1. A system oscillates at 5 Hz and takes 10 seconds to settle to within 5% of its final value.
   a. Sketch the roots on the s-plane
   b. Write out the differential equation
   c. Write out the transient response for the system

2. A second order system does not oscillate. The system has a 5 second and 10 second time constant.
   a. Sketch the roots on the s-plane
   b. Write out the differential equation
   c. Write out the transient response for the system

3. Sketch the roots and the transient response for the following characteristic equation:
   \((s + 5)(s^2 + 25) = 0\)

4. An object with mass \(m\) and \textit{air drag} damping coefficient \(D\) is dropped from the sky. Find the time constant(s) for the object for perturbations about terminal velocity.

5. Find the eigenvalues for a regular pendulum and inverted pendulum.

6. For the following system, size/design/find the maximum spring value without allowing the transient response to oscillate.

7. Design the suspension (k and b) for the rack and pinion to have a 1 second settle time (1%) and a rise time of 0.2 seconds.
1. A 4 kg pendulum of length 1 meter (with negligible damping) oscillates at 1/2 Hz.
   a) Develop the non-linear model of the system
   b) Develop the solution for the system starting from rest from an initial angle offset
   c) Where are the eigenvalues for this system.
   d) Size a rotational damper such that the system a damping ratio of 0.5. What are the
eigenvalues of this new system? What is the natural frequency? Damped
frequency? Plot the response of the actual pendulum with the damper starting
from 20 deg. How does it compare to the designed system?