There are three ~~problems~~ Questions with respective points: 20, 12, 8 (total of 40/40)

Question #1:

You are given the Bode plots corresponding to two dynamical systems, `system A` and `system B`. These are plotted in Figures 1 and 2, respectively. You are also told that they are both second-order systems and that any poles and zeros are real (i.e., no complex-conjugate pairs).

(points: 4) i) Estimate the approximate location of poles and zeros, and the DC gain, and suggest possible transfer functions for each, $T_A(s)$ and $T_B(s)$, respectively.

(points: 8) ii) Draw the corresponding Nyquist plots (this can be done independently of part i)).

(points: 8) iii) Determine whether feedback control, with a negative unity gain in the feedback path around either system, can stabilize it and explain your reasoning.

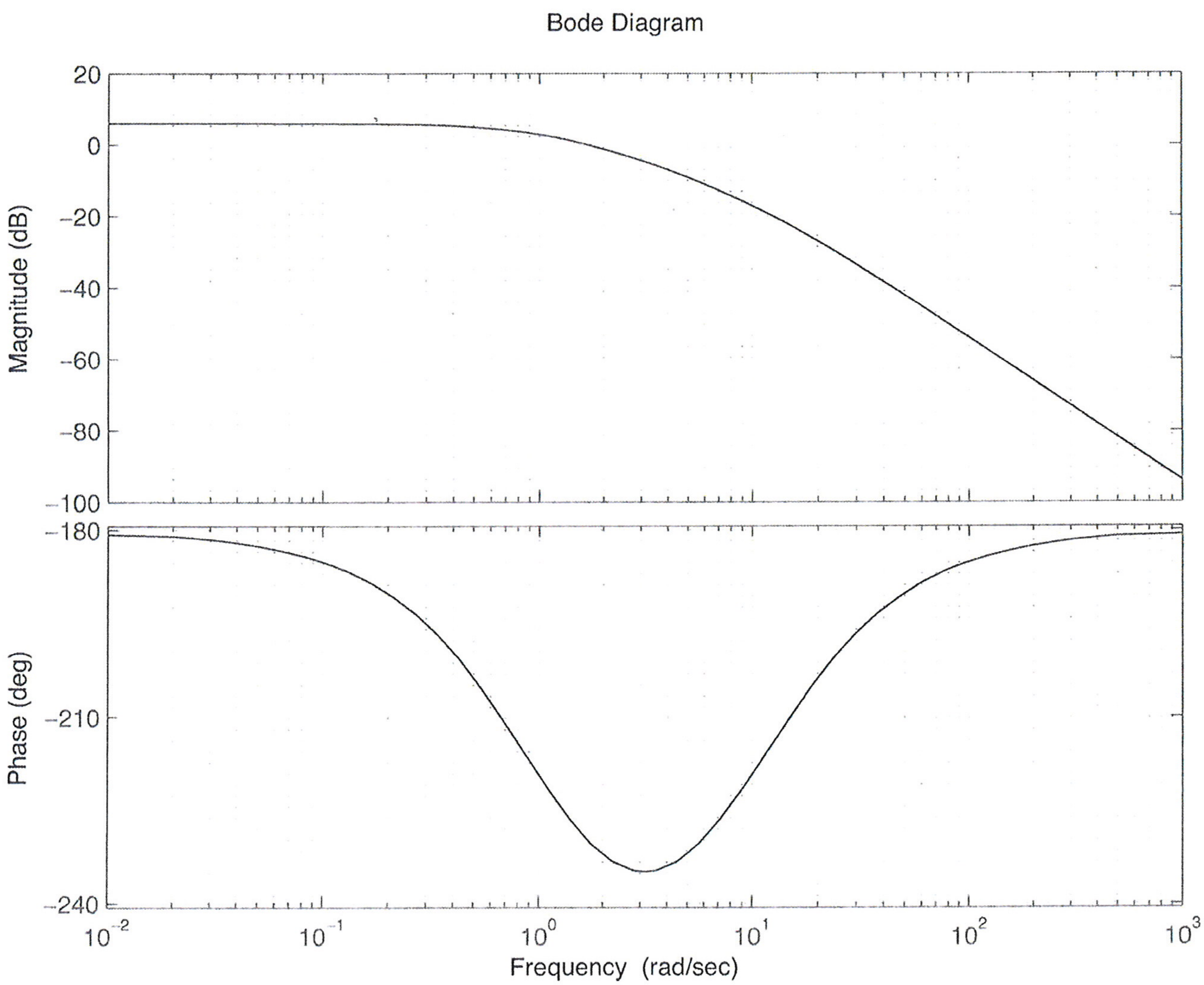

Fig. 1. Bode plot for `system 1`.

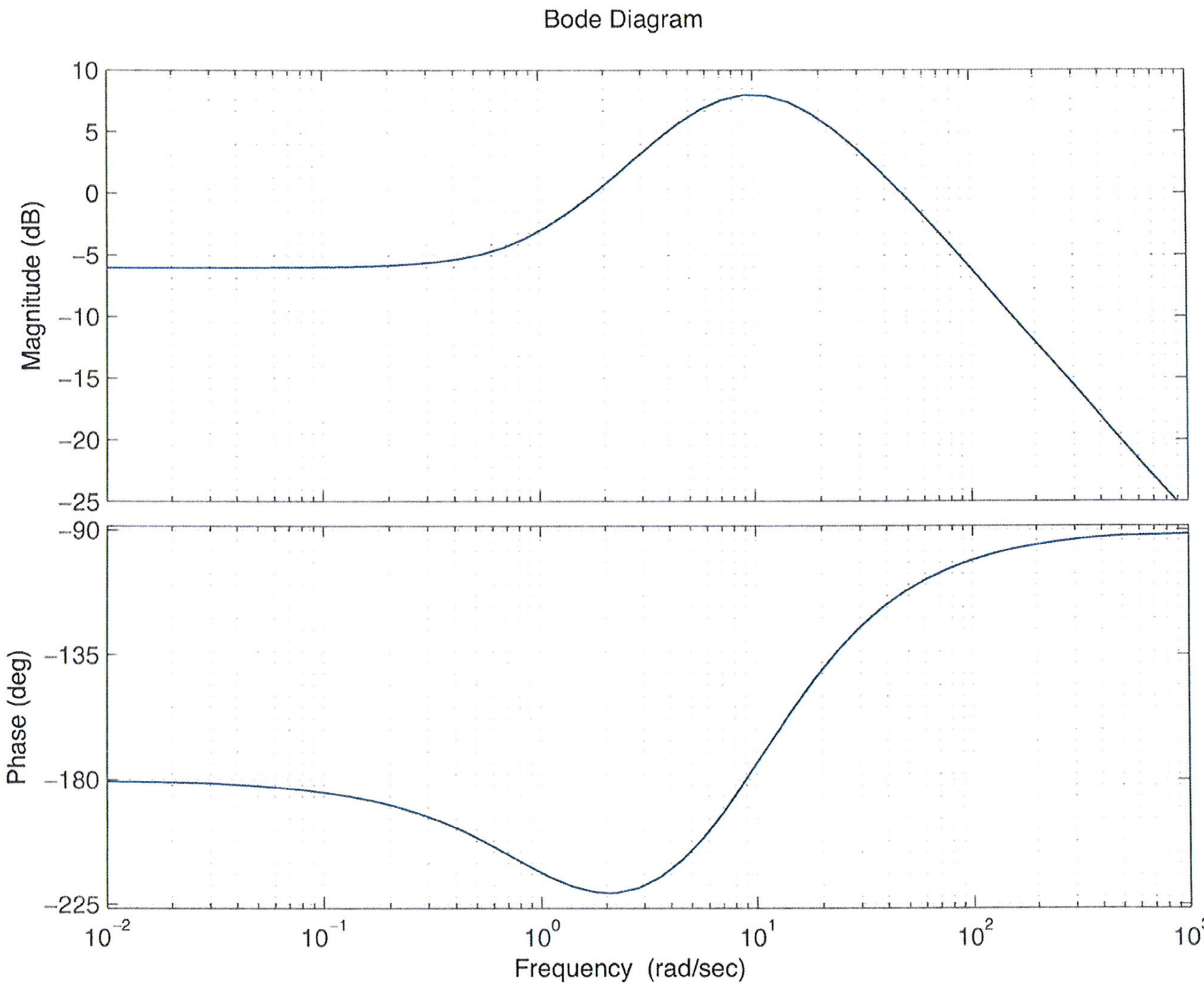

Fig. 2. Bode plot for `system 2`.

Question #2:
You are given a first-order system with transfer function $T(s) = \frac{k}{s+1}$ having adjustable gain k.
(points: 8) i) Determine k so that, with a negative unity feedback, asympotically, the output-response of the closed loop system to a unit step input is equal to $2 - \sqrt{2} = .5858$.
(points: 4) ii) What is the phase margin of the closed loop system?

Question #3:
Consider a dynamical system with a state-space representation

$$\dot{x}(t) = Ax(t) + Bu(t),\ y(t) = Cx(t)$$

where x is the state, u the input, and y the output. Input and output are scalar-valued, whereas the state is of dimension 2. Then

$$A = \begin{bmatrix} 0 & 1 \\ -1 & -1 \end{bmatrix},\ B = \begin{bmatrix} 0 \\ 1 \end{bmatrix},\ C = \begin{bmatrix} 0 & 1 \end{bmatrix}.$$

(points: 8) Design a state-feedback control that will place the closed-loop poles all at -1.