EE4C5 Digital Signal Processing

Lecture 3 – Convolution in action

This lecture

- Convolution covered in Chapter 2 of O&S.
- More in-depth on practical implementation.
- All images from O&S book unless otherwise stated.
- Good explanation in Mitra textbook.

Why is convolution important?

- Filtering.
- Image processing.
- Polynomial multiplications.
- Audio effects.
- Convolutional neural nets.
- Seismic modelling.
- Diffraction patterns in optics.
- Analysis of time-series.

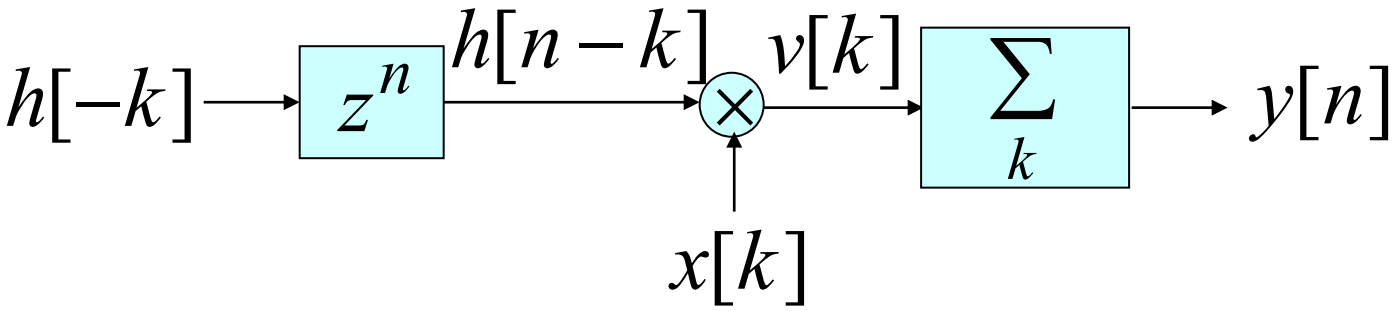
- Lecture #2 (and in previous modules) .
- Convolution relationship.
- $y[n] = x[n] * h[n]$
- $y[n] = \sum_{k=-\infty}^{\infty} x[k]\,\mathrm{h}[n-k]$

Convolution Sum

- Interpretation -
- 1) Time-reverse h[k] to form $h[-k]$
- 2) Shift $h[-k]$ to the right by n sampling periods if n > 0 or shift to the left by n sampling periods if n < 0 to form $h[n-k]$
- 3) Form the product $v[k] = x[k]h[n-k]$
- 4) Sum all samples of v[k] to develop the n-th sample of y[n] of the convolution sum.

Convolution Sum

- Schematic Representation (source Mitra) -



- The computation of an output sample using the convolution sum is simply a sum of products.
- Involves fairly simple operations such as additions, multiplications, and delays.

P35 O&S

35. An LTI system has impulse response given by the following plot:

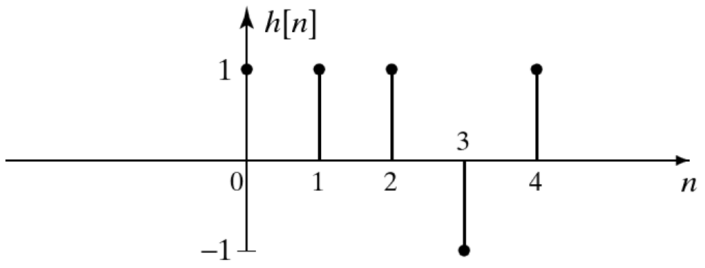


Figure P35-1

The input to the system, $x[n]$, is plotted below as a function of n.

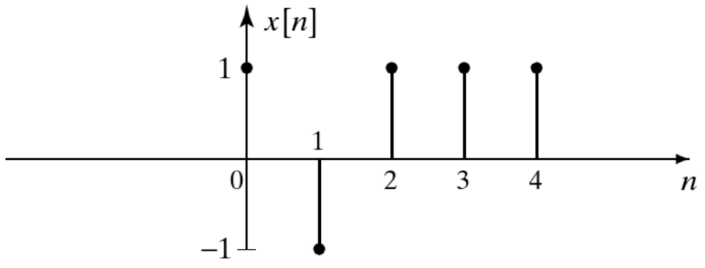


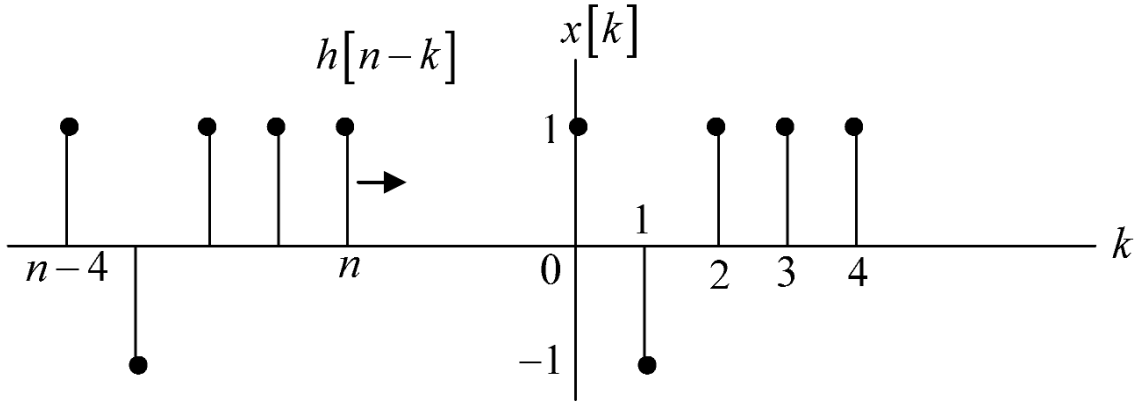
Figure P35-2

(a) Use discrete convolution to determine the output of the system $y[n] = x[n] * h[n]$ for the above input. Give your answer as a carefully labeled sketch of $y[n]$ over a range sufficient to define it completely.

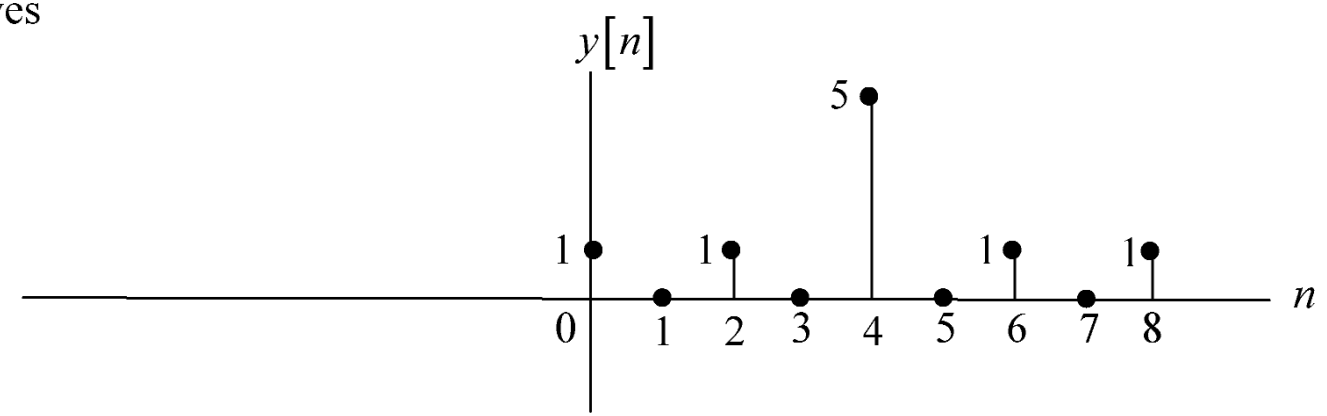
Do this in class…

Briefly

Using “flipping and shifting,”

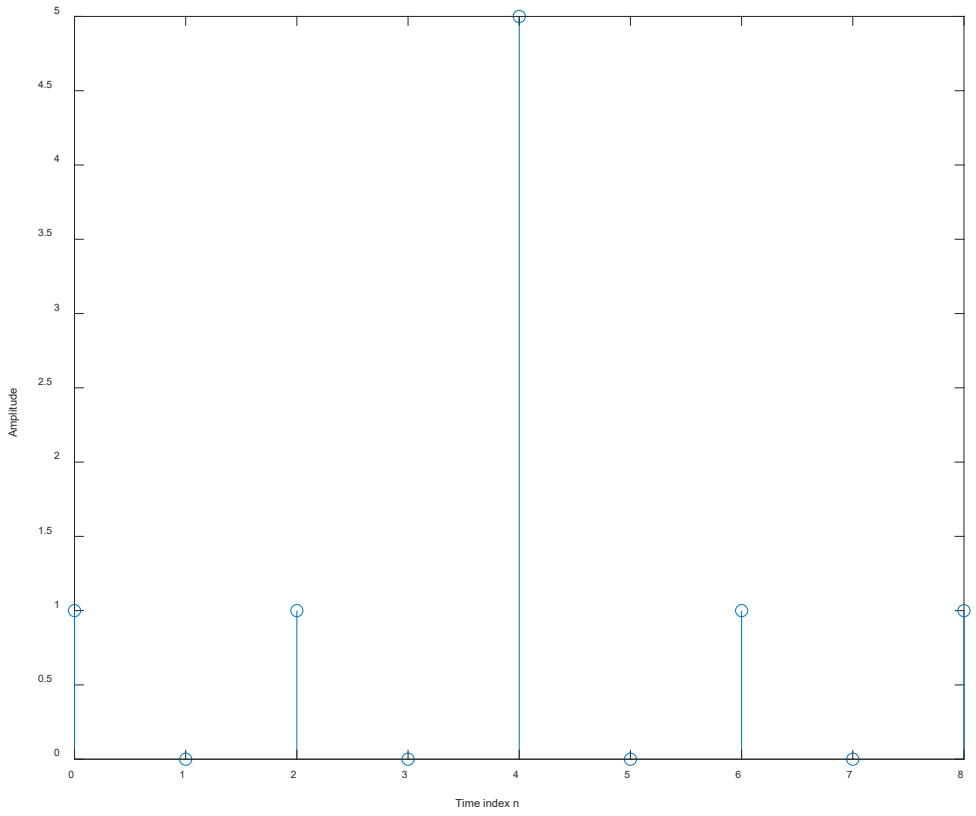


gives



Check with code

- mistra_convolution.m



Required Reading & other material

- Oppenheim & Schafer, Chapter 2.
- Great video:
  - But what is a convolution? – YouTube
  - Though it gets to the FFT which we will cover later.
  - Excellent connecting of concepts.