Indian Institute of Technology Bombay

Department of Electrical Engineering

Handout 3 EE 229 Signal Processing

Homework 1 Aug 27, 2020

Question 1) A train of impulses given by $x(t) = \sum_{n\in\mathbb{Z}} x_n \delta(t - nT)$ was converted to an analog waveform using linear interpolation. However, by mistake, the engineer convolved $x(t)$ with a centered triangle function $h(t)$ with base width T and unit height.

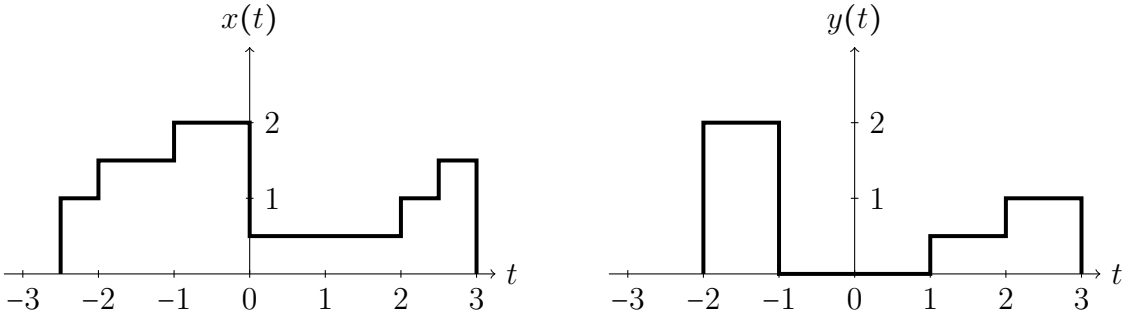
The analog signal $x(t) * h(t)$ was recorded on a tape and given to you. While playing back the tape, being smart enough, you realized that it is $h(t)$ that was used. However, only analog signal processing components which can change the amplitude and delay (along with connecting wires, power supply, input/output ports, transistors, opamps etc) are available to you. Suggest (in less than three line) how you will obtain the correct linear interpolation of the discrete-time waveform $x(t)$.

Question 2) Take your roll number, replace the letter D(if any) by the value 4, and consider the 9 digits thus obtained as a sequence of numbers, say $\bar{x} = x_0, \cdots, x_8$. Sketch the cubic interpolated signal between these samples, assume a separation of 1 second between successive samples. Edge effects can be accounted by adding zeros at the start and end.

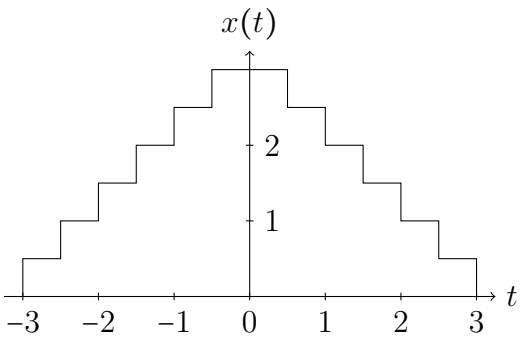
Question 3) Consider a cubic interpolation system, where we insist that the response to an impulse $\delta(t)$ should remain within $[-T, T]$, where T is the time duration between successive samples. Find the response which is consistent in such a way that, the response you derived can interpolate a set of samples such that the interpolated signal and the original samples agree at the correct sampling instants, and the interpolated signal is also differentiable.

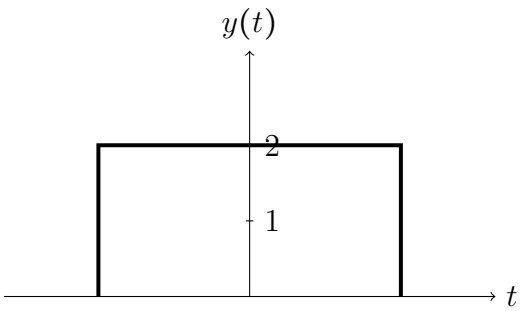
Question 4) (GNURADIO or Python Notebook) In this exercise, you have to sing a song and record (1-1.5 minute is okay). Ensure that you record at the rate of 8 kilo samples per second. If your recorder does not have it, record at 16k and throw away the alternate values. Cubic interpolate the samples to obtain an audio waveform at the rate of 48kilo samples per second. Mail your original and interpolated songs to srbpteach@gmail.com

Question 5) Draw the output of $x(t) * y(t)$, for the signals shown below.



Question 6) Drawn $x(t) * y(t)$ for the following two signals.


$x(t)$
2
1
t
−3
−2
−1
0
1
2
3


$y(t)$
2
1
t