Design of controllers is usually an iterative process. A controller is typically designed for an approximation of the system. Subsequently, it is applied to the full system and refined until all the specifications are met. In this exercise you will go over these steps. **Note that there are typically many choices of the parameter values that will achieve the desired performance.**

1. Consider the closed-loop system:

\[
\begin{align*}
G(s) &= \frac{K_1(s + 2)}{s(s + 1)}, \\
H(s) &= 1 + K_2s.
\end{align*}
\]

We want to select \(K_1\) and \(K_2\) so that the peak time is 0.5 second and the overshoot for a step input is less than 2%.

(a) Approximate \(G(s)\) as a system without a zero. Make sure that the approximation has the same steady-state error as the original system.

(b) Find \(K_1\) and \(K_2\) for the approximated system that would satisfy the above specifications.

(c) Plot the step response of the original system with the chosen \(K_1\) and \(K_2\) and determine the peak time and the percent overshoot.

(d) Tune \(K_1\) and \(K_2\) so that the specifications are met for the original system. Explain how you arrived at your values (why did you increase or decrease the values chosen in 1b).

2. Consider the closed-loop system:
where
\[ G(s) = \frac{10}{(s + 1)(s + 9)}, \]
and
\[ H(s) = \frac{K}{s + 90}. \]

(a) Determine a second-order model for the closed-loop system by approximating \( H(s) \) with its DC gain.

(b) Using the second-order model, select a gain \( K \) so that percent overshoot is less than 15% and the steady-state error to a step is less than 12%.

(c) Verify your design by determining the actual performance of the third-order system (submit the step response plot with your report).

(d) Tune the value of \( K \) so that the specifications are met. Plot the step response of the system to show that your design works. Explain how you arrived at your new value.