What are signals and systems

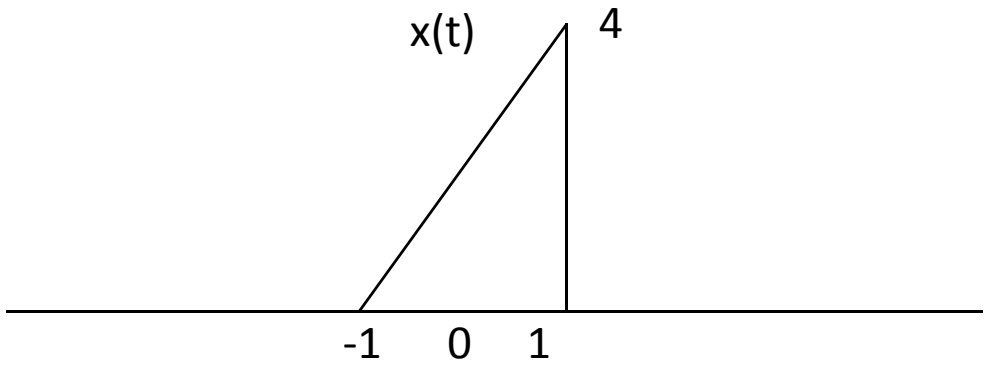
- Examples of signals:
  - Voltage output of a RLC circuit, stock market, ECG, speech, sequences of bases in a gene, MRI or CT scan
- Examples of systems:
  - RLC circuit, an algorithm for predicting future of stock market, an algorithm for detecting abnormal heart rhythms, speech understanding systems, edge detection algorithm for medical images.
- Continuous vs. Discrete

  $x(t)$ $x[n],\ n = \ldots -2, -1, 0, 1, 2 \ldots$

Transformation of signals

- Signal: *x(t)*
- Scaling: *a*x(t)*
- Time shift: $x(t-t_0)$
- Time reversal: *x(-t)*
- Linear stretch: *x(at) , a<1*
- Linear compression: *x(bt), b<1*

Examples: 0.5x(t), x(t-3), x(-t), x(t/2), x(2t), x(3-t/2)



Periodicity

- Continuous:

  $x(t) = x(t+kT)$, $k = 1, 2, \ldots$ T: fundamental period

  Any sinuoid is periodic

  Ex: $\sin(2\pi t/T)$

- Discrete:

  $x[n] = x[n+kN]$, N: fundamental period

  Not all sinusoid is periodic!

  Periodic if $\omega_0/2\pi = m/N$, *where m and N are both integers (pg. 26 O & W)*

  $\omega_0/2\pi$ *must be rational number*

  Ex: $\sin(\omega n)$, $\cos(4\pi n/3)$, $\cos(2n)$

Special signals:

- Sinc: $$\mathrm{sinc}(t) = \frac{\sin 2\pi t}{2\pi t}$$
- Delta function: $$\delta(t) = \begin{cases} n = 0 & \infty \\ otherwise & 0 \end{cases} \quad \int_{-\infty}^{\infty} f(t)\delta(t)dt = f(0)$$
- Unit step (CT): $$u(t) = \begin{cases} t \geq 0 & 1 \\ otherwise & 0 \end{cases}$$
- Unit sample: $$\delta[n] = \begin{cases} n = 0 & 1 \\ otherwise & 0 \end{cases}$$
- Unit step (DT): $$u[n] = \begin{cases} n \geq 0 & 1 \\ otherwise & 0 \end{cases}$$

Note: $\delta[t] = d/dt\ u[t]$ and $d[n] = u[n] - u[n-1]$