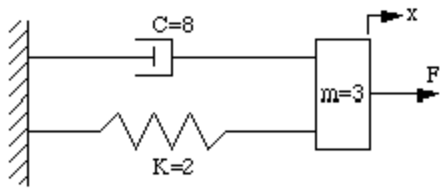
ECE327: Laboratory Exercise 2: Systems Characteristics and Responses

1) (a) Using the Laplace transform write the transfer function *X(s)/F(s)*.

(b) Using the Control System Toolbox:

i. Properly define the system and find its poles and zeros. Draw the poles/zeros of the system. What information does the position of the poles of the system give us about its response?
ii. Find and graphically represent the impulse response of the system (all graphs you make are expected to have axis names, title, etc.).
iii. Find and graphically represent the step response of the system.



2) Depending on the position of the poles the system exhibits different behavior, i.e., underdamped system, overdamped system, critically damped system or undamped system. For each of the following cases calculate the damping coefficient ζ and based on its value find out which of the above cases the system belongs to. Generate and graphically represent the step response of each system. Describe its behavior in each case.

i. $G(s) = \frac{4}{s^2 + 5s + 4}$
ii. $G(s) = \frac{4}{s^2 + 4s + 4}$
iii. $G(s) = \frac{4}{s^2 + s + 4}$
iv. $G(s) = \frac{4}{s^2 + 4}$

3) Consider a system with the following transfer function

$$G(s) = \frac{100}{(s + a)(s^2 + 4s + 10)}$$

a. Let $a = 10$. Can the system be approximated by a second-order system? Find the approximated system, and plot on the same graph the step response of the two systems.
b. Find rise time, peak time, and settling time of the original and the approximated system and compare them.
c. Repeat steps a-b using $a = 40$ and $a = 2.5$. Discuss the results.

4) Consider a system with transfer function given by

$$G(s) = \frac{33s^4 + 202s^3 + 10061s^2 + 24332s + 170704}{s^7 + 8s^6 + 464s^5 + 2411s^4 + 52899s^3 + 167829s^2 + 913599s + 1076555}$$

a. Find the partial fraction residues and poles of G(s).
b. Find an approximation of the above system using its real pole and plot on the same graph the step response of the two systems. Explain the differences between the two plots.

5) For each of the following cases create a program that will plot the step response and the pole-zero map:

a) $G_1(s) = \frac{\alpha}{s+\alpha}$, for $\alpha = 1, \dots, 5$.

b) $G_2(s) = \frac{|w+2wj|^2}{(s+w+2wj)(s+w-2wj)}$, for $w = 1, \dots, 8$.

Discuss your results analytically.

6) Consider the spring-mass-damper system as shown in the figure below. The input is given by $f(t)$, and the output is $y(t)$. Let $m = 10$, $k = 1$, and $b = 0.5$.

a) Determine the transfer function from $f(t)$ to $y(t)$, and plot the system response to a unit step input. Show that the peak amplitude of the output is about 1.8.
b) Solve the derived differential equation directly in the time domain using MATLAB's **ode23** function, with $y(0) = \dot{y}(0) = 0$ and $f(t) =$ unit step. Plot (i) the solution analytically, and (ii) the velocity against the displacement.