Signals

A **signal** is a set of data or information or physical quantity that varies along a dimension (typically time or spatial)

A **system** processes signals, modifying, extracting, or lifting information from them.

LTIC

LTIC: Linear, Time Invariant, Causal

- **Linear**: Only additive and multiplicative transformations or combinations of signals
- **Time Invariant**: The transformation will be deterministic and non-dependent on when the transformation was made; a signal input at any time will output the same signal
- **Causal**: Real world signals can only respond to and react to signals and data from the present and past; not the future

Continuous vs. Discrete

Signals can either be continuous or discrete: where samples are infinitely resolute, or sampled at discrete time/spatial steps.

Analog vs. Digital

Analog signals have infinitesimal resolution in the values of the samples, while digital signals have been **quantized**, where the values must be able to be represented digitally, meaning it may only take certain pre-defined values.

SISO vs. MIMO

Single Input Single Output vs. Multiple Inputs Multiple Outputs; the definition is quite obvious.

Size of a Signal

Energy (AUC):

$$Ex = \int_{-\infty}^{\infty} |x(t)|^2 \, dt$$

Power (time averaged AUC):

$$Px = \lim_{T \to \infty} \frac{1}{T} \int_{-T/2}^{T/2} |x(t)|^2 \, dt$$

Signal Operations

Given: $x(t)$

Time Shift:
$x(t-s)$ where s is the shift

Time Scale:
$x\left(\frac{t}{s}\right)$ where s is the scale

Reversal happens when the time scale is less than 0

Periodic signals

Periodic signals are signals that satisfy the following equation:

$\forall n \in \mathbb{Z} : x(t) = x(t + nT_0)$

Basic Signals

Unit step:

$$u(t) = \begin{cases} 1 & t \geq 0 \\ 0 & t < 0 \end{cases}$$
$$u'(t) = \delta(t)$$