1. Consider the following state-space model for the azimuthal angle of a dish used to track a satellite:

$$\frac{dx}{dt} = \begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -171 & -101.71 \end{pmatrix} x + \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix} u$$

$$y = \begin{pmatrix} 1325 & 0 & 0 \end{pmatrix} x$$

where y is the azimuthal angle, u is the input voltage to a power amplifier, which is used to drive the dish, and x is the state of the system.

(a) Assume that all the state variables are measured and design a controller to yield a 10% overshoot and ±2% settling time of 1 second. Place the third pole 10 times as far from the imaginary axis as the second-order dominant pair. **60%**

(b) Assume that not all the state variables are measured and that only a measurement of the azimuthal angle is available. Design an observer to estimate the states. The desired transient response for the observer should have a 10% overshoot and a natural frequency 10 times as great as the system response in part (a) above. **40%**

Useful information: The damping factor of a second-order system with overshoot M_p (as a fraction) is given by

$$\zeta = \frac{-\ln(M_p)}{\sqrt{\pi^2 + \ln^2(M_p)}}.$$

The ±2% settling time is given by

$$T_s = \frac{4}{\zeta\omega_n},$$

where ω_n is the natural frequency of the system.