

# EN1060 Signals and Systems: Introduction

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# Outline

- 1 Introduction to Signals and Systems
  - Introduction

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- They are functions of independent variables and carry information.

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- Signals and systems have brought about revolutionary changes.
- In this course we will study the fundamentals of signals and systems.
- Types of signals in continuous time and discrete time, linear time-invariant (LTI) systems, Fourier analysis, sampling, Laplace transform,  $z$ -transform, and stability of systems are the core components of the course.

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- Use the Laplace transform and the  $z$ -transform to treat a class of signals and systems broader than what Fourier techniques can handle.

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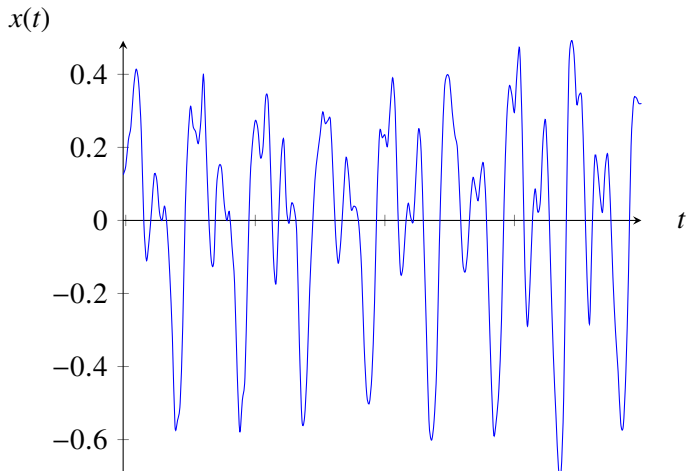
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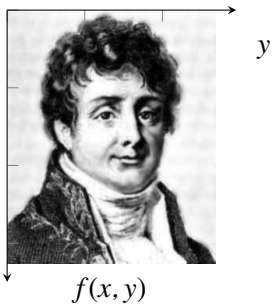
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  - Discrete-time signals: independent variable is an integer,  $x[n]$
- There are some very strong similarities and also some very important differences between discrete-time signals and systems and continuous-time signals and systems.

# Continuous-Time Signals $x(t)$

- The independent variable is continuous.
- E.g., sound pressure at a microphone as a function of time (one-dimensional signal).
- E.g., image brightness as a function of two spatial variables (two-dimensional signal).
- Con convenience, we refer to the independent variable as time.



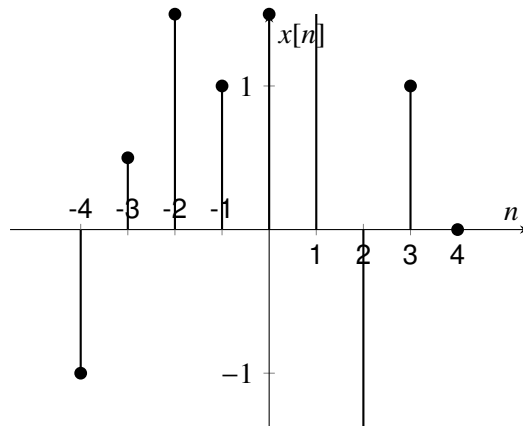
A function of a continuous variable  
A speech signal: a continuous-time,  
one-dimensional signal



An image on a film: a continuous-time, two-dimensional signal

# Discrete-Time Signals $x[n]$

- Function of an integer variable.
- Takes on values at integer values of the argument of  $x[n]$ .





# Digital Signals

- What is a digital signal?
  - A quantized discrete-time signal. I.e.,  $x[n, m]$  can take only a value from a finite set of values.
- What is a digital image?
  - A two-dimensional, quantized, discrete-time signal.
  - A  $600 \times 800$  image:  $n \in [0, 599]$ ,  $m \in [0, 799]$ ,  $x[n, m] \in [0, 255]$ . 8-bit image.

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# CT and DT Systems

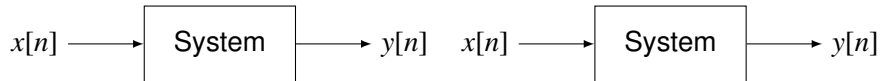


Figure: CT and DT Systems



# Types of Systems

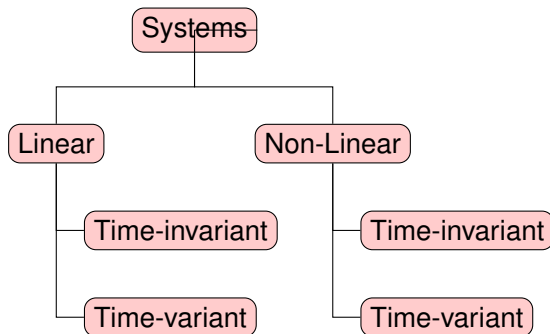


Figure: CT and DT Systems

This course is focused on the class of linear, time-invariant (LTI) systems.

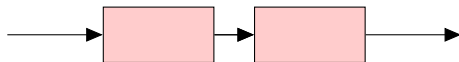
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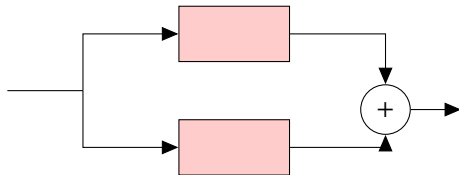
# Systems Interconnections

- To build more complex systems by interconnecting simpler subsystems.
- To modify the response of a system.
- E.g.: amplifier design, stabilizing unstable systems.

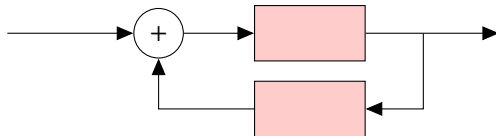
# Signal-Flow (Block) Diagrams



Series (Cascade)

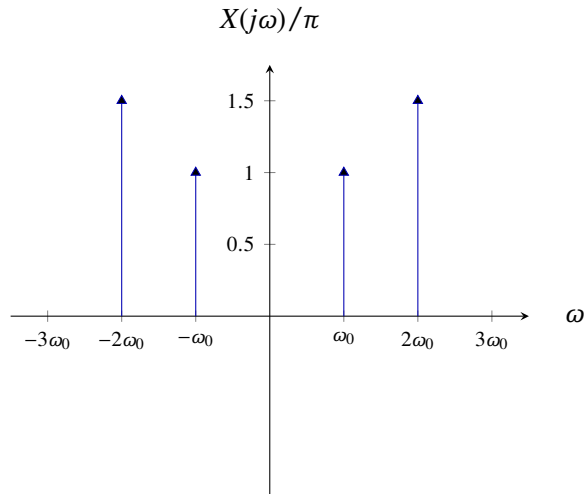
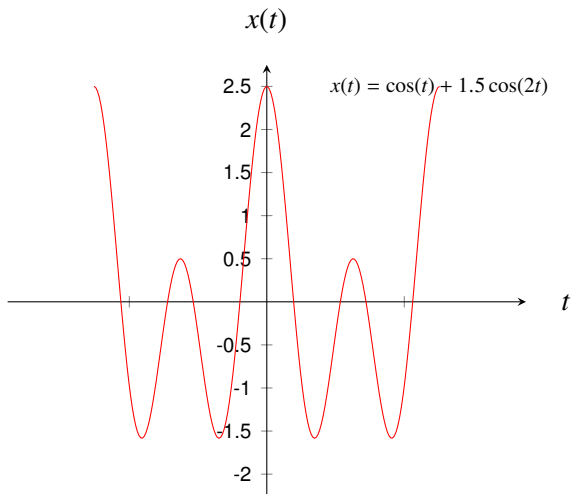


Parallel



Feedback

# Domains



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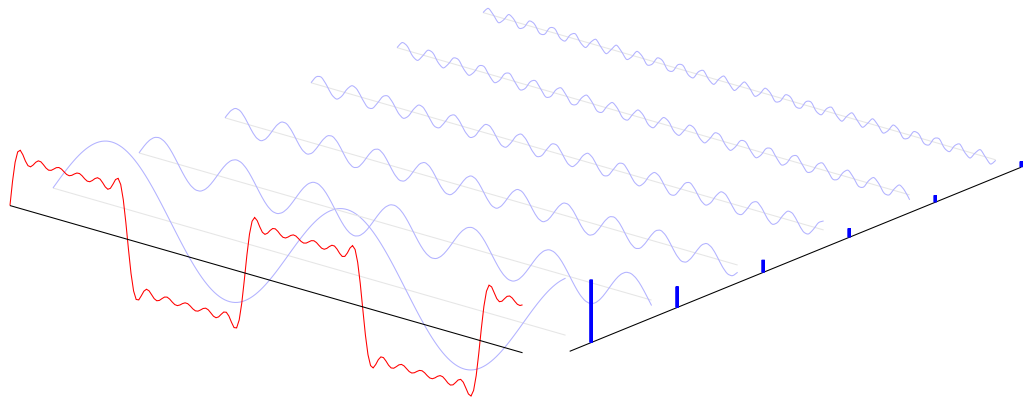


Figure: Square wave: time and frequency domains.