* As a result, for linear systems, there is an alternative way to compute the output

That is: Suppose we know some "test signals" $x_1, \cdots, x_n$ & the corresponding outputs $y_1, \cdots, y_n$

Test signals

$x_1, \cdots, x_n$

$\downarrow$ "A", the given linear system

the corresponding outputs of the test signals

$y_1 \quad y_n$

A new signal

x

① direct computation

y

(2.1) write x as $x = \alpha_1 x_1 + \alpha_2 x_2 + \cdots \alpha_n x_n$

(2.2) y is the weighted sum of the corresponding outputs using the same weights $\alpha_1, \cdots, \alpha_n$)

Q: Why use (2.1) + (2.2) instead of ① ?

A: ① Since most systems are "black boxes," it may be hard to use the mechanism inside the black box to directly compute the output. On the other hand, it might be easier to find the weights $\alpha_1, \dots, \alpha_n$ so that we can "assemble" the new y without knowing what is inside the black box.

② The test signals help you understand the system even before applying the real signals of interest.

Ex: If we know a image-processing program is linear and the output of red and blue pixels are

$$\text{Red} \longrightarrow \boxed{\text{Sys}} \longrightarrow \text{Green}$$

$$\text{Blue} \longrightarrow \boxed{\text{Sys}} \longrightarrow \text{Blue}$$

Q: $\text{Purple} \longrightarrow \boxed{\text{Sys}} \xrightarrow{\ ?\ }$ teal

A: $\because$ Purple $= R + B$ $\therefore$ the output is $G + B =$ Teal

* For linear systems, once we know the outputs of the test signals, we know how to construct the output of "any" signal.

Q: How to choose good / convenient test signals?

Ex: R, G, B, are good choices for images

Q: What about other systems?

A: Convolution integral & Fourier transform.

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* Classification of different signals

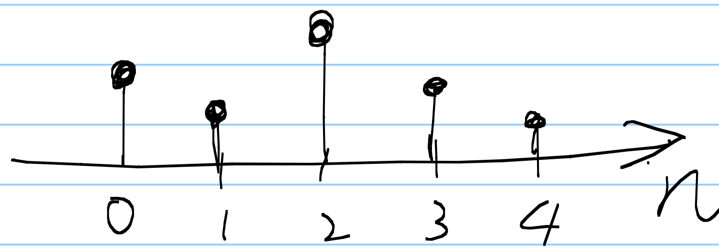
* Classification #1: Discrete-Time (DT) vs. Continuous-Time (CT)

- Discrete-Time:

	Real (-valued) signals	/ Complex (-valued) signals
$x[0] =$	0	$x[0] = 0 + j$
$x[1] =$	$\frac{1}{2}$	$x[1] = \frac{1}{2} - j$
$\vdots$		
$x[n] =$	$\frac{n}{2}$	$x[n] = \frac{n}{2} + (1-2n)j$

$$= x_{Re}[n] + j\,x_{Im}[n]$$

Visualization:



- Continuous-Time (CT)

Real

$x(t) = \frac{t}{2}$

$x(\frac{1}{3}) = \frac{1}{6}$

$x(\pi) = \frac{\pi}{2}$

Complex

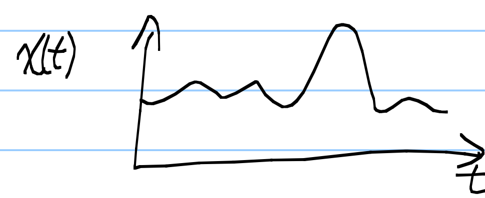
$x(t) = \frac{t}{2} + (1-2t)j$

$= x_{Re}(t) + j x_{Im}(t)$

$x(\frac{1}{3}) = \frac{1}{6} + \frac{1}{3}j$

$x(\pi) = \frac{\pi}{2} + (1-2\pi)j$

visualization



* Classification #2: By energy & by power

infinite (∞) energy

finite power

signals

(Four different types)