⑤ Tabular representation

n	...	-2	-1	0	1	2	3	...
$x(n)$		0	0	1	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$	---

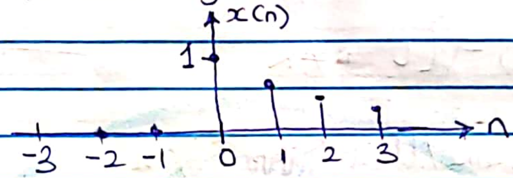
There are several alternative ways of describing the Samples value of a DT Signal. The most common are.

① Sequence Notation

$$x = \{\cdots 0, 0, \bar{1}, \tfrac{1}{2}, \tfrac{1}{4}, \tfrac{1}{8} \cdots\}$$

* The bar on the top of the Symbol 1 indicates origin $(n=0)$ or an arrow ↑

② Graphical



③ Explicit mathematical expression $x(n) = \begin{cases} 0, & n<0, \\ 2^{-n} & n \geq 0 \end{cases}$

④ Recursive approach $x(n) = \begin{cases} 0, & n<0 \\ 1, & n=0 \\ \frac{1}{2}x(n-1) & n>0, \end{cases}$

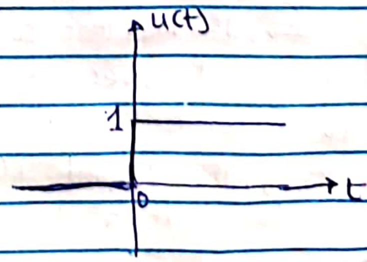
Depending on the Specific sequence $x(n)$, some approach may lead to more compact representation than others

ELEMENTARY SIGNALS (BASIC)

In Signal processing a proper reference frame is needed in order to place the Signals to be analysized. Since we deal with Signals, any reference frame of interest has to be made of Signals with well known properties, which reflect the kind of information we want to extract. There are several elementary signals that feature prominently in the Study of digital Signals and DSP. These basic signals will be the basis of our discussion.

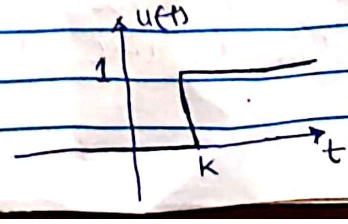
① Unit STEP FUNCTION:

Also called the Dirac Delta function is defined by $u(t) = \begin{cases} 1, & t \geq 0 \\ 0 & t<0 \end{cases}$



This function can also be shifted by ~~a factor~~ an argument

$$u(t-k) = \begin{cases} 1, & t \geq k \\ 0, & t<k \end{cases}$$



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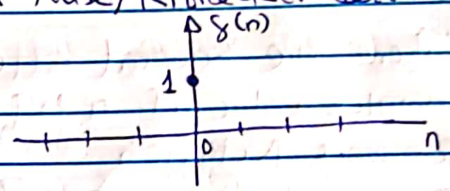
DT SIGNAL

→ **Unit Sample Sequence/ Unit Impulse / Unit Pulse / Kronecker delta**

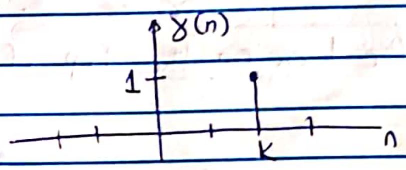
Denoted as $\delta(n)$ and is defined as

$$\delta(n) = \begin{cases} 1, & n = 0 \\ 0, & n \neq 0 \end{cases}$$



The USS can also be shifted by an argument

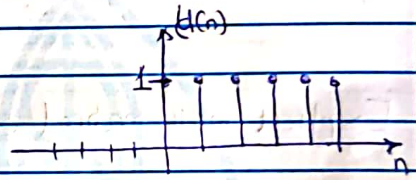
$$\cancel{\delta(n) =}$$
$$\delta(n-k) = \begin{cases} 1, & n = k \\ 0 & n \neq k \end{cases}$$



→ **Unit Step Sequence / Unit Step Signal**

Denoted as $u(n)$ and is defined as

$$u(n) = \begin{cases} 1, & n \geq 0 \\ 0, & n < 0 \end{cases}$$

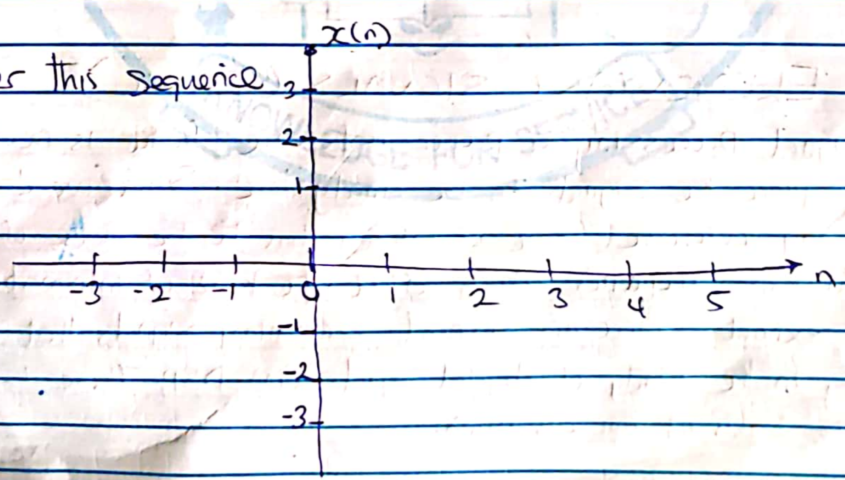


It is the discrete time counterpart for the Unit step function. It can also be shifted.

ASSIGNMENT There are other elementary Signals (Talk about them

- * Exponential Signal/sequence Real & Complex
- * Sinusoidal Signal
- * (Unit) ramp signal

Consider this sequence



It is important to note that a DT signal is not defined at instants between two successive samples. Additionally, It is wrong to think that $x(n)$ is equal to zero if n is not an integer. Simply, the signal $x(n)$ is not defined for non integer values of n.

Again if a discrete Time signal is written as a sequence of numbers inside braces, the location of the sample value associated with the time index $n=0$ is indicated by an arrow under it (↑)

The sample values to its right are for positive values of n, and the sample values to its left are for negative values of n. So from the diagram, $x(0) = ?$, $x(-1) =$; $x(2) = 8$

Therefore, for a sequence $x(n)$, which is zero from $n < 0$, can be represented as. $x(n) = \{\underset{\uparrow}{0}, 1, 2, 4, 0, 0, 5, 6\}$

The time origin for a sequence $x(n)$ which is zero for $n < 0$, is understood to be the ~~left~~ first (leftmost) point in the sequence. A finite-duration sequence can be represented as
$x(n) = \{3, -1, \underset{\uparrow}{-2}, 5, 0, 4, -1\}$
whereas a finite-duration sequence that satisfies the condition $x(n) = 0$ for $n < 0$ can be represented as
$$x(n) = \{0, 1, 4, 1\}$$
Thus the first signal has seven samples or points (in time), thus it is called or identified as a seven-point sequence, and the other a four point sequence. The DT signal may be a finite-length or an infinite-length sequence. A finite-length (also called finite-duration or finite-extent) sequence is defined only for a finite time interval: $N_1 \leq n \leq N_2$, where $-\infty < N_1$ and $N_2 < \infty$ with $N_2 \geq N_1$. The length or duration of the above finite length sequence is $N = N_2 - N_1 + 1$.

Thus as said before, a length-N discrete-time sequence consists of N samples and is called an N-point sequence.

A finite length sequence can also be considered an infinite length sequence by assigning zero values to samples whose arguments are outside the above range. The process of lengthening a sequence by adding zero-valued samples is called appending with zeros or zero-padding

ASS: Three types of Infinite-length sequence (1) A Right-sided sequence (2) A left sided sequence (3) A Two-sided sequence

112 162 163 164

DSP 165 512 161

OPERATION OF SEQUENCE

① TIME REVERSAL / folding / Reflection

It involves replacing the independent variable n by −n

note that the origin remains the same

$$x(n) = \{1, 2, 3, \underset{\uparrow}{4}, 5, 6, 7\}$$

$$x(-n) = \{7, 6, 5, \underset{\uparrow}{4}, 3, 2, 1\}$$

② Shifting (Delay & Advance) $y(n) = x(n-N)$ If $N>0$ = delay, $N<0$ = advance

Shifting can be done to the left or to the right

for $x(n)$; $x(n-k)$

Shift the origin of the sequence to K

set $n-k=0$ (set the argument equal to zero)

Then move the origin to k.

$$y = x(n+k)$$

Therefore move the origin to the left

ASS: What if it is reversed? How do you shift.

$$y(n) = x(-n+2)$$

$$x(-n-2)$$

③ Amplitude Scaling

④ Addition / Substraction — Zero Padding is needed here.

ASS: Time Scaling for continuous signals and discrete signal.

Conjugate Symetric Sequence

Conjugate assymetric Sequence

Classification of Sequence based on Symmetry

There is a general misconception among student about cummulative properties of shifting and folding. They are not commulative in nature. i.e Folding delayed signal is not the same as delaying a folded signal. To illustrate.

① $x(n)$ is first folded and then delayed by k units. So this mean

$$x\{x\{-(n-k)\}\} = x(-n+k)$$

② $x(n)$ is first delayed by k units and then folded.

$$x(-n-k)$$