ME-221
PROBLEM SET 12

Problem 1

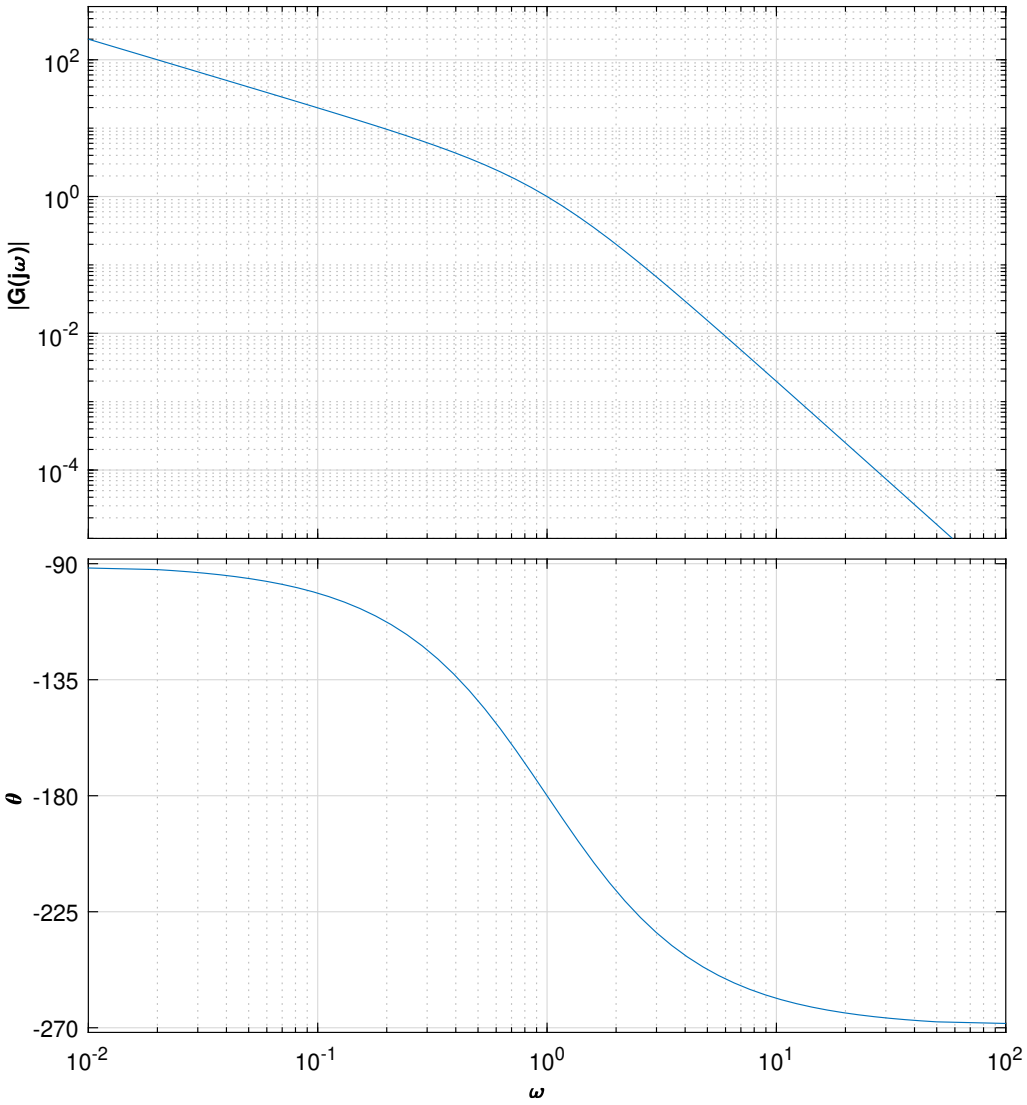
Consider the system described by the following transfer function.

$$G(s) = \frac{6}{(s+1)^2(s+2)}$$

Sketch the Bode diagram first and use the magnitude and phase information to sketch the Nyquist plot.

Problem 2

Consider a dynamical system with the following Bode Diagram.



a) Calculate the transfer function of the system $G(s)$. What is the order of the system and where are the poles located? Find the static gain and the time constant of the system.

b) Sketch the Nyquist plot.

c) Imagine that we want to design a first order filter (denoted by the transfer function $F(s)$) with a zero at -1. The filtered system is expected to have a magnitude of 1 and phase shift of -145° at $\omega = 1$ rad/s. Find the gain and the time constant of $F(s)$ that would lead to the desired specifications. Note that, the transfer function of the filtered system $G_f(s)$ is simply the product of the transfer function of the original system and the transfer function of the first order filter (i.e. $G_f(s) = G(s)F(s)$).

Problem 3

Consider a mechanical system with the following transfer function.

$$G(s) = \frac{2(s+1)}{10s+1}e^{-2s}$$

a) Sketch the Bode plot (magnitude + phase).

b) Calculate the output of the system for the input $u(t) = 10sin(t)$ using the Bode plot.

c) Sketch the Nyquist plot with and without the e^{-2s} term.

d) We would like to design a first order filter $F(s) = \frac{\alpha s+1}{s+1}$ in a way that the new system with the transfer function $G'(s) = G(s) \times F(s)$ has a phase shift of $\phi = -120^\circ$ at $\omega = 1$ rad/s. Find the value of α.

Problem 4

Determine the effect of the parameter τ on the magnitude plot of the following transfer function.

$$G(s) = \frac{\tau s+1}{(s^2+4.8s+64)(s^2+36s+8100)}$$

Is it possible to choose a value for τ to increase the gain at low frequencies?

Problem 5

Explain the differences between the Bode and Nyquist plots of the following two transfer functions:

$$G_1(s) = \frac{1}{(s^2+0.5s+1)} \quad G_2(s) = \frac{1}{(s^2+2s+1)}$$