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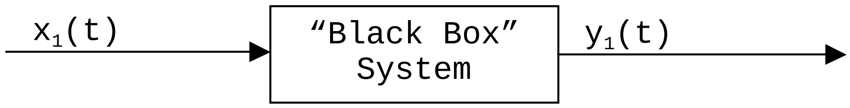
Notes on Linear Systems (Basics)

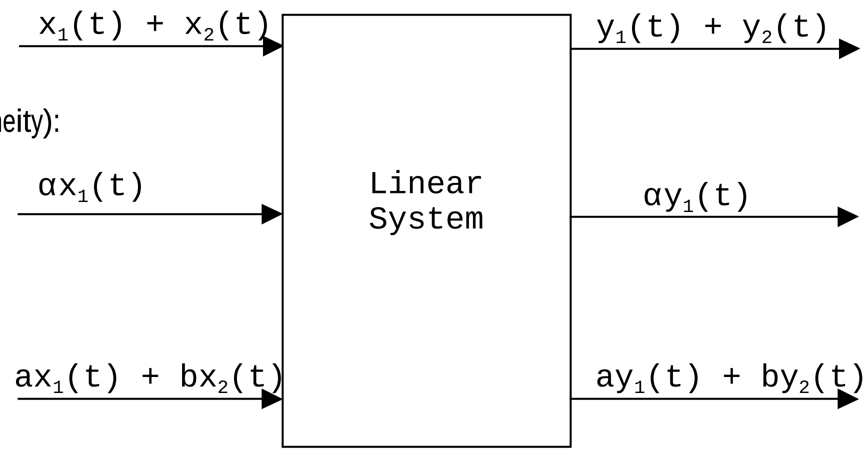
Linear Systems have 3 characteristic properties:
- **Additivity**
- **Scaling**
- **Superposition**



Additivity:

Scaling (Homogeneity):

Superposition:



Def'n: A <u>Causal Signal</u> is a signal that does not depend on future signals. Output at any time t_0 depends only in input from times prior to t_0 ($t \leq t_0$).

Def'n: A <u>Time Invariant</u> system is a system where the following holds:
If y(t) is the output when x(t) is the input, then $y(t - t_0)$ is the output when $x(t - t_0)$ is the input. I.e. the time when output is received is predictable.

Convolution Theorem: If x(t) is the input to a Linear Time Invariant system and h(t) is the impulse response, then the output of the system is:

$y(t) = x(t) * h(t)$, where "*" denotes convolution

In LTI systems, the result of a convolution is known as the convolution sum in discrete cases and the convolution integral in continuous time.

The Convolution Sum:

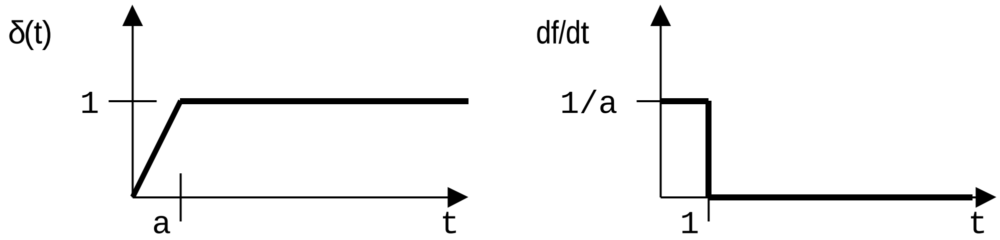
$$y[n] = \sum_{k=-\infty}^{+\infty} x[k]h[n-k]$$

The Convolution Integral:

$$y[t] = \int_{-\infty}^{+\infty} x(\tau)h(t-\tau]d\tau$$

The two are equivalent in their respective domains.

Def'n: An Impulse Function aka Delta Function has the following characteristics in the discrete and continuous space:



The characteristics of Linear Time Invariant systems are such that their behavior can be determined by using the impulse function as input to the system and observing the corresponding output, the impulse response.

The impulse function at time k sifts through the values of x[k] and preserves those values which correspond to k = n. This property is known as the sifting property of the impulse function.

The Convolution Sum is just the representation of the resultant signal y[n] as a linear combination of shifted unit samples.