Convolution :- for two sequence $x[n]$ and $h[n]$, Convolution is defined as,

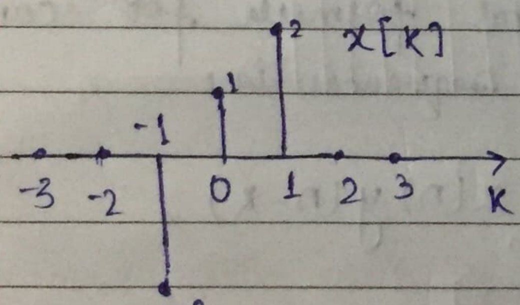
$$y[n] = \sum_{K=0}^{\infty} x(K)\, h(n-K)$$

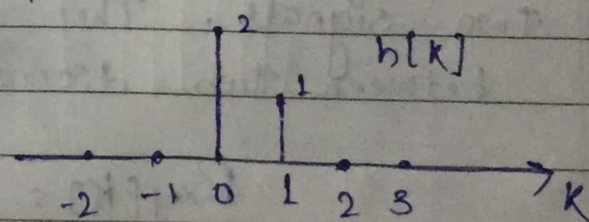
In any LTI System, with the knowledge of input and impulse response, we can determine system output with convolution.

If impulse response of an LTI system is known as $h[n]$, the output $y[n]$ is convolution of input $x[n]$ and impulse response $h[n]$

Steps for finding convolution :-

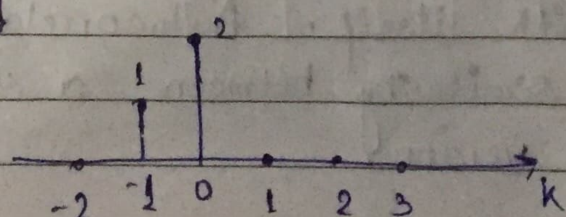
Consider two sequences $x[n]$ and $h[n]$. Plot these functions as functions of K, i.e. $x[K]$ and $h[K]$.





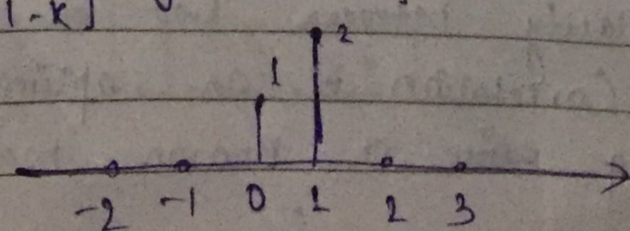
1. Invert $h[K]$ about $K=0$ to obtain $h[-K]$

$h[-K]$



2. Obtain $h[n-K]$ by shifting $h[-K]$ by n.

eg: $n=1, \Rightarrow h[1-K]$



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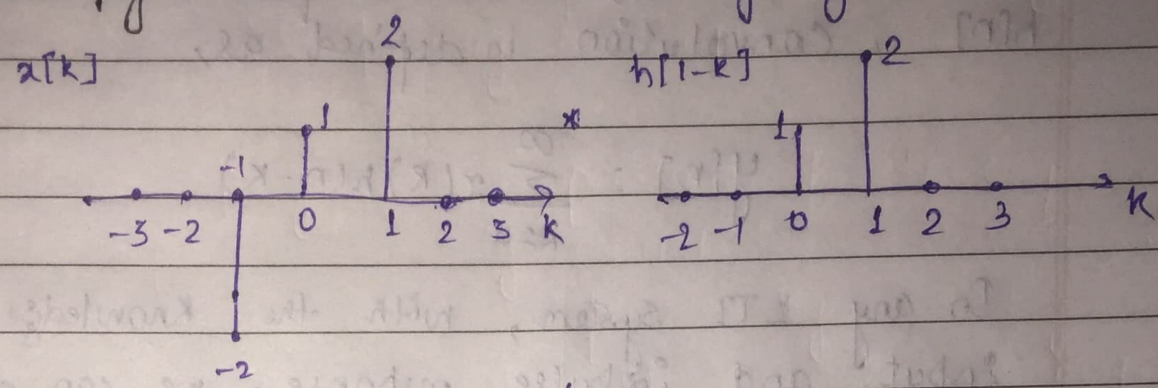
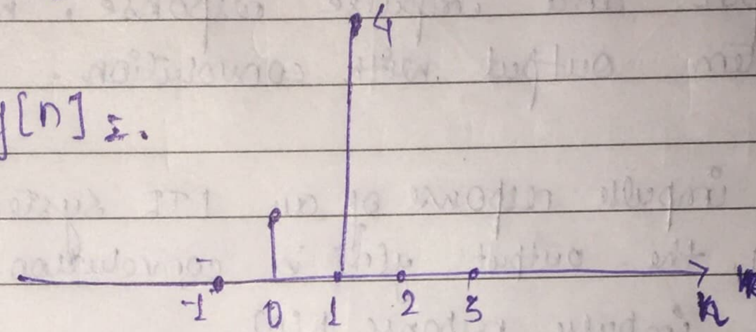
3. Multiply $x[k]$ with $h[1-k]$ to get $y[1]$



$y[n] =$



Correlation:-

Correlation is a measure of similarity between two signals. The general formula for correlation between two discrete sequences is,

$$R_{xy}[K] = \sum_{n=-\infty}^{\infty} x(n)\, y(n-k)$$

There are two types of correlation :-

1. Auto Correlation : It is defined as correlation of a signal with itself. Autocorrelation is a measure of similarity between a signal and its ~~time~~ delayed version.

2. Cross Correlation; It is defined as a measure of similarity between two ~~a~~ different signals.

Correlation is an optimal technique for detecting ~~noise~~ a known waveform in random

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noise. Using correlation to detect a waveform is frequently called matched filtering.

Mathematically, steps for correlation is identical, except for signal inside convolution machine is flipped left-to-right.

Hence, ~~convolution~~ correlation can also be written as,

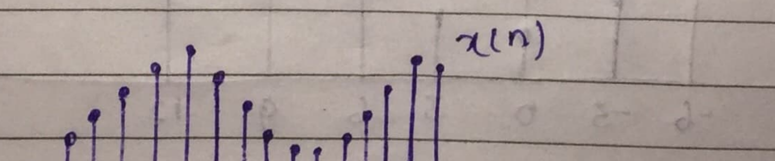
$$\boxed{R_{xy}[k] = x[k] * h[-k]}$$

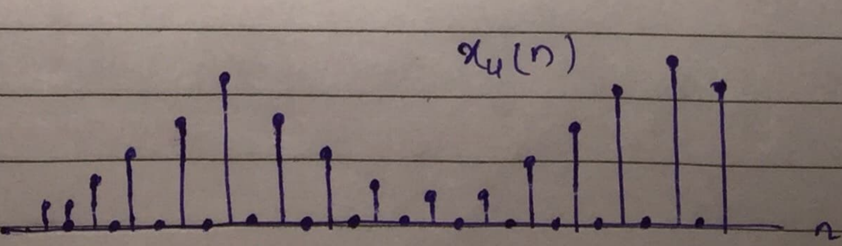
Upsampling:- The process of converting a sequence into a higher equivalent sampling rate is referred to as Upsampling or interpolation.

In upsampling by an integer factor $L > 1$, $L-1$ equidistant zero-valued samples are inserted between each two consecutive samples of the input signal $x(n)$ to generate and output signal $x_u(n)$, such that,

$$x_u(n) = \begin{cases} x(n/L), & n = 0, \pm L, \pm 2L, \dots \\ 0, & \text{otherwise} \end{cases}$$

The sampling rate of $x_u(n)$ is L times larger than that of original signal $x(n)$.

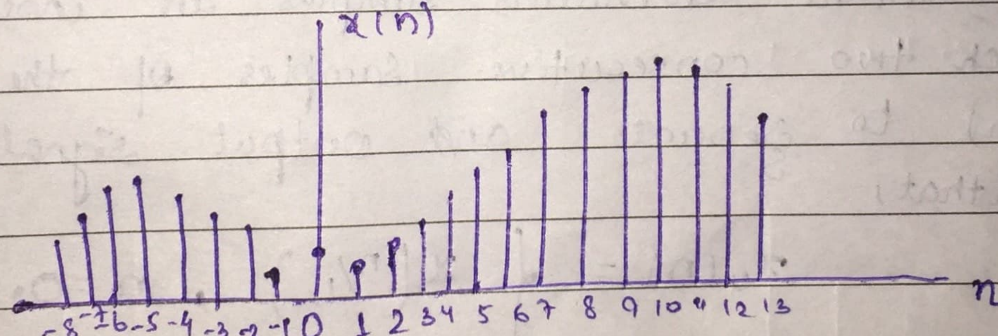




Down-Sampling :- The operation of extracting every N_s^{th} sample is commonly referred to as decimation. Thus, the decimation operation by an integer factor $N_s > 1$ on a signal $x(n)$ consists of keeping every N_s^{th} sample of $x(n)$ and removing $N_s - 1$ in between samples, such that,

$$x_d(n) = x(N_s \cdot n)$$

This result in a sequence $x_d(n)$ whose sampling rate is $1/N_s^{th}$ of that of $x(n)$.



for $N_s = 3$.