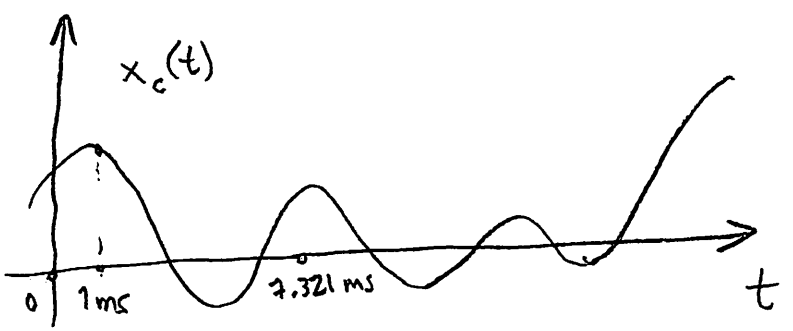
- Main characters: Signals and Systems

① Signals: physical quantity that carries information

(i) continuous-time (analog, real-world)

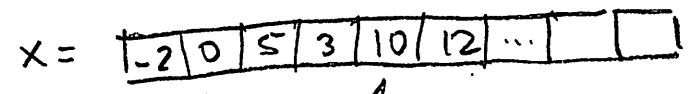
$x(t), \quad t \in \mathbb{R}$



speech
light intensity

(ii) discrete-time (domain) (digital, computer)

$\{x[n]\}_{n=-\infty}^{\infty}$



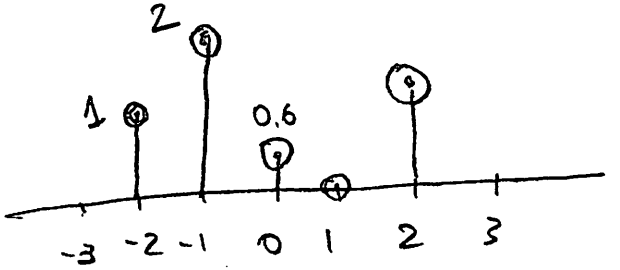
. bytes stored in memory

$= \{\ldots, x[-1], x[0], x[1], x[2], \ldots\}$

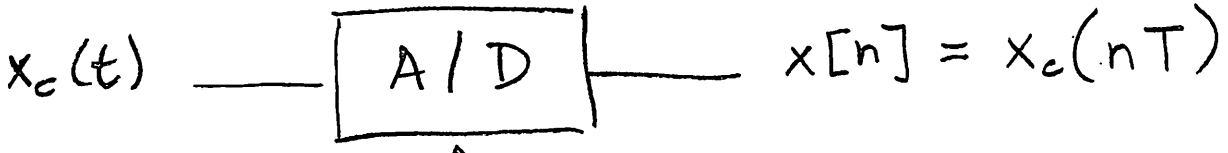
Samples

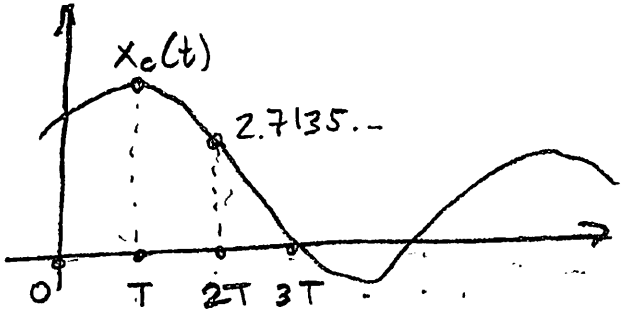
sample index

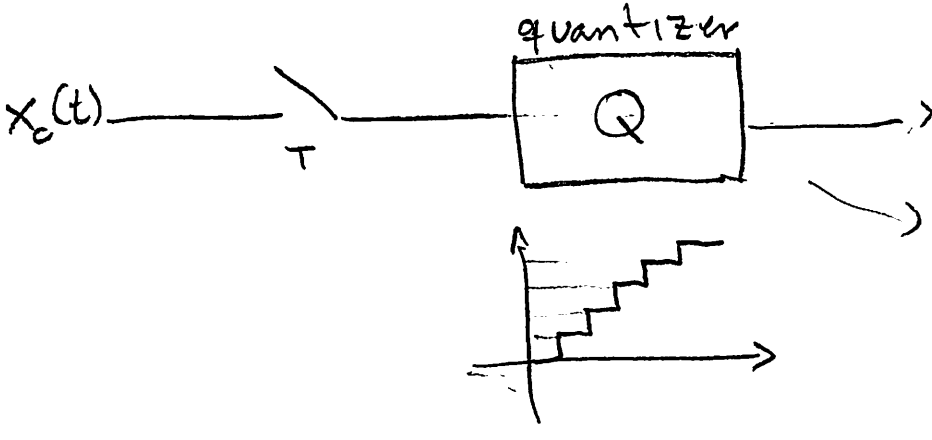
stem plot:



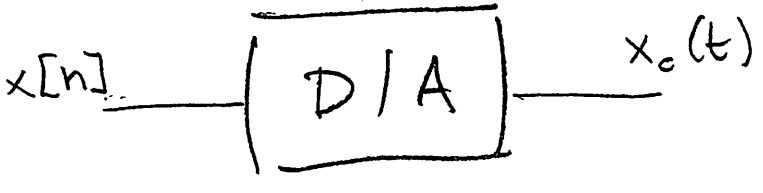
- converting between discrete and continuous

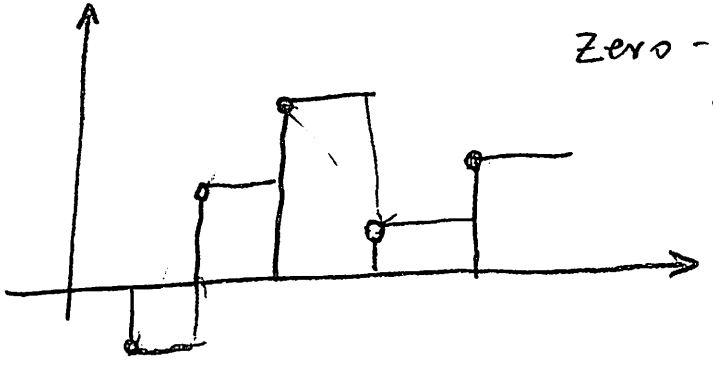




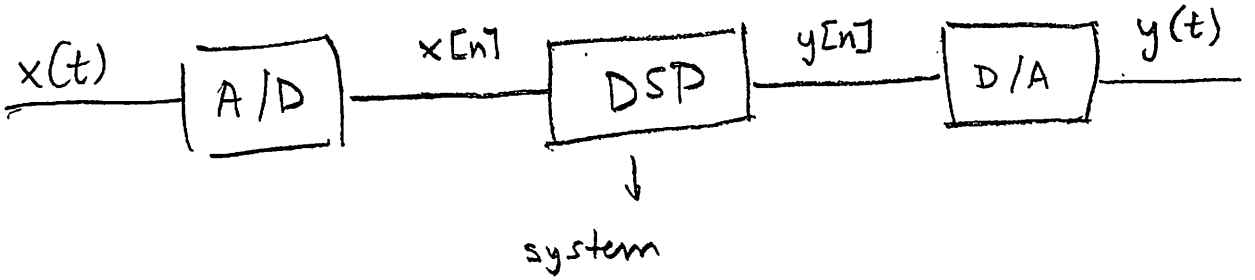


ignored in this course

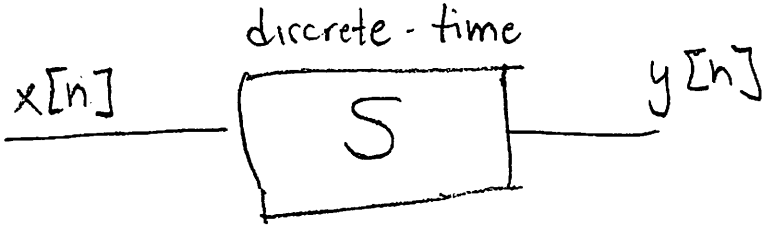




In this course

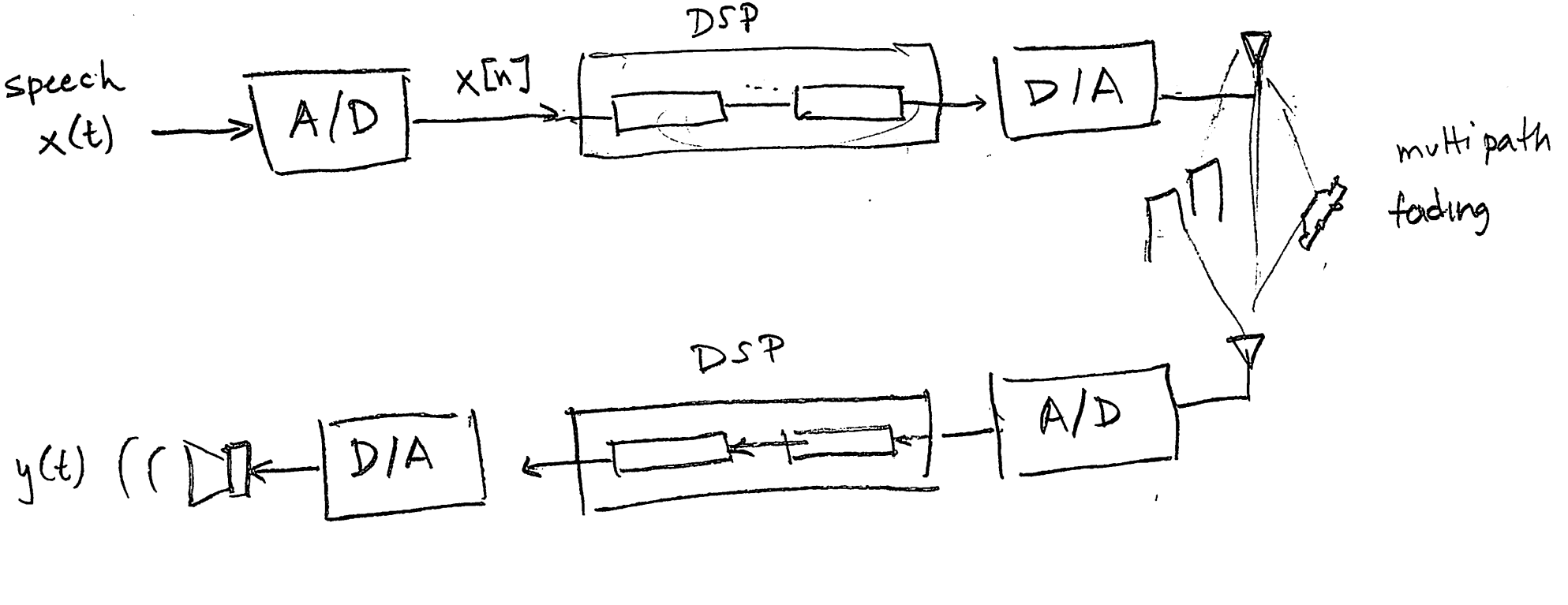


(2) System : maps an input signal to an output signal



$$\{y[n]\}_{n=-\infty}^{\infty} = S\left(\{x[n]\}_{n=-\infty}^{\infty}\right)$$

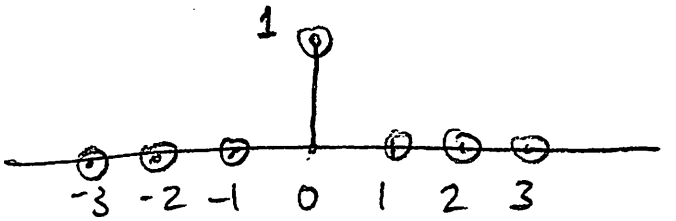
- Example DSP application (Cell phone)



Basic discrete-time signals and systems

(1) Impulse signal

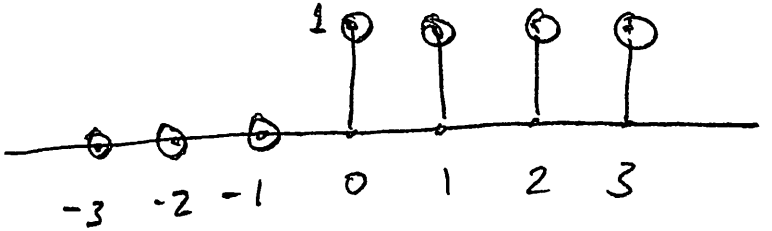
$$\delta[n] = \begin{cases} 1 & \text{if } n = 0 \\ 0 & \text{otherwise} \end{cases}$$



$$\{\delta[n]\}_{n=-\infty}^{\infty} = \{\ldots, 0, 0, \underset{\uparrow}{1}, 0, 0, \ldots\}$$

(2) Unit step signal

$$u[n] = \begin{cases} 1 & \text{if } n \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

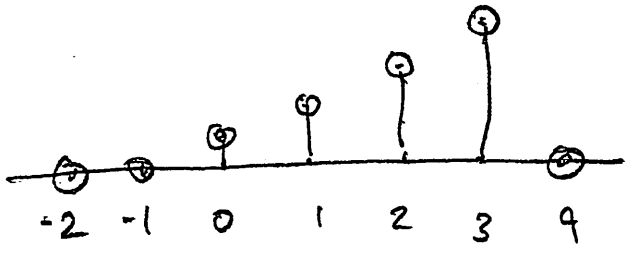


$$\{u[n]\} = \{\ldots, 0, 0, \underset{\uparrow}{1}, 1, 1, \ldots\}$$

(3) Delay by n_0 (system) — n_0: constant

$$\{x[n]\} \longrightarrow \boxed{y[n] = x[n - n_0]} \longrightarrow \{y[n]\}$$

Ex$_1$: $\{x[n]\}_{n=0}^{3} = \{1, 2, 3, 4\}$, delay by $n_0 = 2$



$y[-1] = x[-1-2] = x[-3] = 0$

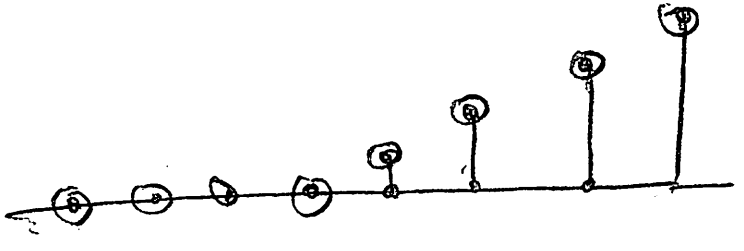
$y[0] = x[-2] = 0$

$y[1] = x[-1] = 0$

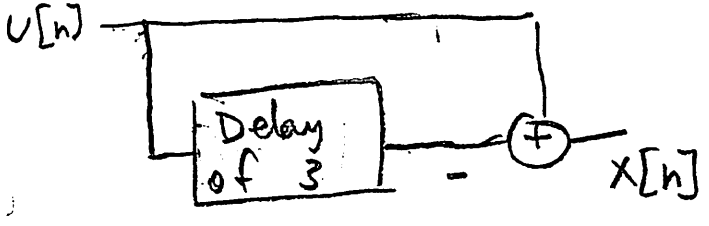
$y[2] = x[0] = 1$

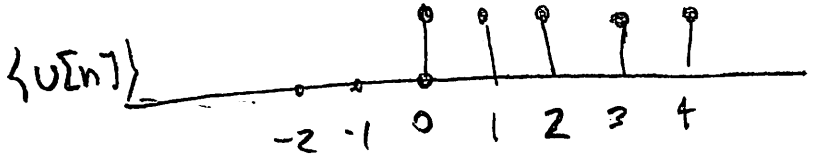
$\vdots$

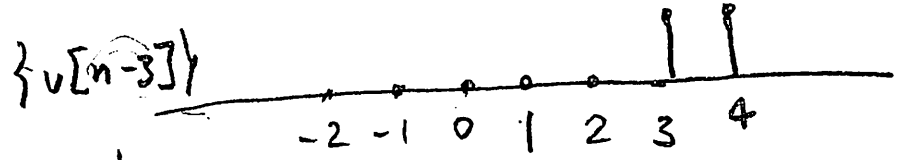
$y[5] = x[3] = 4$



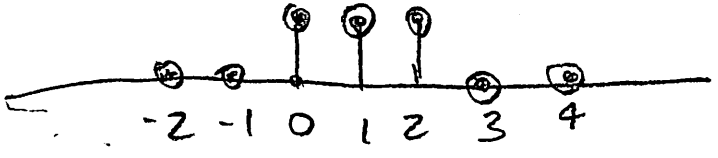
Ex$_2$: $x[n] = u[n] - u[n-3]$







rectangular window signal



Ex$_3$: $\delta[n] \longrightarrow$ | Delay by n_0 | $\longrightarrow \delta[n-n_0]$