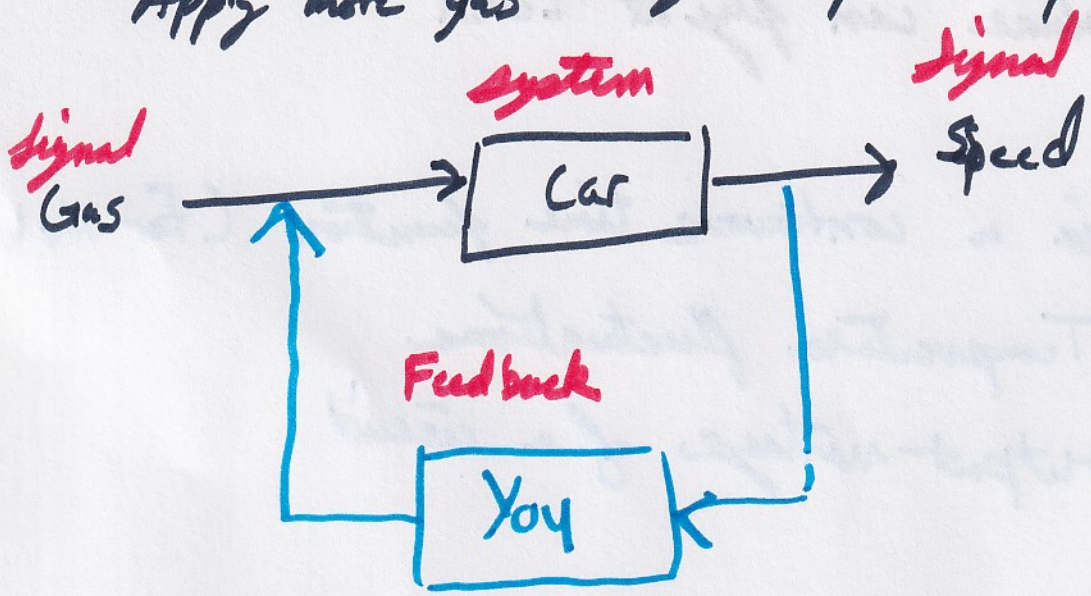
Signals & Systems L1

Basic Signals

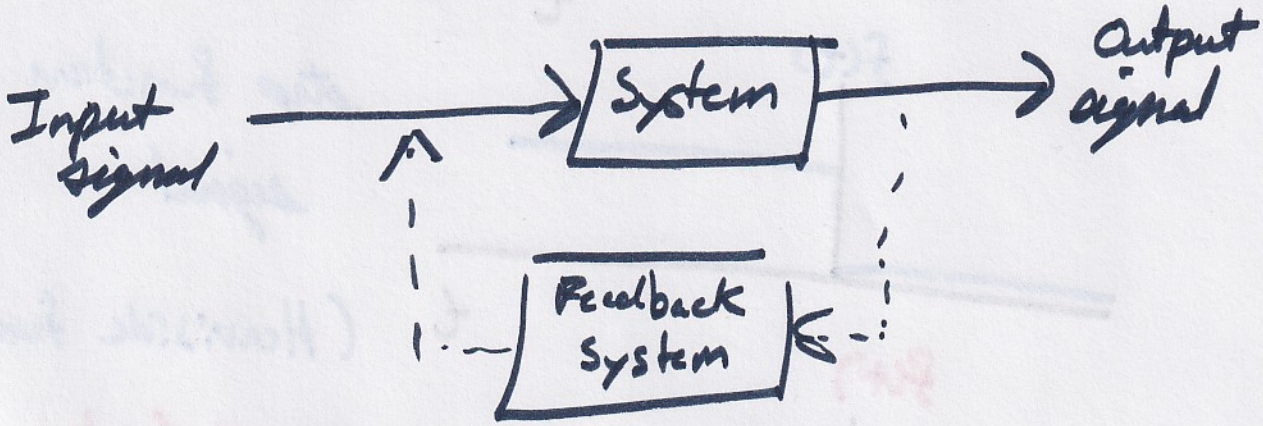
Car speed

Apply more gas → car speeds up



You control the speed

Another way of looking at it...



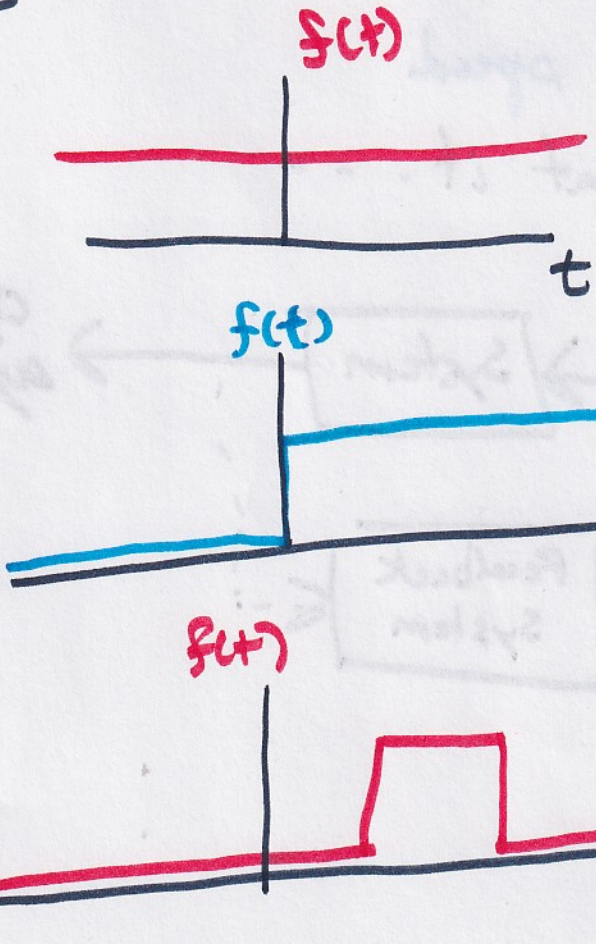
Feed back system is able to do this

- Car moves at a constant speed
- Room can remain at a constant temperature
- Aeroplane can fly at Level

A signal is a continuous time function (For Now)

- Temperature fluctuations
- output voltage of a circuit

Examples

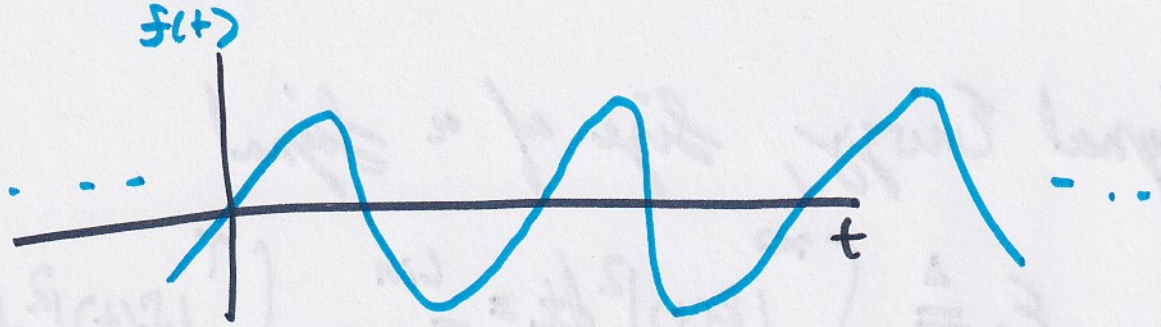


constant signal

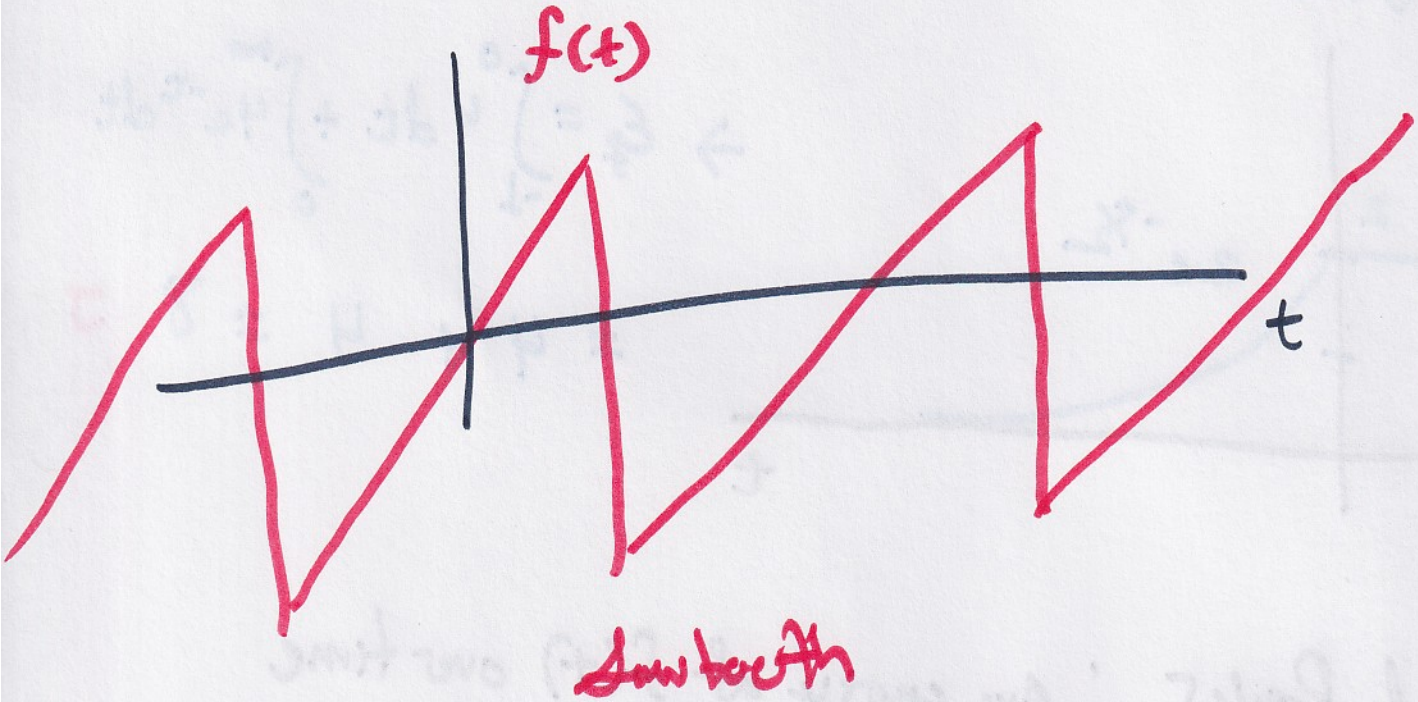
step function signal

(Heaviside function)

square / pulse signal



A wiggle signal (sinusoid signal)



sawtooth

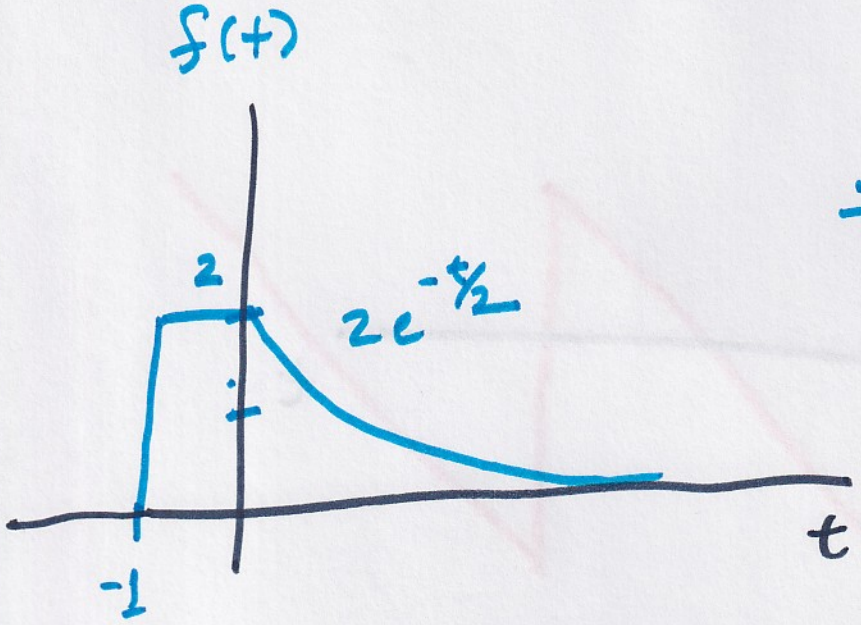
Real Signals

AM Radio	cable TV	telephone
FM Radio	Ethernet	telegraph

Properties of real signals can be characterized mathematically.

Signal Energy, Size of a Signal

$$\mathcal{E}_f \triangleq \int_{-\infty}^{\infty} |f(t)|^2 dt = \lim_{T\to\infty} \int_{-T}^{T} |f(t)|^2 dt$$



$$\rightarrow \mathcal{E}_f = \int_{-1}^{0} 4\,dt + \int_{0}^{\infty} 4e^{-t} dt$$

$$= 4 + 4 = 8 \text{ J}$$

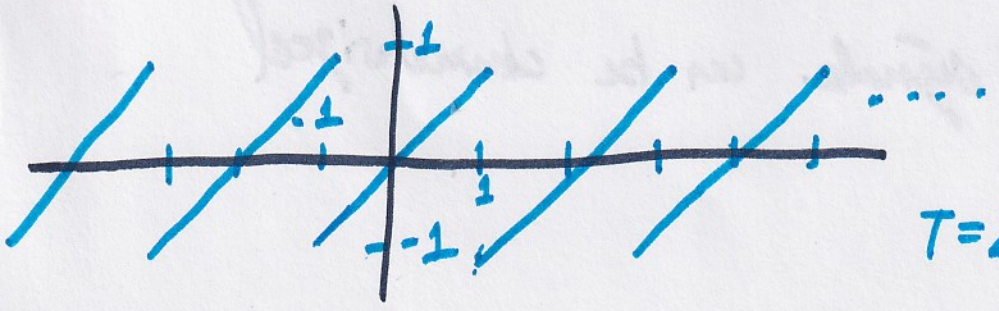
Signal Power: Avg energy of f(t) over time

recall $W = \frac{J}{s}$

$$P_f = \lim_{T\to\infty} \frac{1}{2T} \int_{-T}^{T} |f(t)|^2 dt$$

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

$$\int_{-1}^{1} x^2 dt = \frac{2}{3}$$



$T = 2 \rightarrow P_f = \frac{1}{3}$

Signal Classification: Energy vs Power Signals

- Energy signal: $f(t)$ is an energy signal if

$$E_f < \infty$$

- What is the power of an energy signal?

Zero

$$P_f = \lim_{T\to\infty} \frac{1}{2T} \int_{-T}^{T} |f(t)|^2 dt = 0$$

This guy would be finite

$$\rightarrow \lim_{T\to\infty} \frac{\text{Constant}}{2T} \rightarrow 0, \quad \lim_{T\to\infty} \frac{c}{2T} \rightarrow 0$$

- Power Signal: $f(t)$ is a power signal if $0 < P_f < \infty$
  - What's the energy of a power signal? Infinity

$$E_f = \lim_{T\to\infty} \int_{-T}^{T} |f(t)|^2 dt = \lim_{T\to\infty} 2T \frac{1}{2T} \int_{-T}^{T} |f(t)|^2 dt = \infty$$

This is finite and converges

Signal classification

- Energy Signal: $f(t)$ is an energy signal if $E_f < \infty$

- Power Signal: $f(t)$ is a Power signal if $0 < P_f < \infty$

A signal cannot be a power signal and an energy signal at the same time.

$$W = \frac{J}{S}$$

$$J = W \cdot S$$