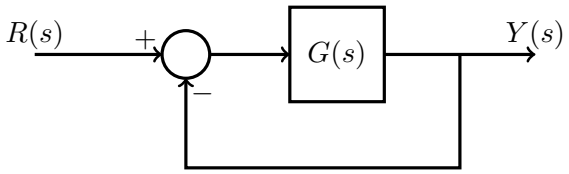
EENG307: Intro to Feedback Control

Spring 2020

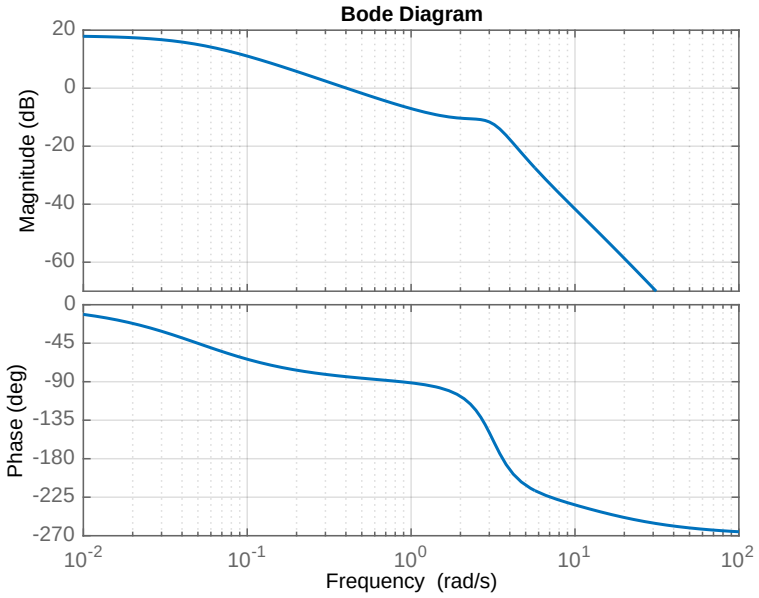
Homework Assignment #12

Due: Friday, May 1st, 11:59pm

1. Consider following unity gain feedback system.



The Bode plot of $G(s)$ is shown below. $G(s)$ is BIBO stable.



Estimate the following characteristics of the feedback control system.

(a) Gain margin:

(b) Frequency at which gain margin is measured:

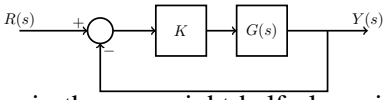
(c) Phase margin:

(d) Frequency at which phase margin is measured:

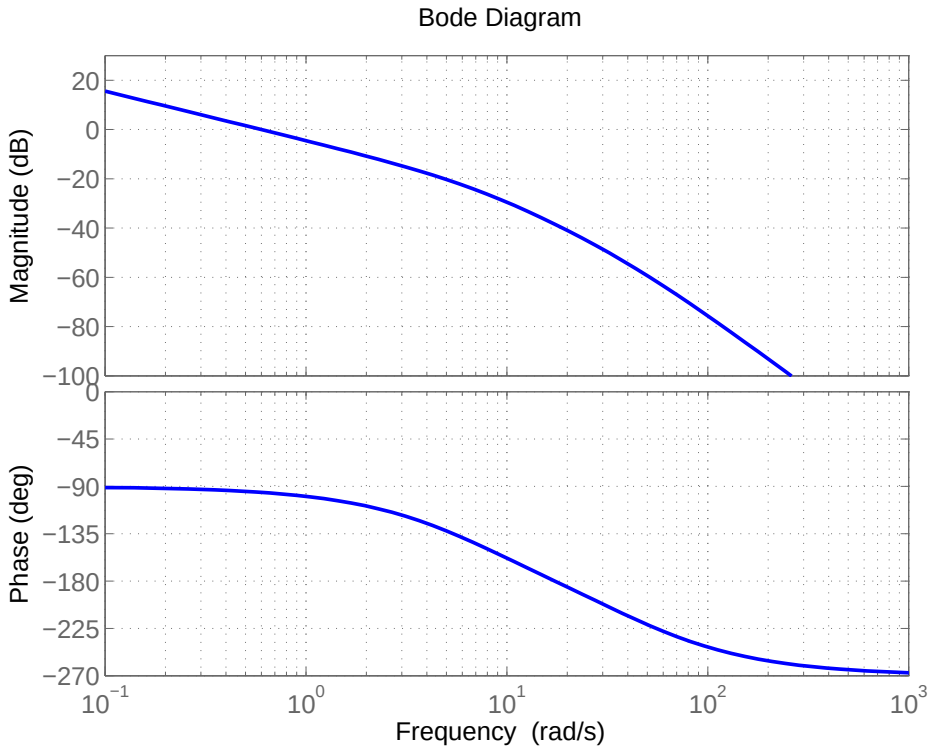
(e) Closed loop rise time:

(f) Closed loop overshoot:

(g) Maximum delay in sensor measurement (i.e. delay in feedback path) that can be tolerated before closed loop system is unstable:

2. Consider a unity gain feedback system: 

The Bode plot of $G(s)$, which has one pole at $s = 0$ and no poles in the open right half plane, is shown below. *Note that this is the Bode plot of the loop gain when* $K = 1$. You wish to design a proportional control system such that $t_r = 0.44$s.



(a) What gain should you choose to achieve this design specification?

(b) What is the resulting phase and gain margin for this design?

3. Design a PI or PD controller for the system

$$G(s) = \frac{1}{(s+1)(s+10)}$$

to meet the following specifications

- Zero steady state error for unit step reference input
- $t_r < 0.31$ s
- $\%\text{OS} < 20\%$.

(a) Determine the low frequency gain, crossover frequency and phase margin necessary to meet the specifications

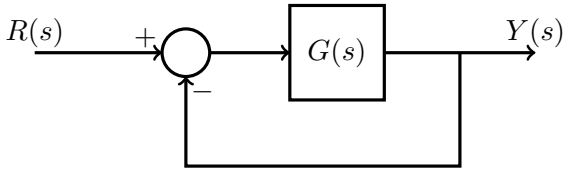
(b) Decide if $C(s)$ needs an integrator. Plot the bode plot of either $G(s)$ or $G(s)/s$, depending on your choice

(c) Use `sisotool` (or iteration) to choose a gain and place a zero to meet the specifications

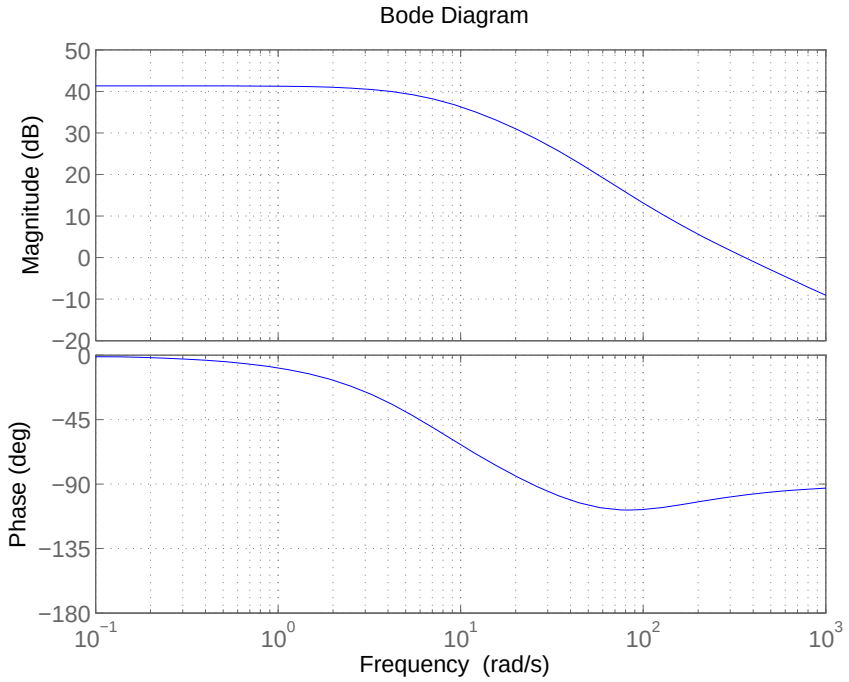
(d) Write the transfer function of the resulting controller where $C(s)$ includes the integrator, if used. State whether this is a PI or PD controller

(e) Plot the bode plot of the loop gain $C(s)G(s)$, the bode plot of the closed loop transfer function, and the closed loop step response.

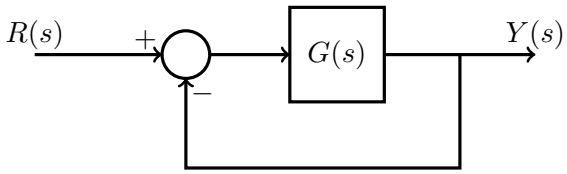
4. Quiz Question: Consider the following feedback system.



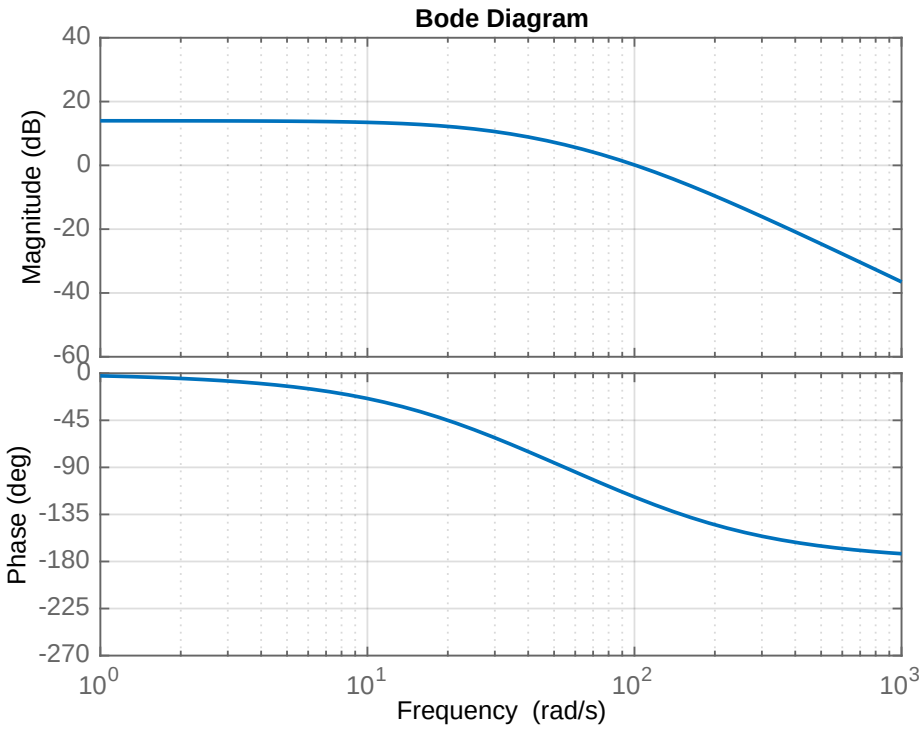
$G(s)$ is a BIBO stable system, and the frequency response for $G(s)$, is shown below. Determine if the closed loop step response would meet a specification of rise time $t_r < 0.1$s and overshoot %OS$< 10\%$, and explain your reasoning



5. Quiz Question: Consider the following unity gain feedback control system.



The Bode plot of $G(s)$ is shown below.



Estimate the closed loop rise time, settling time, overshoot, and steady state error to a step reference $r(t) = u(t)$.

Solutions:

1. (a) $GM = 12$ dB
   (b) $\omega = 3.5$ rad/s
   (c) $\phi_{PM} = 93^\circ$
   (d) $\omega_{co} = 0.4$ rad/s
   (e) $t_r = 5.5$ s
   (f) $\%OS = 0$
   (g) 1.25π s
2. (a) $K = 10$
   (b) $\phi_{PM} = 45^\circ$, $GM = 20$ dB
3. No partial solution