Lecture 3
Signals and Systems (ELL205)

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Outline

- What are signals?
- What are systems?
- Different kinds of Signals
    - Continuous-time vs. Discrete-time signals
    - Energy vs. Power signals
- Signal transformations
    - Flipping
    - Scaling
    - Shifting

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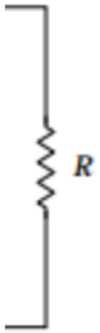
Types of signals

- **Energy vs. power signals**

$$p(t) = v(t)i(t) = \frac{v^2(t)}{R}$$



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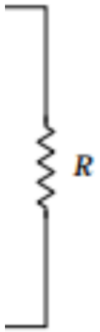
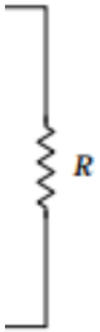


$$E(t_2 - t_1) = \int_{t_1}^{t_2} \frac{v^2(t)}{R} dt$$

Types of signals

- **Energy vs. power signals**



$$p(t) = v(t)i(t) = \frac{v^2(t)}{R}$$

$$E(t_2 - t_1) = \int_{t_1}^{t_2} \frac{v^2(t)}{R} dt$$

$$\langle p(t) \rangle = \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} \frac{v^2(t)}{R} dt$$

Types of signals

- **Energy vs. power signals**

Analogous to defining energy and power of signals in electric circuit, we can also define Energy of a signal as

$$E = \int_{t_1}^{t_2} |x(t)|^2 dt$$

Types of signals

- **Energy vs. power signals**

Analogous to defining energy and power of signals in electric circuit, we can also define Energy of a signal as

$$E = \int_{t_1}^{t_2} |x(t)|^2 dt$$

Note that this is not physical energy as $x(t)$ can be any signal such as sound pressure, voltage, current, etc. Thus, energy conservation cannot be applied.

Types of signals

- **Energy vs. power signals**

Similarly, Power of a signal is

$$P = \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} |x(t)|^2 dt$$

Types of signals

- **Energy vs. power signals**

$$E_{\infty} =$$

$$P_{\infty} =$$

Types of signals

- **Energy vs. power signals**

$$E_\infty = \lim_{T\to\infty} \int_{-T}^{T} |x(t)|^2 dt$$

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

Types of signals

- **Energy vs. power signals**

For discrete-time signals

$$E_\infty = \lim_{N\to\infty} \sum_{n=-N}^{N} |x[n]|^2$$

$$P_\infty = \lim_{N\to\infty} \frac{1}{2N+1} \sum_{n=-N}^{N} |x[n]|^2$$

Types of signals

- **Energy vs. power signals**

If $E_\infty = finite, P_\infty =?$

Types of signals

- **Energy vs. power signals**

If $E_\infty = finite, P_\infty = 0$

Energy signal

Types of signals

- **Energy vs. power signals**

If $E_\infty =?, P_\infty = finite$

Power signal

Types of signals

- **Energy vs. power signals**

If $E_\infty = \infty, P_\infty = finite$

Power signal

Types of signals

- **Energy vs. power signals**

If $E_\infty = \infty, P_\infty = \infty$

Neither Energy nor Power signal

Useless signal !!

Types of signals

- **Energy vs. power signals**

E_∞	P_∞	
∞	∞	Useless signal
$Finite$	0	Energy signal (only possible practically)
∞	$Finite$	Power signal

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  - Shifting
- Further classifications of Signals
  - Even vs. Odd signals
  - Periodic vs. Aperiodic signals

Signal and its transformation

1) Time-reversal/flipping/folding

$$x(t) \rightarrow x(-t)$$

Signal and its transformation

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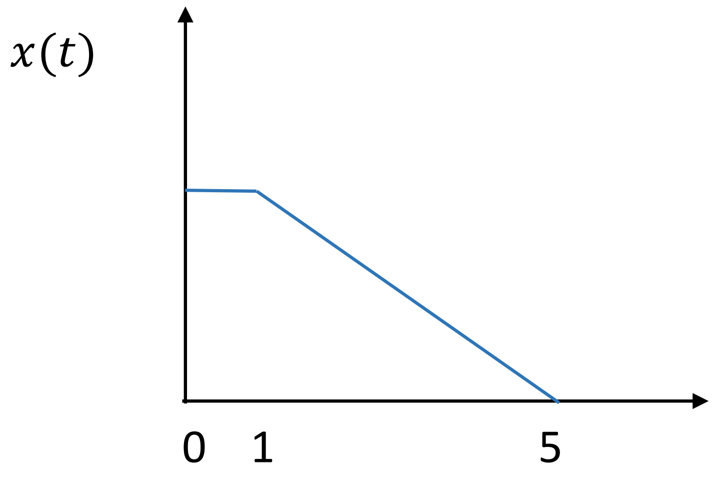
$$x(t) \rightarrow x(-t)$$



$x(-t) = ?$

Signal and its transformation

2) Time-scaling

$$x(t) \rightarrow x(\alpha t)$$

Signal and its transformation

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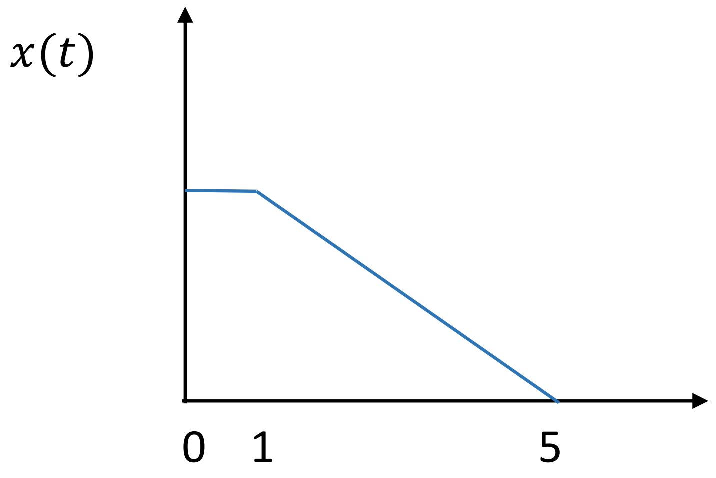
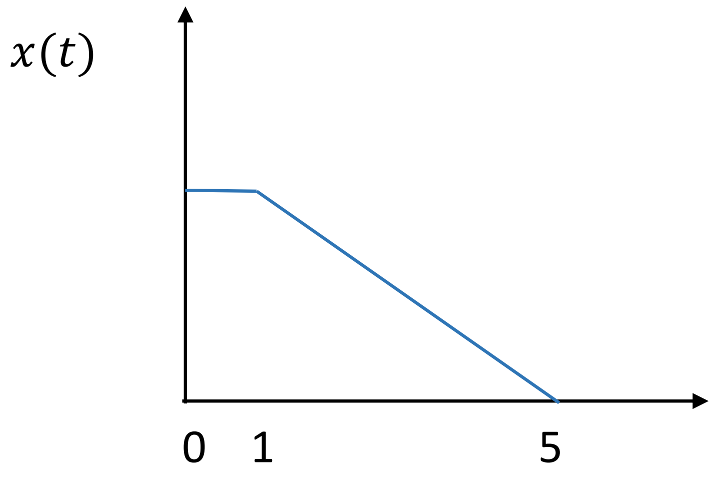


$x(2t) = ?$

Signal and its transformation

2) Time-scaling

$$x(t) \rightarrow x(\alpha t)$$



$$x\left(\frac{1}{2}t\right) = ?$$

Signal and its transformation

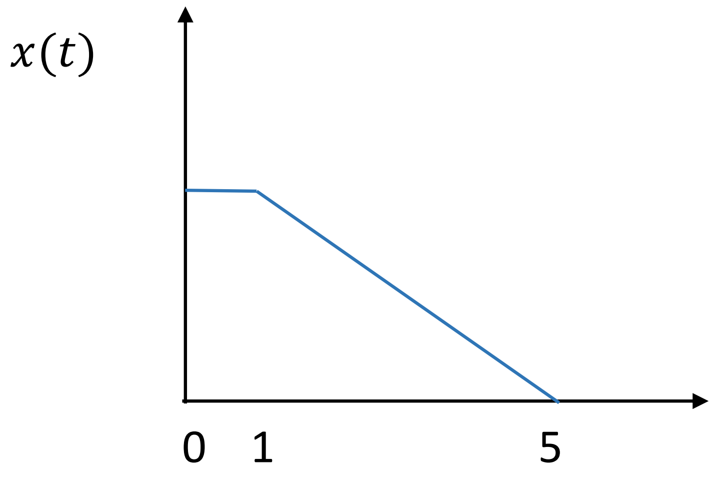
3) Time-shifting

$$x(t) \rightarrow x(t + t_o)$$

Signal and its transformation

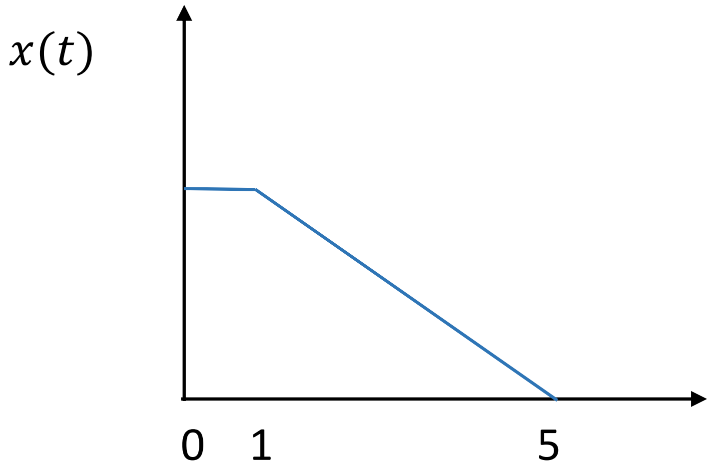
3) Time-shifting

$$x(t) \rightarrow x(t + t_o)$$



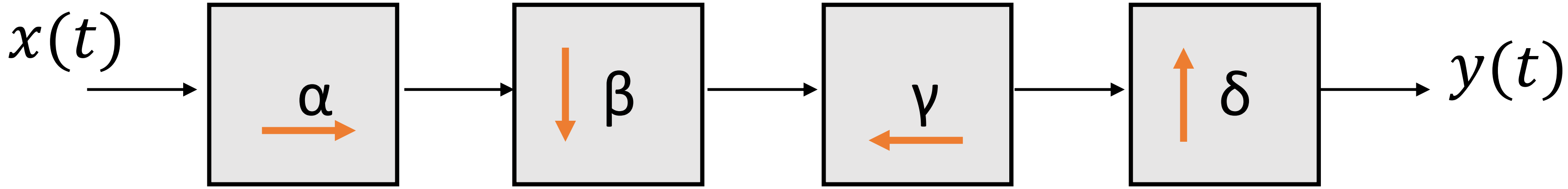
$x(t + 5) =?$

Signal and its transformation



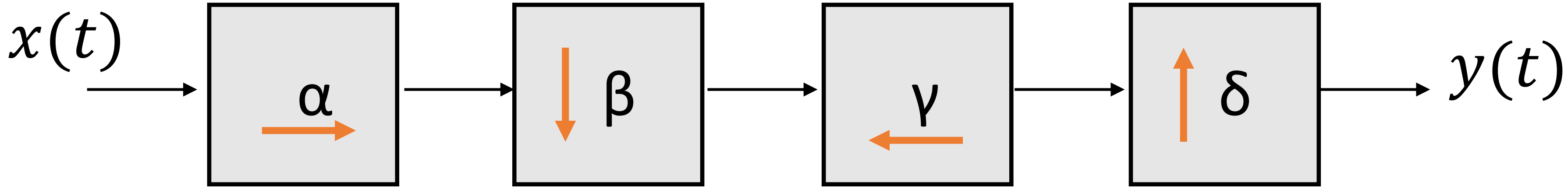
$x(-2t+3) = ?$

Which is the correct option?



1) $y(t) = x\left(\frac{\beta}{\delta}t + \beta\gamma - \alpha\right)$	2) $y(t) = x\left(\frac{\beta}{\delta}t - \beta\gamma + \alpha\right)$
3) $y(t) = x\left(\frac{\delta}{\beta}t - \beta\gamma + \alpha\right)$	4) $y(t) = x\left(\frac{\delta}{\beta}t + \beta\gamma - \alpha\right)$
5) None of these	

Which is the correct option?



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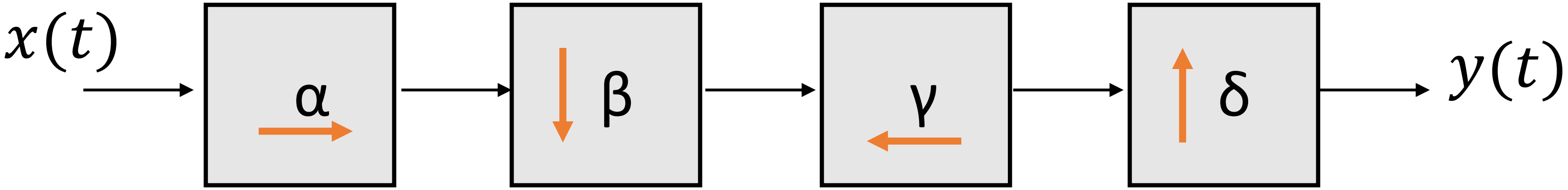

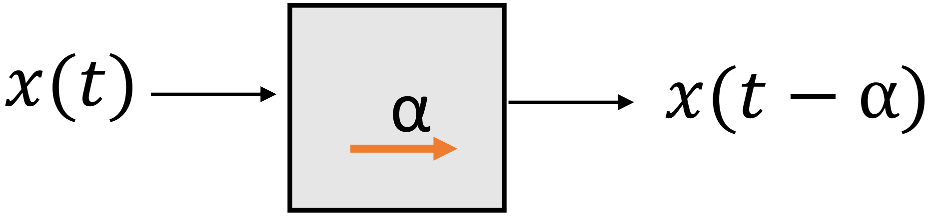

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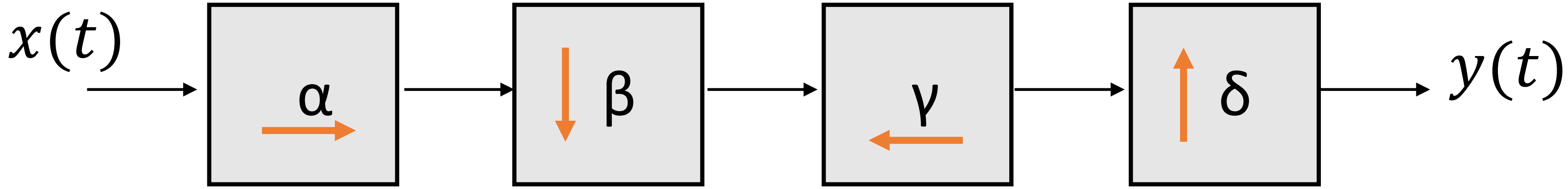

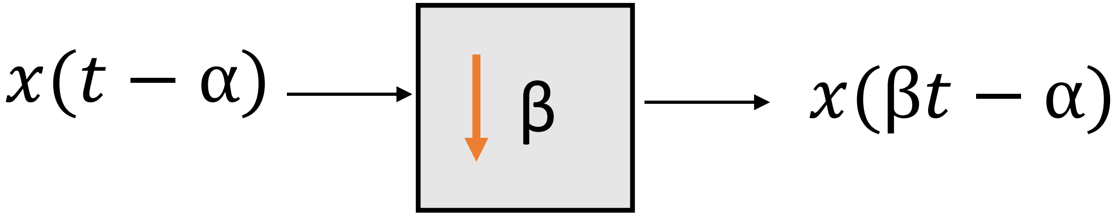

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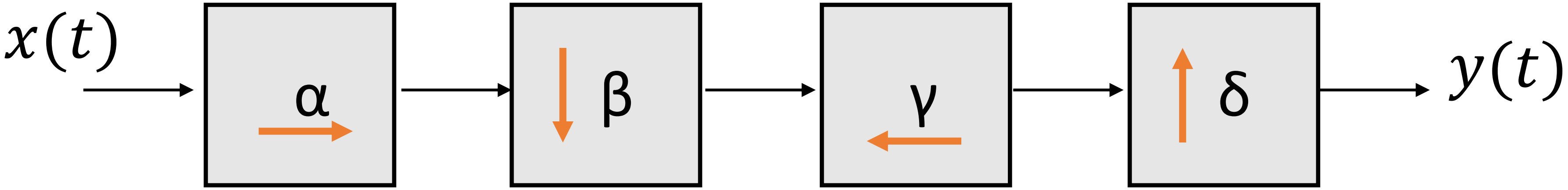

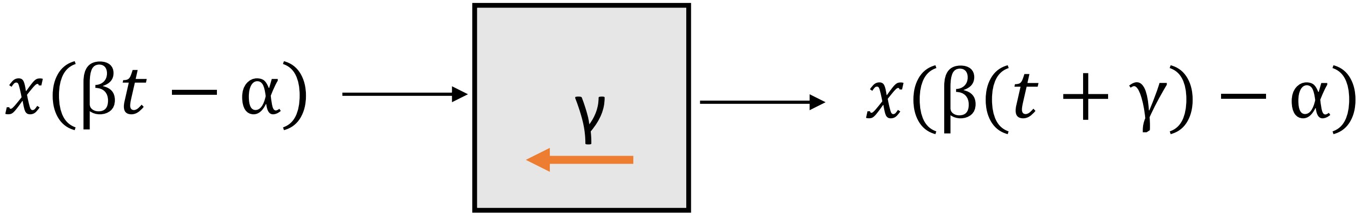

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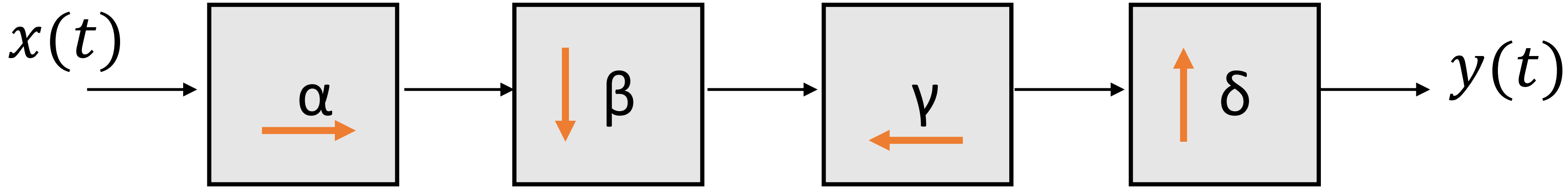

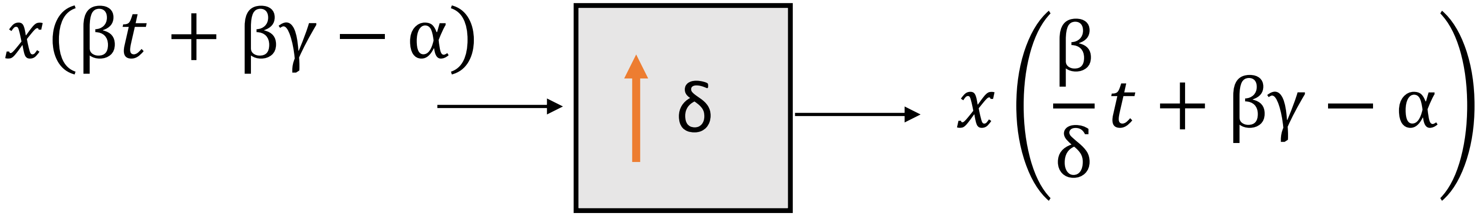

How many options are correct?

$$f(t)$$

1 $f(4t)$

2 $-f(t)$

3 $f(-t)$

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