1 Introduction to System Response and Linear Convolution

1. Zero State Response and Linear convolution:

(a) A LTI system has an impulse response function

\[ h(t) = (t-3)[u(t-3) - u(t-5)] \]

and the input signal

\[ x(t) = u(t+2) - u(t-2). \]

i) Find the time duration, the starting time and ending time of the zero state response of the system to the input signal; ii) Is the system causal? Why (explanation required)? iii) Find the expression of zero state response \( y(t) \) using the linear convolution integral by hand; iv) Calculate zero state response using linear convolution function, \texttt{conv()}, in Matlab.

(b) Repeat problem 1a) with the signals in figure (1).

(c) Find the zero state response of a LTI system with impulse response \( h(t) = 2e^{-2t}u(t-3) \) and input \( x(t) = 2u(t-1) \) and verify your results by showing the first 10 seconds of output signal \( y(t) \) in Matlab.

2. LTI System Transfer functions, Differential equations and Stability:

(a) A LTI system is described by the following canonical differential equation.

\[
\frac{d^2 y(t)}{dt^2} - 6 \frac{dy(t)}{dt} + 8y(t) = 2 \frac{dx(t)}{dt}
\]

i) Find the polynomials \( A(s) \) and \( B(s) \) and its transfer function \( H(s) \); ii) Find the poles (solve \( A(s) = 0 \)) and zeros (solve \( B(s) = 0 \)) of the system; iii) Is this system stable? Why?
(b) The dynamic behavior of a LTI system is described by the following transfer function.

\[ H(s) = \frac{2s^2 - 5}{s^3 - 2s + 4} \]

i) Find the differential equation expression of the system; ii) Find poles and zeros and plot them using Matlab function zplane(); iii) Is this system stable? Why?

(c) The dynamic behavior of a LTI system is described by its impulse response function:

\[ h(t) = (e^{-t} - 2e^{-2t})u(t) \]

Show that the LTI system is stable using absolute integration.

3. Problems in text book: 2.4-8 (a and c), 2.4-16 (a, b and c), 2.7-1 and 2.7-2.