MAE 3134: Final Exam

Problem 1 The frequency response of two systems are shown in Figure 1. Using the plots, circle the correct descriptions:

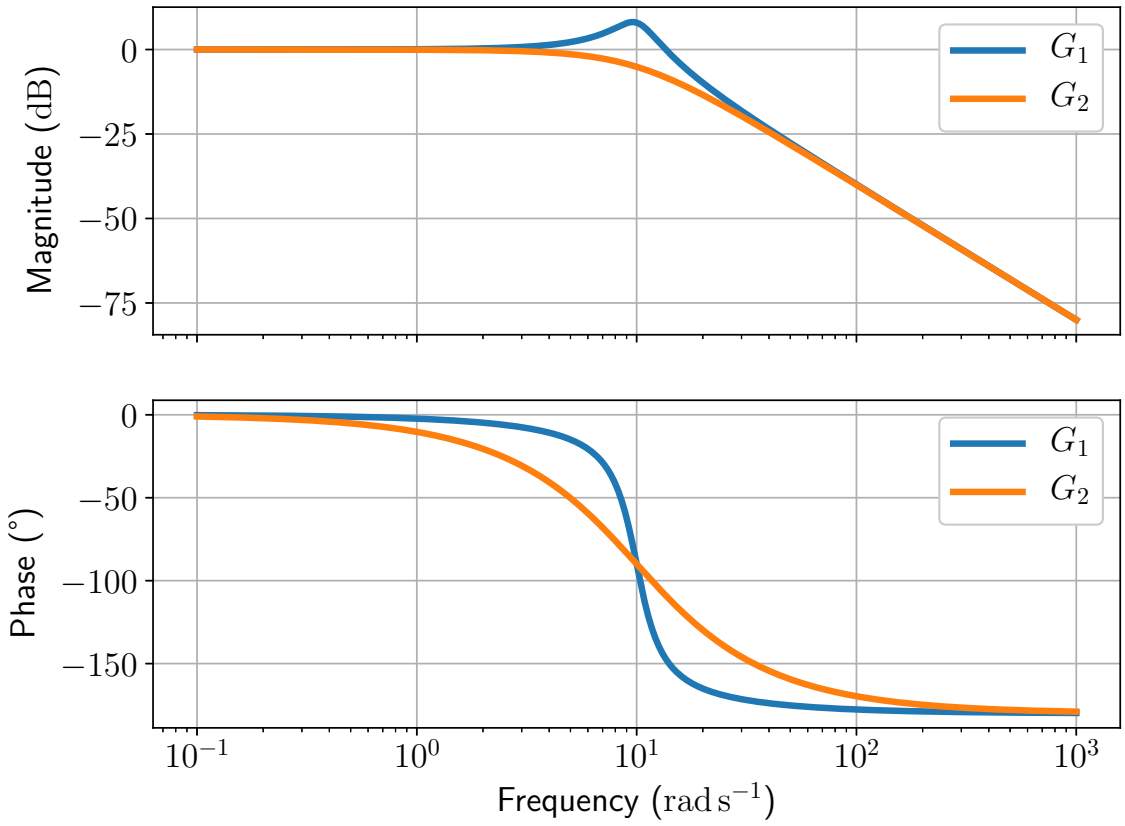


Figure 1: Frequency Response

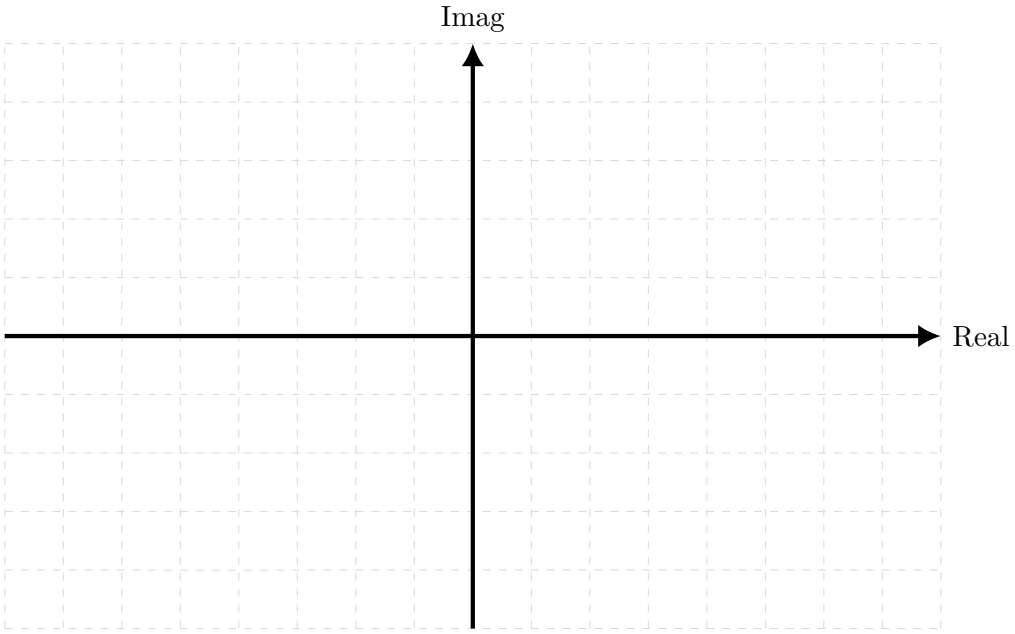
1. Which of the following statements are true about the damping ratios of the two systems?
   (a) The damping coefficients are the same.
   (b) The damping coefficient of G_1 is greater than the damping coefficient of G_2.
   (c) The damping coefficient of G_2 is greater than the damping coefficient of G_1.
   (d) Not enough information to make any statements about the damping ratio.
2. Which of the following statements are true about the general form of G_1?
   (a) It is a first order system.
   (b) It must have two free s terms in the denominator since the phase ends at 180°.
   (c) It must have two free s terms in the numerator since the final magnitude slope is 40 dB per decade.
   (d) None of the above.

Problem 2 Elon Musk, CEO of SpaceX and Tesla Motors, has a background in physics but unfortunately has never passed a Linear Dynamics course. His newest space vehicle must satisfy the following second order time response specifications for a unit step input:

- Percent Overshoot must be less than 5%,
- Rise time less than 1 s,
- Settling Time less than 5 s.

Elon needs your help to choose a set of poles which will satisfy the specifications and save humanity from impending disaster.

1. On the s-plane, or complex plane, map out the acceptable regions where you could locate poles and meet the requirements.
2. Label the specifications lines and show your work.
3. Choose a set of poles that will meet the requirements.



Problem 3 List at least two advantages of state-space or "modern control" techniques as compared to "classical control" approaches.

Problem 4 The transfer functions of three systems are given as follows:

$$G_1 = \frac{1}{s^2 + 0.2s + 1}, \qquad G_2 = \frac{2s + 4}{s^2 + 0.5s + 4}, \qquad G_3 = \frac{-2s + 4}{s^2 + 0.5s + 4}. \tag{1}$$

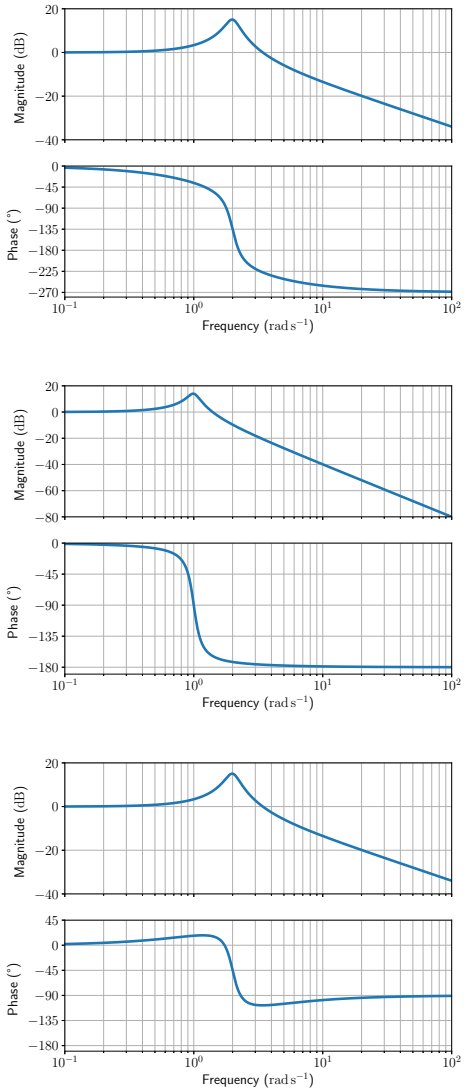


Figure 2: Bode Plots