4.6 MATLAB Laboratory Experiment

Purpose: This experiment presents the frequency domain analysis of continuous-time linear systems using MATLAB. The impulse, step, sinusoidal, and exponential responses of continuous-time systems will be examined using the transfer function method based on the Laplace transform. In addition, MATLAB will be used to perform the partial fraction expansion and to find the inverse Laplace transform.

Part 1. Consider the linear system represented by the transfer function

$$H(s) = \frac{s+1}{s^2+5s+6}$$

Using MATLAB, find and plot:

(a) The system impulse response.

(b) The system step response.

(c) The system zero-state response due to the input signal $f(t) = \sin(2t)u(t)$.

(d) The system zero-state response due to the input signal $f(t) = e^{-t}u(t)$.

Part 2. Consider the transfer function

$$H(s) = \frac{2s^5+s^3-3s^2+s+4}{5s^8+2s^7-s^6-3s^5+5s^4+2s^3-4s^2+2s-1}$$

(a) Find the factored form of the transfer function by using the MATLAB function `[z,p,k]=tf2zp(num,den)`.

(b) The partial fraction expansion of rational functions can be performed using the MATLAB function `residue`. Find the Laplace inverse of the given transfer function using the MATLAB function `residue`; that is, find analytically the system impulse response.

Part 3. Consider the system defined by

$$y^{(2)}(t) + 5y^{(1)}(t) + 4y(t) = f(t)$$

and the input signal represented in Figure 4.13. Use MATLAB to plot the zero-state response of this system. (*Hint:* See Example 4.24.)

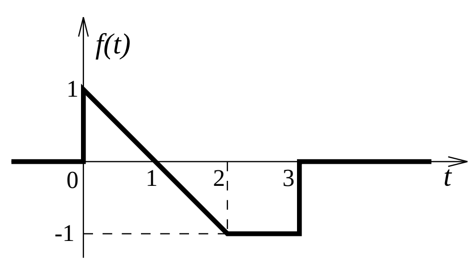

FIGURE 4.13: An input signal

Part 4. Find and plot the zero-input response of a flexible beam [9], whose transfer function is given by

$$H(s) = \frac{1.65s^4 - 0.331s^3 - 576s^2 + 90.6s + 19080}{s^6 + 0.996s^5 + 463s^4 + 97.8s^3 + 12131s^2 + 8.11s}$$

with the initial conditions $y^{(4)}(0^-) = 1,\ y^{(j)}(0^-) = 0,\ j = 0, 1, 2, 3, 5$. (*Hint:* Find $I(s)$ and $\Delta(s)$ as defined in formulas (4.36) and (4.52) and use the MATLAB function `impulse`.)

Submit four plots for Part 1, one plot for Part 3, and one plot for Part 4, and present analytical results obtained in Parts 2–4.

SUPPLEMENT:

$$\begin{aligned} I(s) = &\Big(a_1 y(0^-) + a_2 y^{(1)}(0^-) + \cdots + a_{n-1} y^{(n-2)}(0^-) + y^{(n-1)}(0^-)\Big) \\ &+ s\Big(a_2 y(0^-) + a_3 y^{(1)}(0^-) + \cdots + a_{n-1} y^{(n-3)}(0^-) + y^{(n-2)}(0^-)\Big) \\ &+ s^2\Big(a_3 y(0^-) + a_4 y^{(1)}(0^-) + \cdots + a_{n-1} y^{(n-4)}(0^-) + y^{(n-3)}(0^-)\Big) \\ &+ \cdots + s^{n-2}\Big(a_{n-1} y(0^-) + y^{(1)}(0^-)\Big) + s^{n-1} y(0^-) \end{aligned} \tag{4.36}$$

$$\Delta(s) = s^n + a_{n-1}s^{n-1} + \cdots + a_1 s + a_0 \tag{4.52}$$