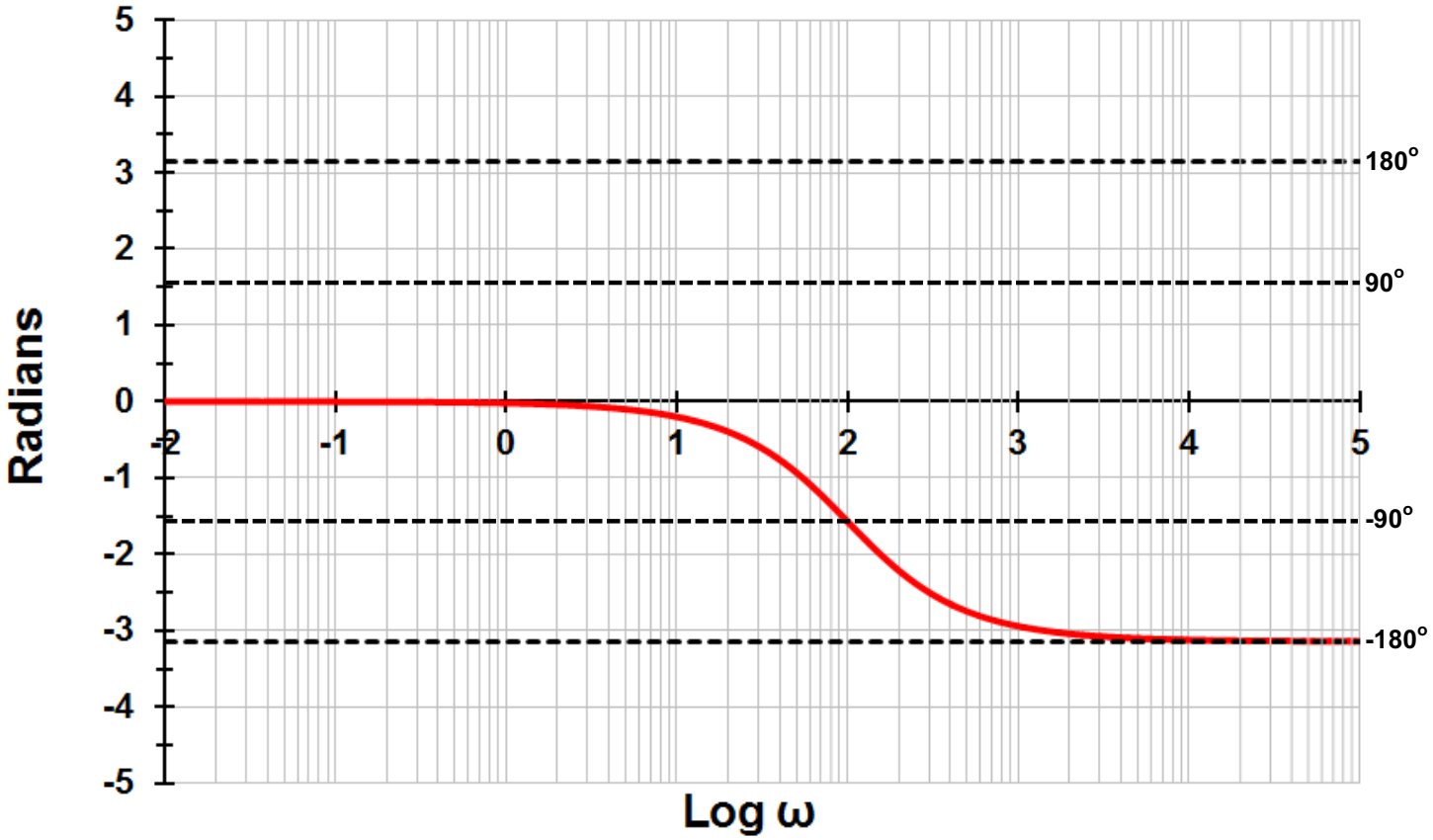
ω is in units of rad/s



ω is in units of rad/s

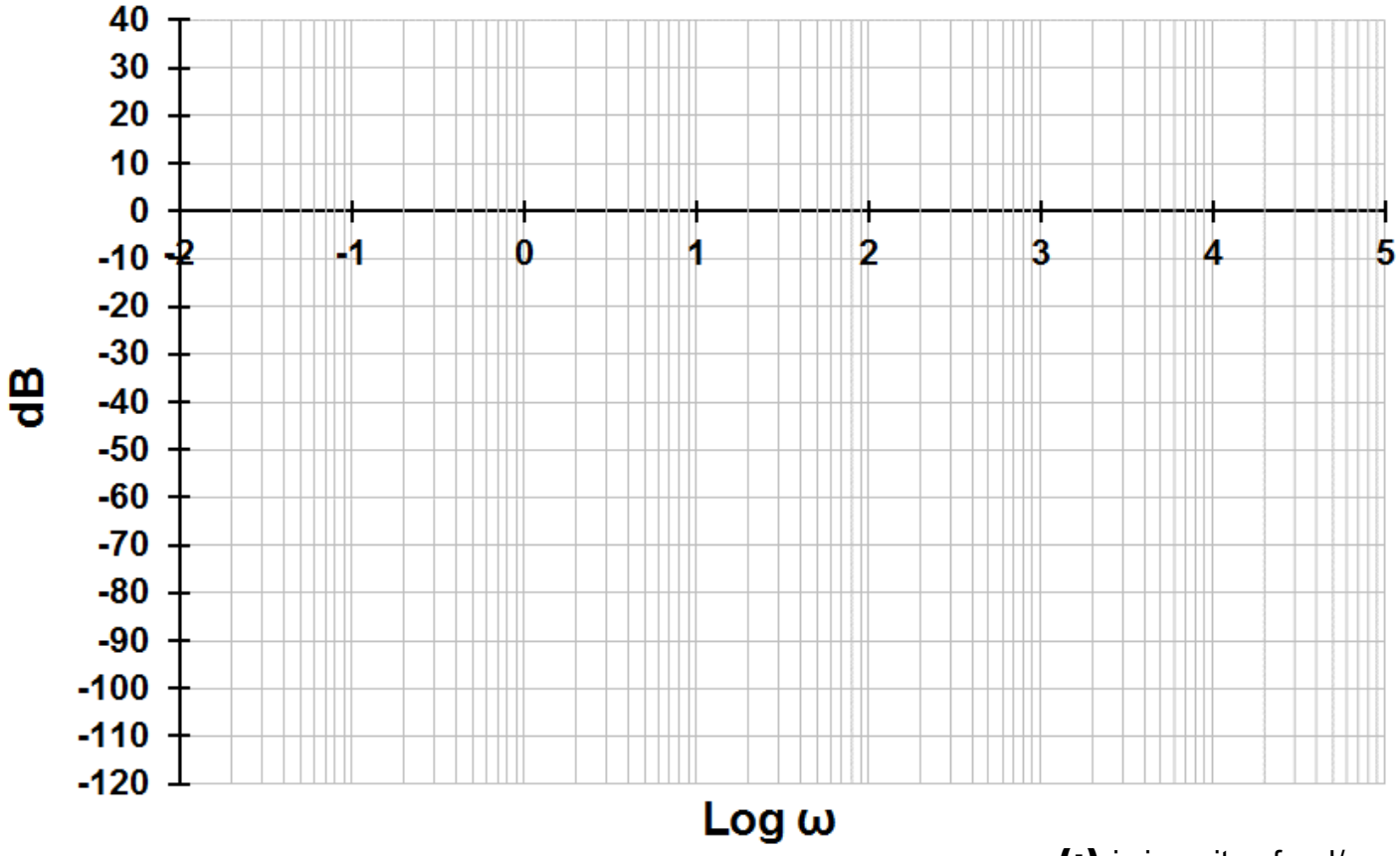
PLANT

ω is in units of rad/s

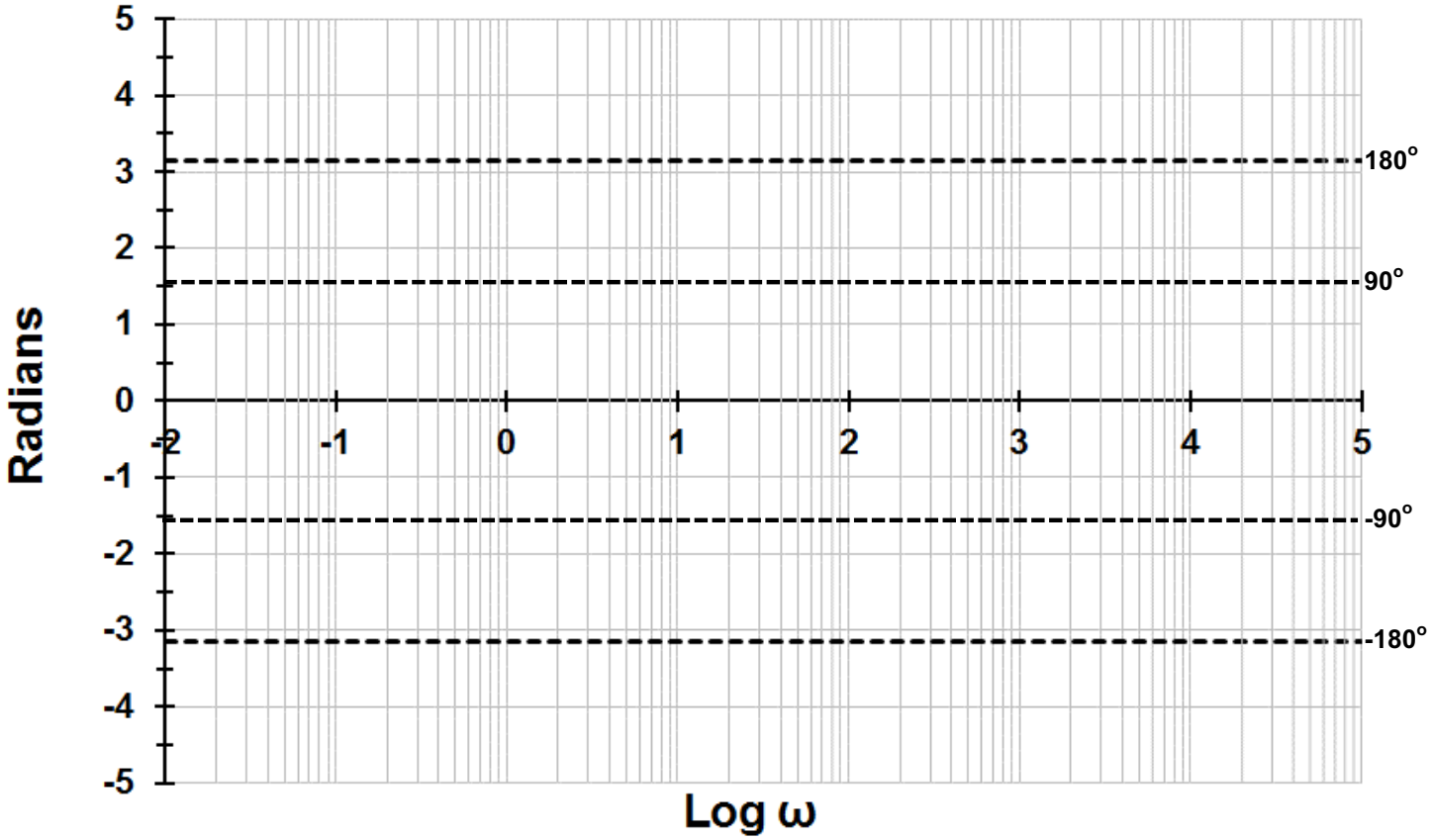


ω is in units of rad/s

COMBINED ACTUATOR AND PLANT SYSTEM

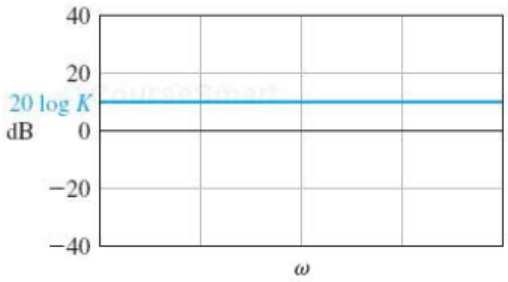
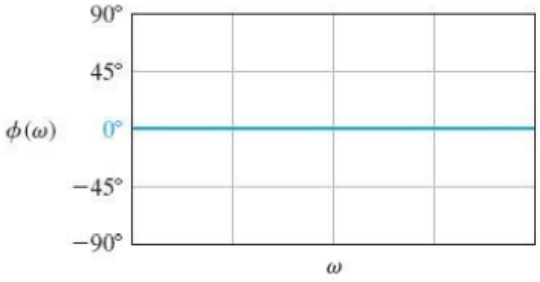
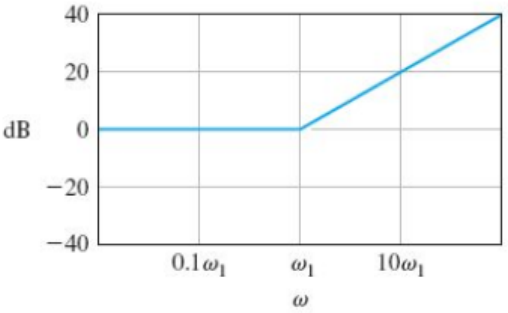
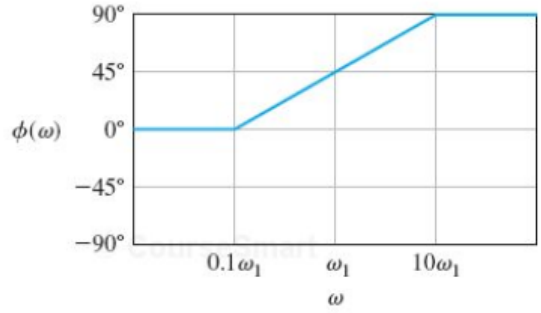
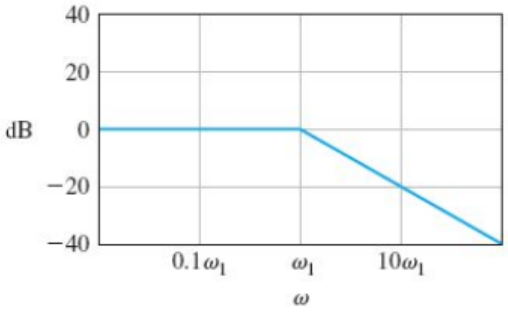
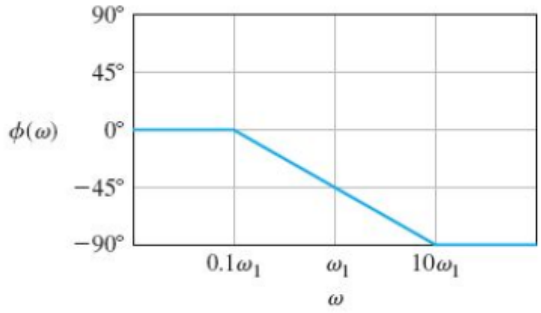
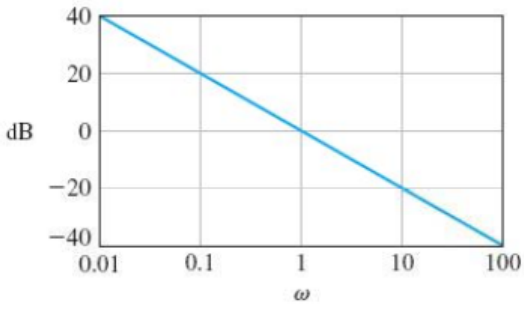
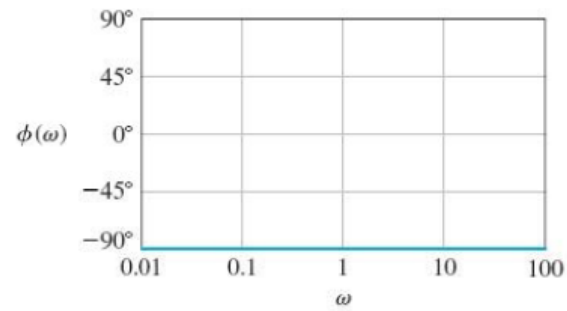


ω is in units of rad/s



ω is in units of rad/s

FOR REFERENCE

Term	Magnitude 20 log $\|G\|$	Phase $\phi(\omega)$
1. Gain, $G(j\omega) = K$		
2. Zero, $G(j\omega) = 1 + j\omega/\omega_1$		
3. Pole, $G(j\omega) = (1 + j\omega/\omega_1)^{-1}$		
4. Pole at the origin, $G(j\omega) = 1/j\omega$		
5. Two complex poles, $0.1 < \zeta < 1$, $G(j\omega) = (1 + j2\zeta u - u^2)^{-1}$ $u = \omega/\omega_n$