Objective:

- Using MATLAB, Control System Toolbox and SIMULINK to analyze the transient response of a system.

Requirement:

- Show all your plots, Simulink Model and MATLAB codes. Please label your plots.
- Clearly state your comments and explanations if required.

Problem:

Using Matlab Control System Toolbox

1. Given that the equation of motion for the system is as below:

\[ y(t) + 52 \ddot{y}(t) + 104 \dot{y}(t) + 200y(t) = 50x(t) \]  \hspace{1cm} (1)

(a) [15%]: Compute the transfer function of the above equation, \( H(s) \). (Note: \( x(t) \) is the input of the system. \( y(t) \) is the output of the system. Assume all initial condition is zero.)

(b) [5%]: Plot the unit step response (i.e., \( x(t) = u(t) \)) of the transfer function, \( H(s) \) in 1(a). (Note: “unit” refers to the gain is equal to one).

(c) [18%]: From the response in 1(b) clearly indicate the following transient response specifications:

- Percentage Maximum overshoot, \( M_p \)
- Rise Time, \( t_r \)
- Delay Time, \( t_d \)
- Peak Time, \( t_p \)
- Settling time, \( t_s \)
- Steady-State value

(d) [3%]: Compute the \( y(\infty) \) using the Final Value Theorem. Do the computed value matches the steady state value found from the response?
(e) **[6%]**: Plot the Bode diagram and Nyquist Plot of the transfer function, \( H(s) \) in Problem 1(a).

(f) **[15%]**: Use the “\textit{residue}” command to solve the transfer function, \( H(s) \) in Problem 1(a), where \( u(t) \) is an unit step input. (Hint: Solve for \( y(t) \)). Then plot \( y(t) \) for the time, \( t \) in the range from 0 to 6 sec, varying by 0.01. Does the plot of \( y(t) \) match the plot in 1(b)?

(g) **[5%]**: Given a new model, \( G(s) = 1 \), combine both models, i.e \( H(s) \) and \( G(s) \), as shown in the following figure:

![Block diagram](image)

What is the mathematical model (in S-domain) of this combine model? (Note: this model is closed-loop transfer function)

**Using Simulink**

2. **[10%]**: Use Simulink to create the combine model in Problem 1(g). Let the input block to be a unit step input and the stop time is 6 sec. Plot the unit step response.

(a) **[10%]**: Compare the unit step response from your Simulink model and the unit step response in Problem 1(b). State your observations. (Hint: Compare the transient response specifications)

(b) Simulate the combine model with

   i. **[5%]**: unit ramp input (or as shown in figure below)

   ![Ramp input](image)

   ii. **[8%]**: Impluse input shown on figure below:
Plot the unit ramp response and unit impulse response. Attach your all Simulink model and output plots to your report.

\[ \delta(t) \]

\( \Delta t = 0.001 \text{ sec} \)