Signals and systems

Homework #2

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- Homeworks will not be accepted after the deadline.
- For theoretical problems, gather them in a single ***.pdf** file.
- For the matlab problems, provide both these materials:
  - **codes [*.m files]**
  - a simple **report** that includes all plots and screenshots.
- Notice that the homeworks will be **checked by plagiarism detectors**, avoid any similarities.
- Matlab problems and theoretical problems will be graded seperately (both will be graded out of 100), but their weights may be different and is determined by the course professor.

Question 1 (10 points)

(a) Consider a system with the impulse response

$$h(t) = e^{-t}\left[u(t) - u(t-1)\right]$$

let the input signal applied to this system be

$$x(t) = \Pi(t - 0.5) - \Pi(t - 1.5)$$

Determine and sketch the output signal y(t) using convolution.

(b) Consider a system with the impulse response

$$h(t) = \delta(t) + 0.5\,\delta(t-1) + 0.3\,\delta(t-2) + 0.2\,\delta(t-3)$$

Determine and sketch the output signal y(t) using convolution.

$$x(t) = e^{-t}u(t)$$

Question 2 (10 points)

(a) A discrete time signal is described through the impulse response

$$h[n] = \{4,\ 3,\ 2,\ 1\}$$

let the input signal applied to this system be

$$x[n] = \{-3,\ 7,\ 4\}\ (starting\ from\ n = 0)$$

Determine and sketch the output signal y(t) using convolution.

(b) Consider a system with the impulse response

$$h[n] = (0.8)^n\, u[n]$$

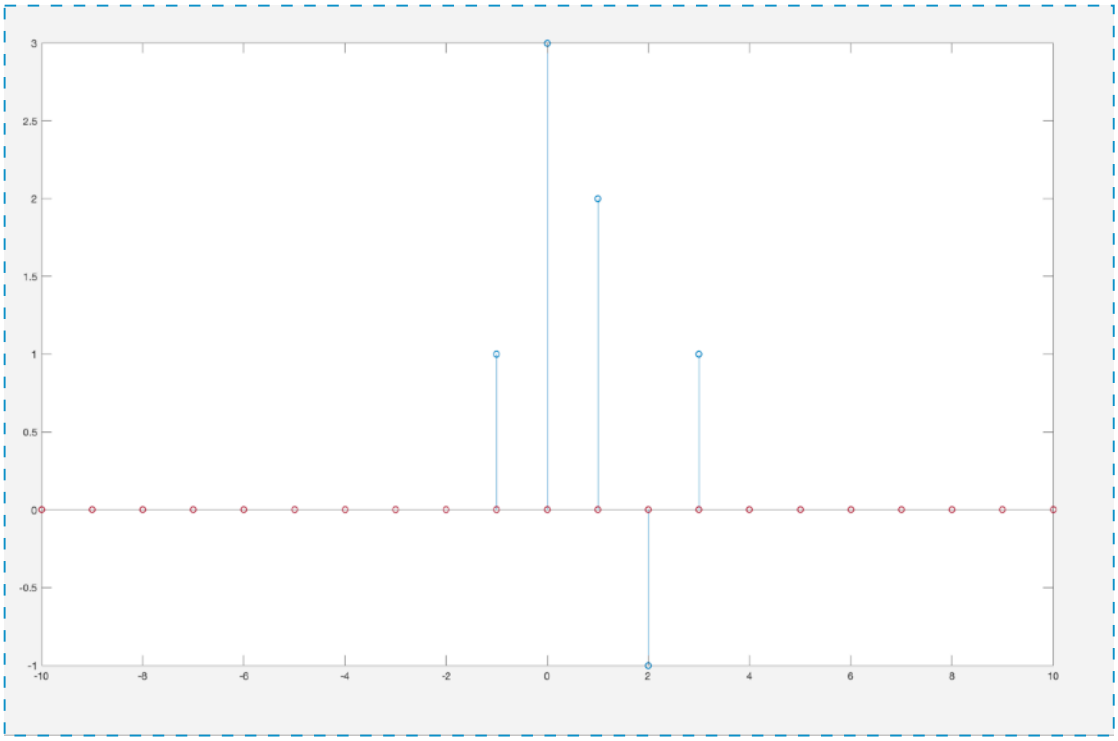
let the input signal applied to this system be

$$x[n] = u[n] - u[n-6]$$

Determine and sketch the output signal y(t) using convolution.

Question 3 (10 points)

a discrete time LTI system has the impulse response h[n] depicted in the figure below.



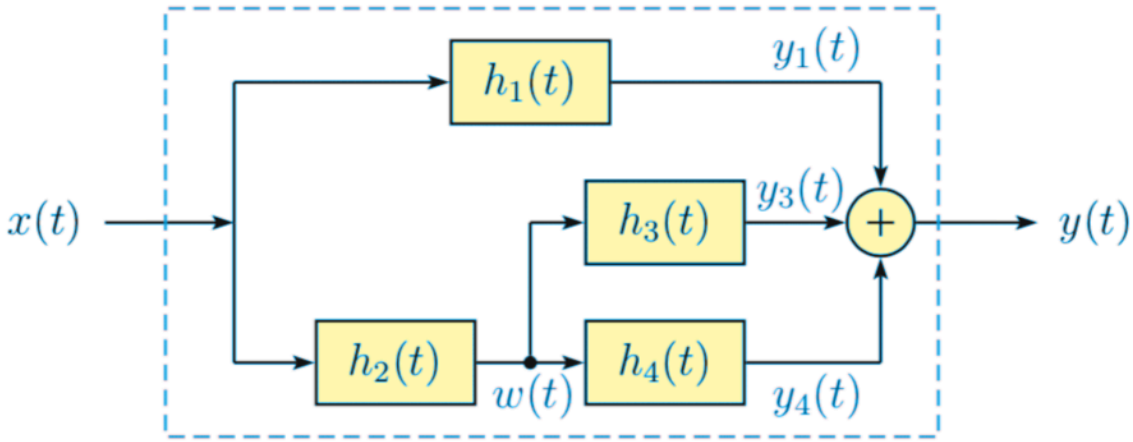
use linearity and time invariance to determine the system output y[n] for the given inputs :

(a) $x[n] = 3\delta[n] - 2\delta[n-1]$

(b) $x[n] = u[n+1] - u[n-3]$

Question 4 (15 points)

Consider the CTLTI system shown below



Express the impulse response of the system as a function of the impulse responses of the subsystems.

$h_1(t) = e^{-t}u(t)$

$h_2(t) = h_3(t) = u(t) - u(t-1)$

$h_4(t) = \delta(t-1)$

determine the impulse response $h_{eq}(t)$ of the equivalent system.

let the input signal be a unit step. determine and sketch the signals $y_1(t),\ y_3(t),\ y_4(t)\ and\ \omega(t)$

Question 5 (20 points)

for each of the following impulse responses, determine wether the corresponding system is memoryless, causal and stable. justify your answers.

(a) $h(t) = u(t+1) - u(t-1)$

(b) $h(t) = u(t) - 2u(t-1)$

(c) $h(t) = e^{-2|t|}$

(d) $h(t) = \cos(\pi t)\, u(t)$

(e) $h[n] = 2^n u[-n]$

(f) $h[n] = e^{2n} u[n-1]$

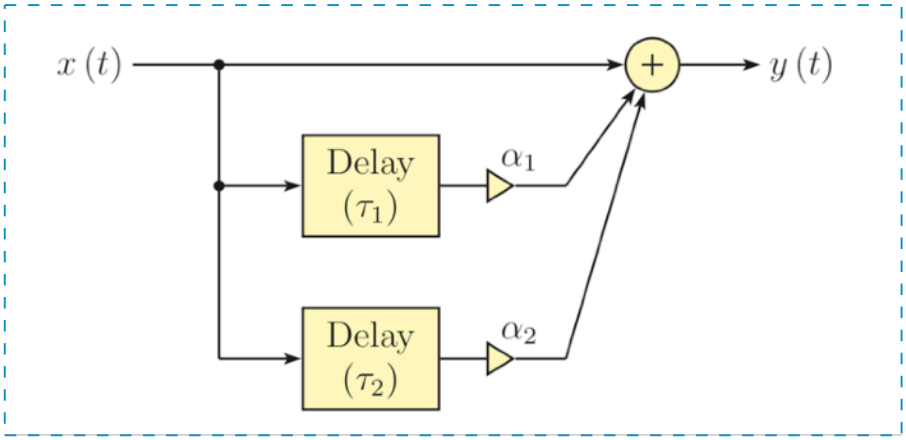
(g) $h[n] = \left(\frac{1}{2}\right)^n u[n]$

(h) $h[n] = \cos\left(\frac{\pi}{2} n\right) u[n+3]$

Question 6 (5 points)

For the following systems, comment on their

- linearity
- ime invariance
- causality
- stability



Question 7 (10 points)

find the step response for the systems with following impulse responses :

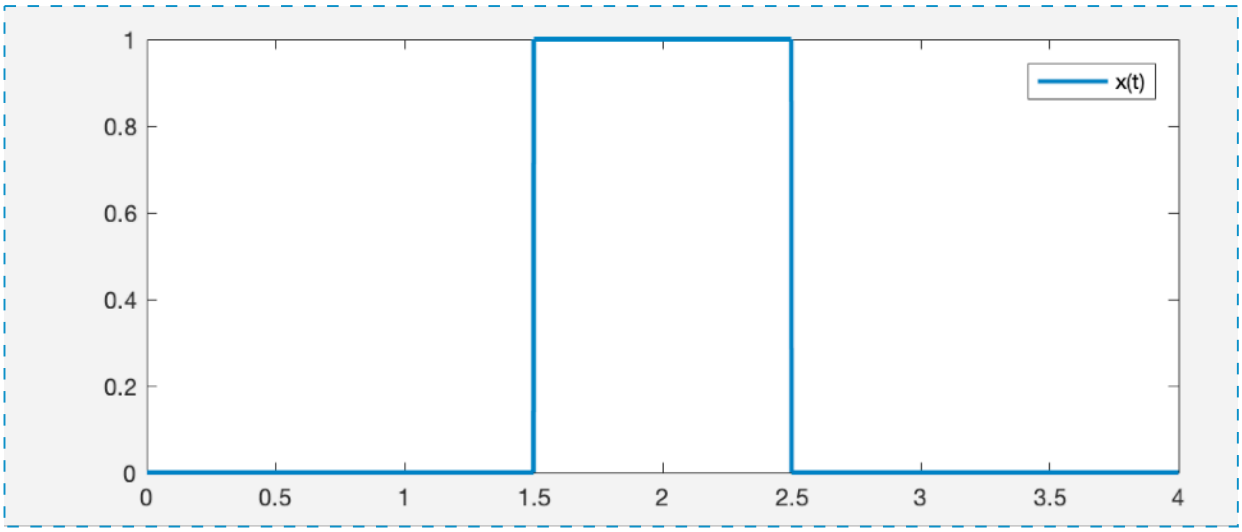
(a) $h[n] = \left(\frac{1}{2}\right)^n u[n]$

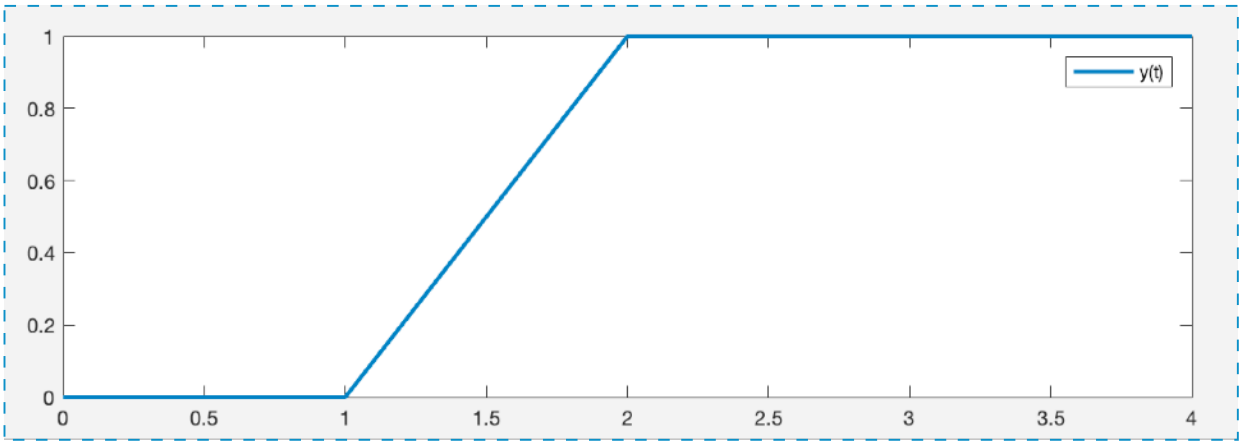
(b) $h(t) = e^{-|t|}$

(c) $h(t) = \delta(t) - \delta(t-1)$

Question 8 (10 points)

determine the impulse response of a system where x(t) and y(t) are :

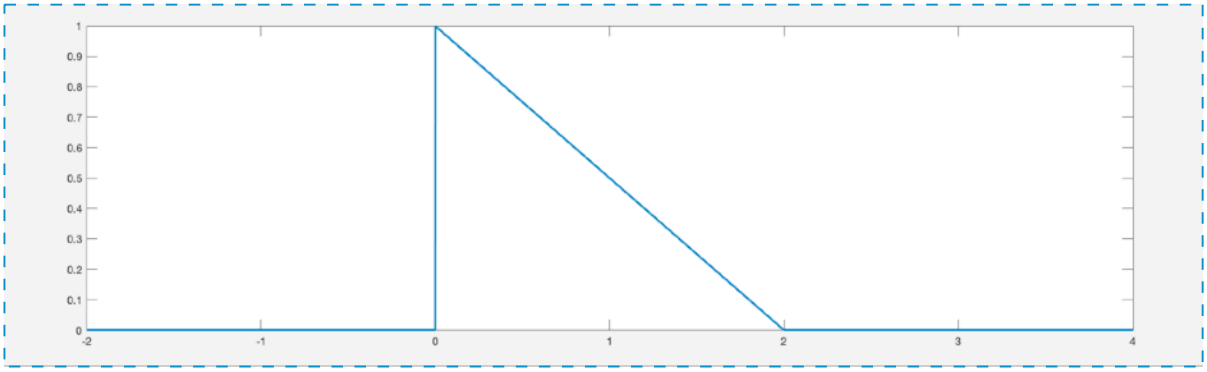




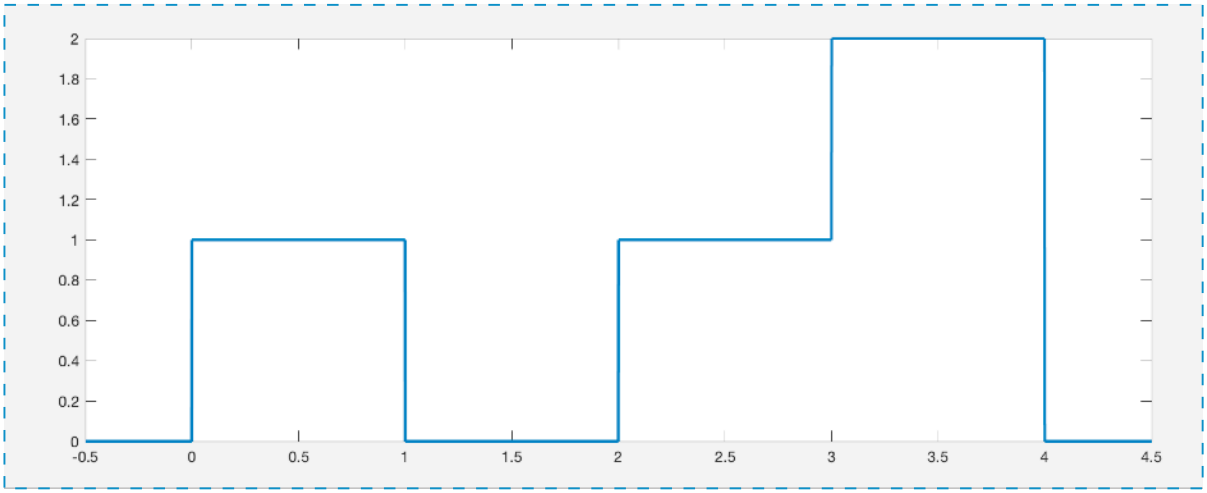
Question 9 (10 points)

determine the output of the following systems

(a) $x(t) = u(t)$ and h(t) is :



(b) $h(t) = u(t) - u(t-1)$ and x(t) is :



Matlab question 1 (30 points)

use matlab **conv** function to compute the output of the following systems with input :

(a) 2nd question, part a
(b) System with following input and impulse responses

$$x[n] = u[n+2] - 3u[n-10]$$

$$h[n] = 0.8^n \left(u[n-2] - 2u[n-3]\right)$$

Matlab question 2 (30 points)

Load the appended signal.mat file into matlab workspace.

(a) implement median and gaussian denoising methods on this signal. set the window size to 5, 10 and 100. compare the results and bring up an example to show in which condition, the median filter is more suitable and vice versa.
(b) can you express the gaussian method in terms of convolution theorem? if the answer is true, express it for window size = 5.
(c) can you express the median method in terms of convolution theorem? if the answer is true, express it for window size = 5.

Matlab question 3 (40 points)

implement the following filters on the appended picture. note that you need to implement the convolution operation without using matlab functions.

(a) box blur with kernel size of 3, 5.
(b) gaussian blur with kernel size of 3, 5 (standard deviation = 1)