

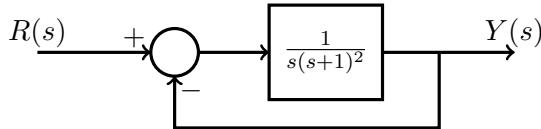
EENG307: Intro to Feedback Control

Fall 2020

Homework Assignment #11

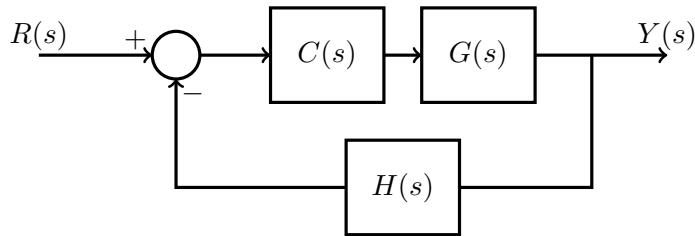
Due: Monday, Nov 30th, 11:59pm

1. Consider the following feedback control system



Use MATLAB to plot the Bode plot for $G(s)$. Using this, sketch the Nyquist plot. Determine if the closed loop system is stable or unstable.

2. Consider the feedback system



Suppose

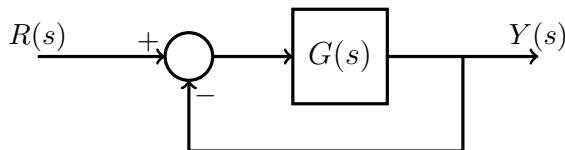
$$L(s) = H(s)G(s)C(s) = \frac{K}{s^3 + 9s^2 + 30s + 40}$$

- (a) Using MATLAB, find the Bode plots for $K = 50$ and $K = 100$.
 - (b) By hand, sketch the Nyquist plots for each case.
 - (c) Find the Gain and Phase margins for each case, and, annotate your Nyquist and Bode plots to show these calculations graphically (writing by hand on a printout is fine).
3. Consider a feedback control system with the following loop gain:

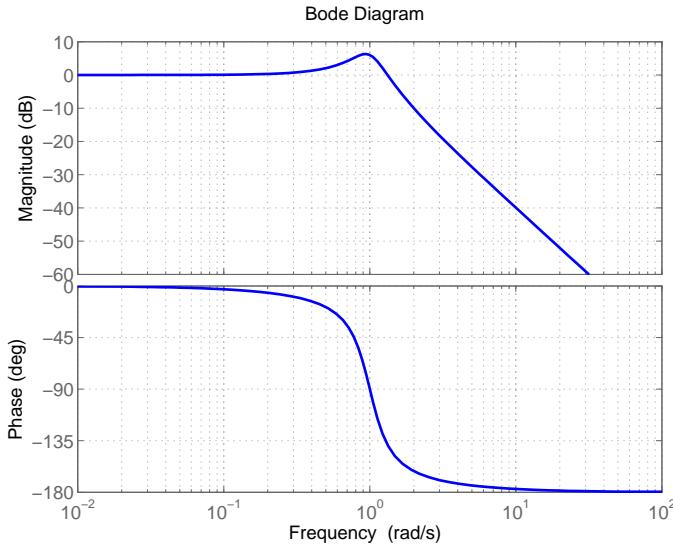
$$L(s) = H(s)G(s)C(s) = \frac{90}{s^2 + 9s + 18}.$$

Using MATLAB, obtain a Nyquist plot.

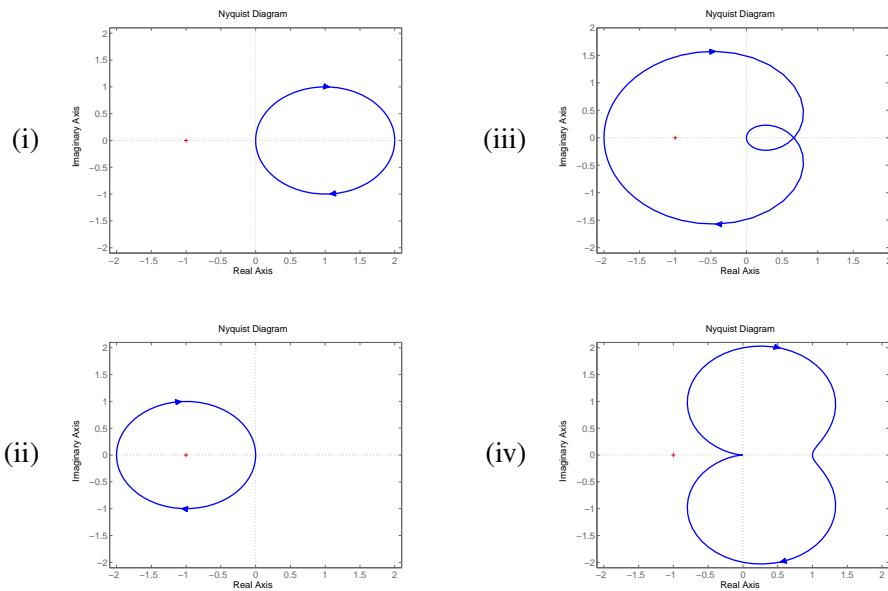
- (a) Using the Nyquist stability criterion, determine if a feedback system with this loop gain is closed loop stable.
 - (b) Now add a delay of 0.5 sec to $G(s)$, plot the Nyquist plot, and reevaluate this stability. (Hint: add an exponential term as in section 4 of Lecture 31).
4. Consider following unity gain feedback system.



The following is the Bode plot of $G(s)$, which is stable.

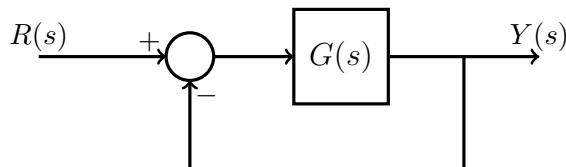


- What is the gain margin GM ?
- What is the phase margin ϕ_{PM} ?
- Which of the following is the correct Nyquist plot?

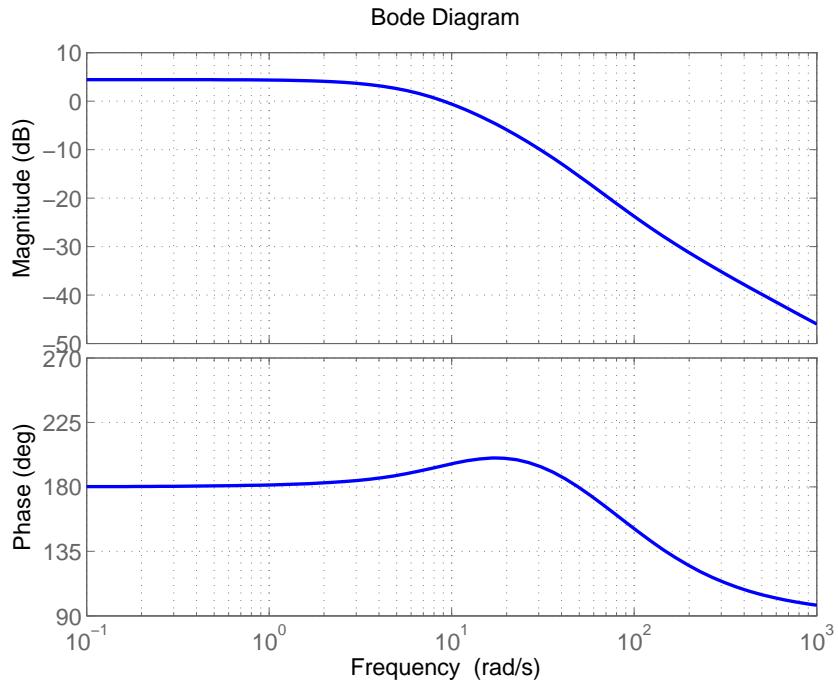


- Is the closed-loop system stable?
- If the closed loop system is stable, what is the maximum delay that can be tolerated (i.e. a change of the open loop system to $e^{-sT_d}G(s)$) before the closed loop system becomes unstable?

5. Quiz Question Friday: Consider following unity gain feedback system.

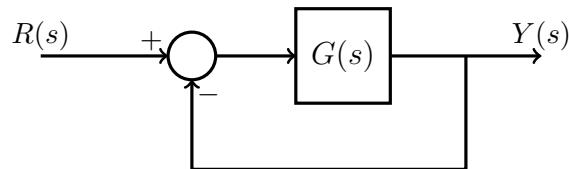


The following is the Bode plot of $G(s)$, which has 1 unstable pole.

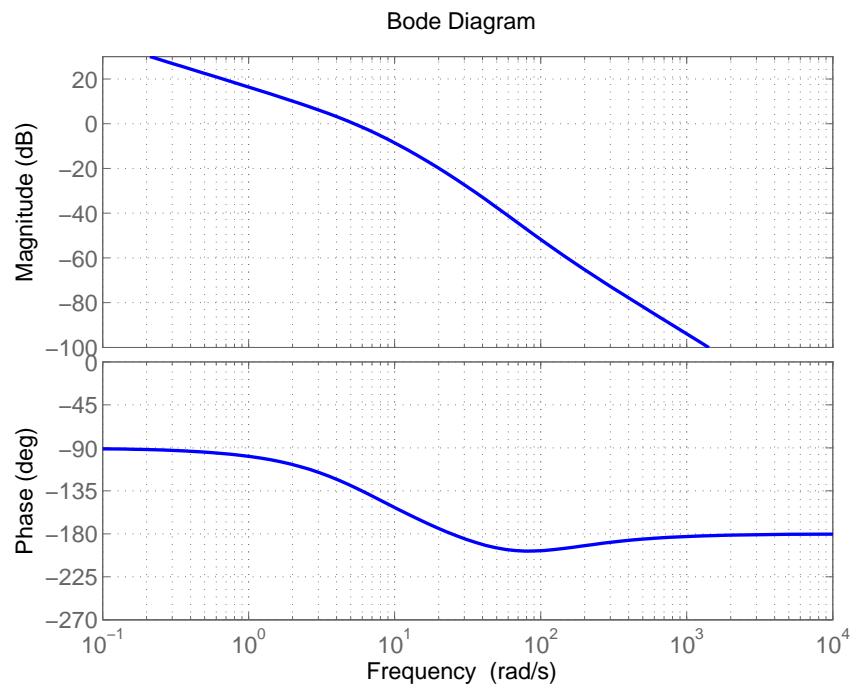


Sketch the Nyquist plot, and use the Nyquist stability criterion to determine if the closed loop system is stable.

6. Quiz Question Monday: Consider following unity gain feedback system.



The following is the Bode plot of $G(s)$, which has all poles in the left half plane, except for one pole at $s = 0$. Sketch the Nyquist plot and find the phase and gain margins



Solutions:

1. Closed loop stable
2. (c) For $K = 50$, $GM = 13$ dB or $k_{GM} = 4.4$, $\phi_{PM} = 100^\circ$. For $K = 100$, $GM = 7$ dB or $k_{GM} = 2.2$, $\phi_{PM} = 37^\circ$.
3. (a) Closed loop stable
(b) Not closed loop stable
4. (a) ∞
(b) 40°
(c) (iv)
(d) yes
(e) $T_d = 0.54$ s