Republic of Iraq

Ministry of Higher Education

and Scientific Research

Al-Mustaqbal University College

Computer Engineering Techniques Department

Subject: Digital Signal Processing

Third Class

Lecture Five

By

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Signal Manipulations

These manipulations are generally compositions of a few basic signal transformations.

1- **Time Shifting**

A signal x(n) may be shifted in time by replacing the independent variable *n* by *n-k* , where *k* is an integer. If *k* is a positive integer x(n) is shifted to the right by *k* unit of time $x(n-k)$ (this is referred to as a delay), and it is shifted to the left by *k* unit of time $x(n+k)$ if *k* is negative (referred to as an advance).

2- **Time Reversal**

This transformation is given by $x(n) = x(-n)$ where the independent variable *n* is replaced by -*n* and simply involves flipping the signal x(n) with respect to the index *n*.

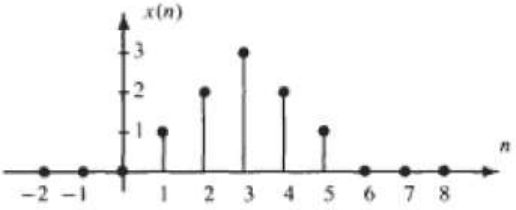
3- **Time Scaling**

This transformation involves the replacing of the independent variable *n* by *kn* or *n/k* where *k* is an integer number. The replacing by using *kn* is $x(kn)$ can be expressed by down-sampling while the replacing by *n/k* is $x({}^{n}/_{k})$ can be expressed by up-sampling.

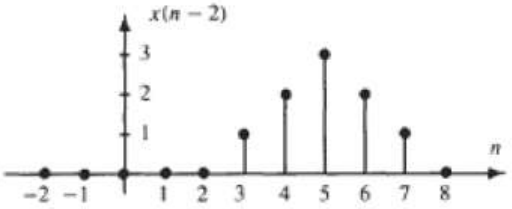
Example 1: for the given signal x[n], draw the following

x[n-2], x[-n], x[n/2].

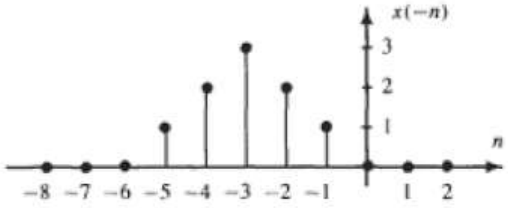
Sol:



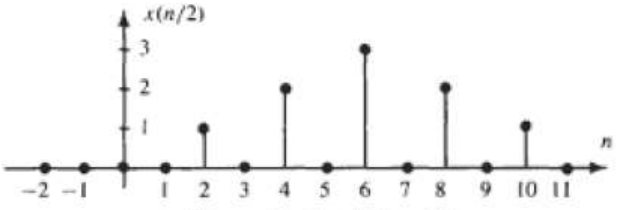
(a) A discrete-time signal.



(b) A delay by $n_0 = 2$.



(c) Time reversal.



(e) Up-sampling by a factor of 2.

4- Amplitude Scaling

Amplitude scaling of a signal x(n) by a constant c is accomplished by multiplying every signal value by c :

$$y(n) = c\, x(n)$$

Example 2: multiply the sequence x[n]={ 2, 4, 3, 0, 7} by a constant c =3.

y[n]= 3{2, 4, 3, 0, 7}= {6, 12, 9, 0, 21}

5- **Addition**

The sum of two signals is formed by the pointwise addition of the signal values.

$$y(n) = x_1(n) + x_2(n)$$

Example 3: add the two sequences { 0.5, 3, 1.5, 6} and { 2.5, 0.75, 4, 0.8}

y[n] = { 0.5, 3, 1.5, 6} + {2.5, 0.75, 4, 0.8} = {0.5+2.5, 3+0.75, 1.5+4, 6+0.8}

={ 3, 3.75, 5.5, 6.8}