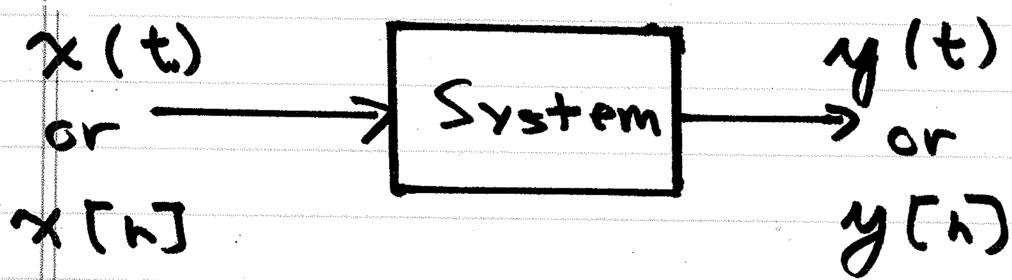
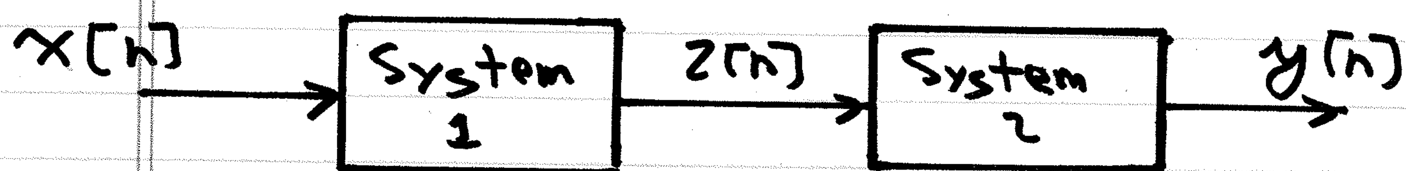
Systems

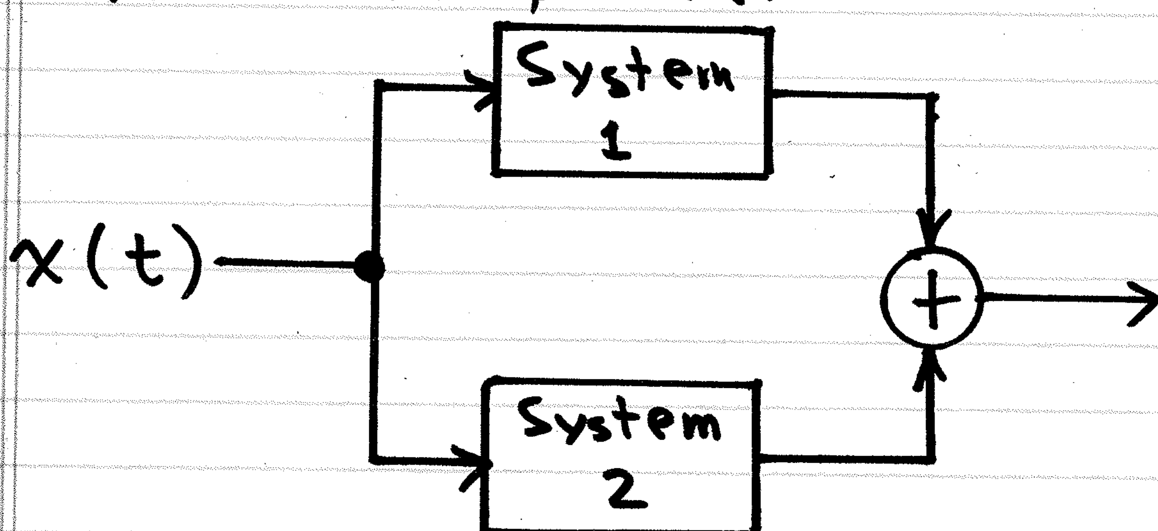
- Take "black-box" viewpoint of systems in this course



- Systems in series:



- Systems in parallel:



Potential System Properties

Linear:

$$x_i(t) \rightarrow \boxed{S} \rightarrow y_i(t)$$

$$i = 1, 2$$

$$a_1 x_1(t) + a_2 x_2(t) \rightarrow \boxed{S} \rightarrow a_1 y_1(t) + a_2 y_2(t)$$

Time Invariance

$$x(t) \rightarrow \boxed{S} \rightarrow y(t)$$

$$x(t-t_0) \rightarrow \boxed{S} \rightarrow y_{t_0}(t)$$

$$y_{t_0}(t) \stackrel{?}{=} y(t-t_0)$$

Causal: $y(t)$ does not depend on future (time) values of $x(t)$.

Stable:

$$x(t) \rightarrow \boxed{S} \rightarrow y(t)$$

$|x(t)| < B_{in}$ $\forall t$ guarantees $|y(t)| < B_{out}$ $\forall t$

$B_{in} \neq \infty$ $\quad B_{out} \neq \infty$

Memoryless: $y(t_0)$ only depends on $x(t_0)$

true for any t_0

Invertible:

$$x(t) \rightarrow \boxed{S} \rightarrow \underbrace{\boxed{S^{-1}}}_{\text{inverse system}} \rightarrow x(t)$$

for any and all inputs $x(t)$

CT: Common Systems Encountered in Practice

$$y(t) = \int_{-\infty}^{t} x(\tau)\, d\tau$$

Linear and TI

LTI

or: $$y(t) = \int_{t-T_1}^{t+T_2} x(\tau)\, d\tau$$

LTI

$$y(t) = x^2(t)$$

not L, TI

nonlinear

$$y(t) = x(at)$$

L, not TI

$$y(t) = g(t)\, x(t)$$

L, not TI

$$y(t) = \frac{d}{dt} x(t)$$

LTI

$$y(t) = x(t - t_0)$$

LTI

$$y(t) = \begin{cases} x(t), & \text{if } a < x(t) < b \\ b, & \text{if } x(t) > b \\ a, & \text{if } x(t) < a \end{cases}$$

nonlinear

TI

DT: Common Systems Encountered in Practice

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

$$y[n] = \sum_{k=n-N_1}^{n+N_2} x[k]$$ LTI

$$y[n] = x^2[n]$$ not L, TI

$$y[n] = x[Ln]$$ L integer — L, not TI

$$y[n] = g[n]\, x[n]$$ L, not TI

$$y[n] = x[n] - x[n-1]$$ LTI

$$y[n] = x[n - n_o]$$ LTI

Difference Equation

$$y[n] = -\sum_{k=1}^{N} a_k\, y[n-k] + \sum_{k=0}^{M} b_k\, x[n-k]$$

LTI