ECE- 314
SIGNALS AND SYSTEMS
Summer 2013

INTRODUCTION

- ✓ What is a signal? What is a system?
- ✓ Overview of signals
- ✓ Classification of Signals: Continuous-Time, Discrete-Time. Periodic, non-periodic
- ✓ Basic operations on signals

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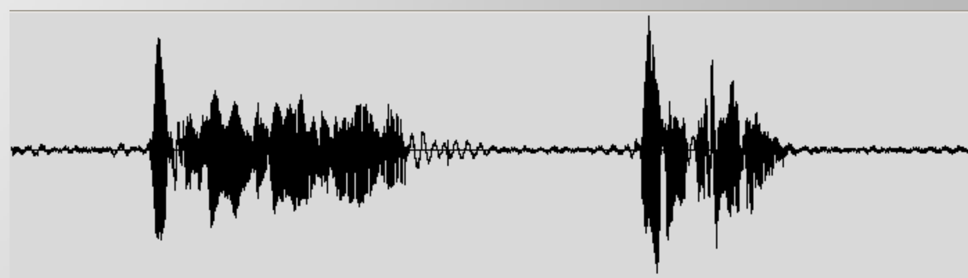
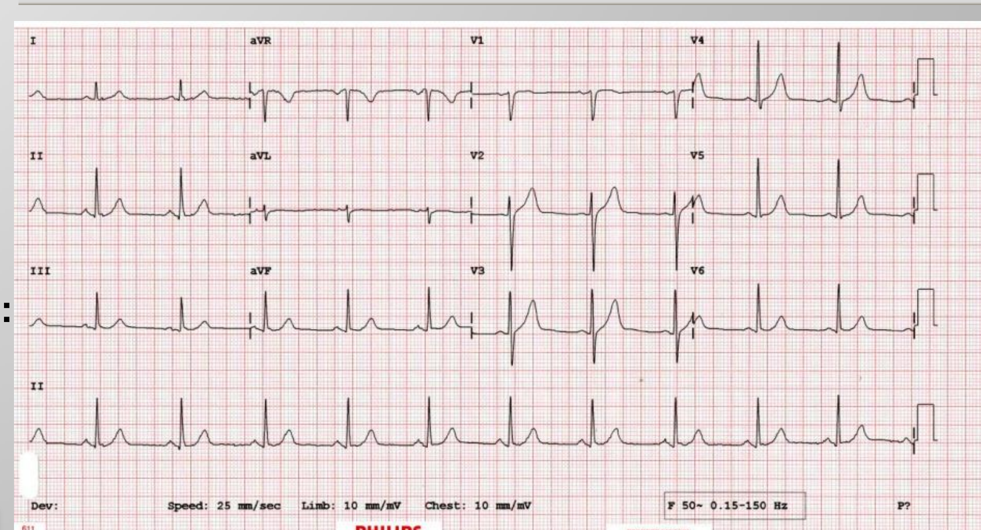
- **Signal**: Function of one or more independent variables that typically contains information about the behavior or nature of some phenomenon.
- Examples:
  1-dimensional continuous-time signals.

Speech:



Electrocardiogram: (ECG)



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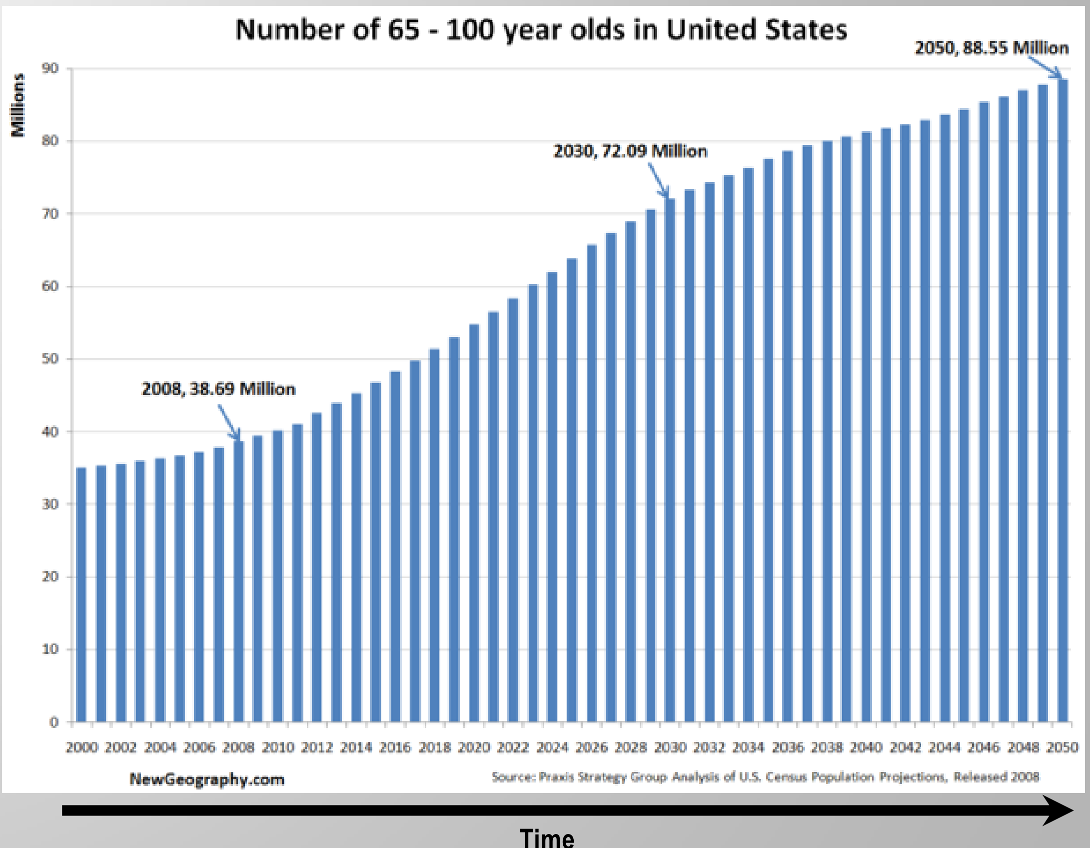
- Example:
  1-dimensional discrete-time signal: signal values only exist at discrete times.



- Other discrete-time signals: Dow-Jones stock market index, population growth (tabulated per year).
- 1-D signals: We will refer to the independent variable as 'time' (although this is not always the case).

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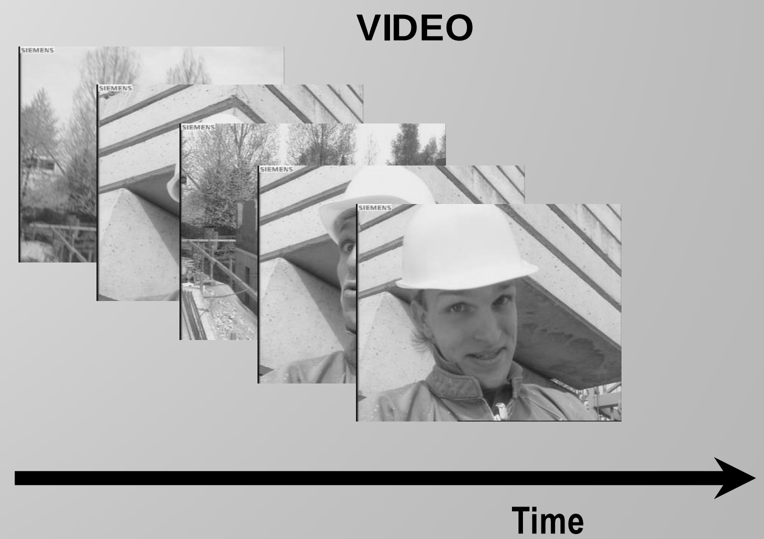
- Examples: 2-d and 3-d signals.

  Image (2-D): Independent variables: Spatial positions (x,y)
  Video (3-D): Besides (x,y), we have time (t).

2-D signal



3-D signal

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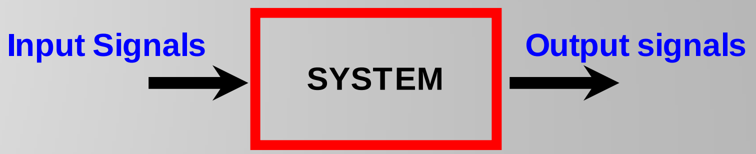
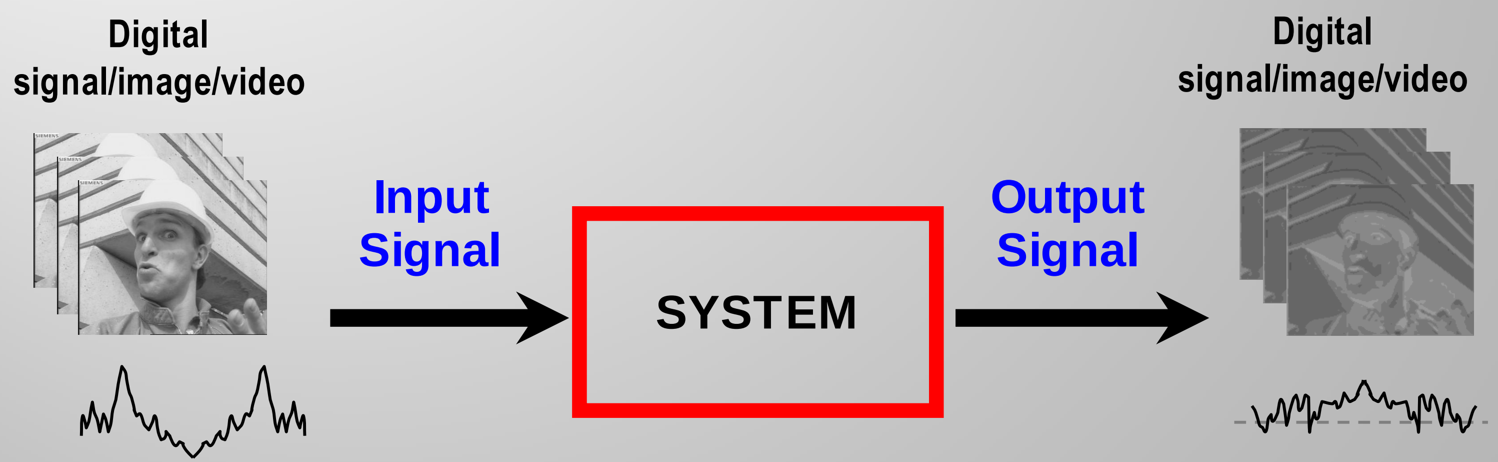
- **System**: Entity that manipulates one or more signals to produce new signals.
- Example: System that process digital signal, image, and video.





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- Other examples of systems:
  - Automatic speech recognition: A computer reads a speech signals and identifies words.
  - Face recognition: A computer reads an image and identifies the subject.
  - Digital Video compression: A system reads a digital video and generates a digital file that is a portion of the size of the original video, which can then be easily transmitted (e.g., MPEG, H.264 video files)
  - Adaptive noise cancellation: The system filters undesired signals while keeping the signal of interest (e.g.: acoustic noise cancellation headphones)

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- Throughout the class we will focus our attention on **one-dimensional signals** defined as single-valued functions of time (for every instant of time, there is a unique value of the function). Note that:
  - The value of the function can be a real number or a complex number.
  - The independent variable (known as 'time') is always real-valued.

- We will now explore two manners by which we can classify signals:
  - Continuous time and discrete-time signals
  - Periodic signals and nonperiodic (or aperiodic) signals.

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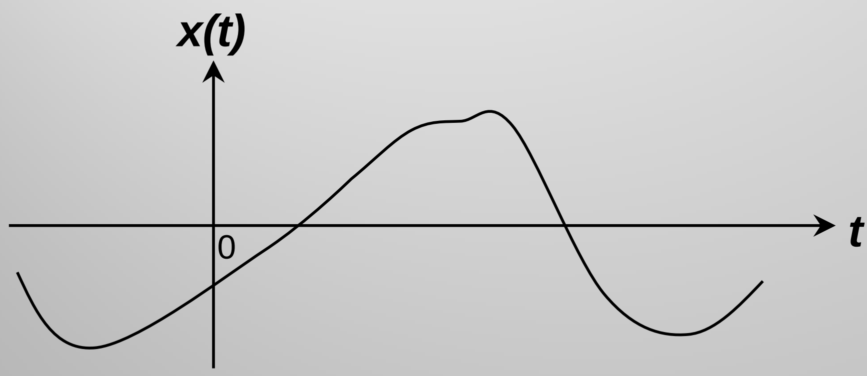
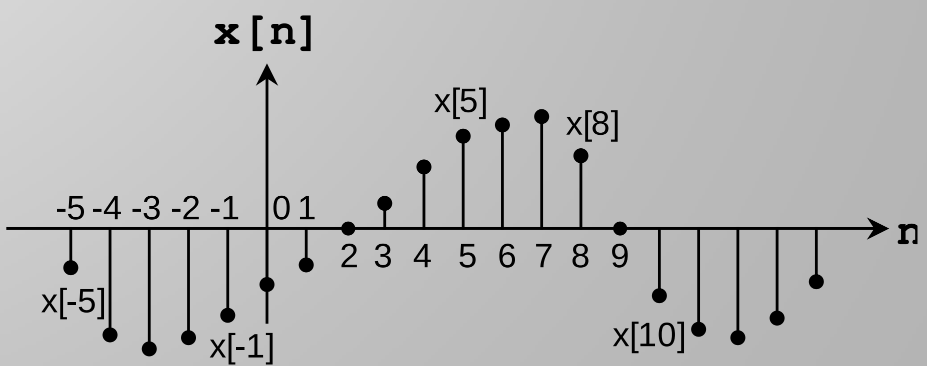
- **Continuous-time** and **discrete-time** signals:
- *x(t)*: It is defined for all time *t*.

  Continuous-time signals arise naturally when a physical waveform (e.g., acoustic wave, light wave) is converted into an electrical signal.
- `x[n]`: Defined only at discrete instants of time (only for integer values of the independent variable `n`):

  `x[-5], x[-4], … x[-1], x[0], x[1], x[2], …`





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- Discrete-Time signals: x[n]
- A discrete signal is often derived from a continuous-time signal by sampling it a uniform rate.

  Let Ts be the sampling period and n an integer that may take positive and negative values.

  Then, sampling a continuous-time signal $x(t)$ at time $t = nTs$, yields a sample with the value $x(nTs)$:

  $x[n] = x(nTs)$, n = 0, ±1, ±2, ± 3, ⋯ (show example)
- A discrete-time signal is represented by a sequence of numbers. Such a sequence is called a time series.
- The symbol t is used to represent time for a continuous-time signal and the symbol n to denote time for a discrete-time signal.

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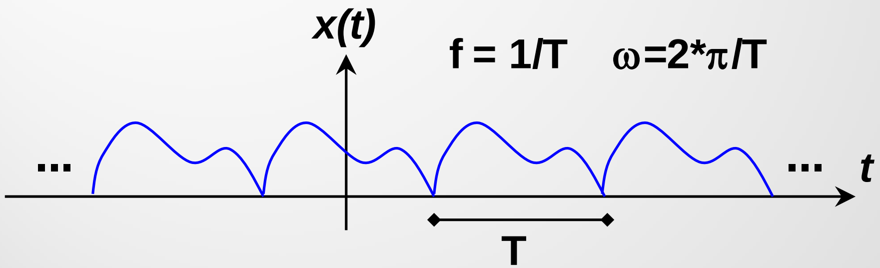
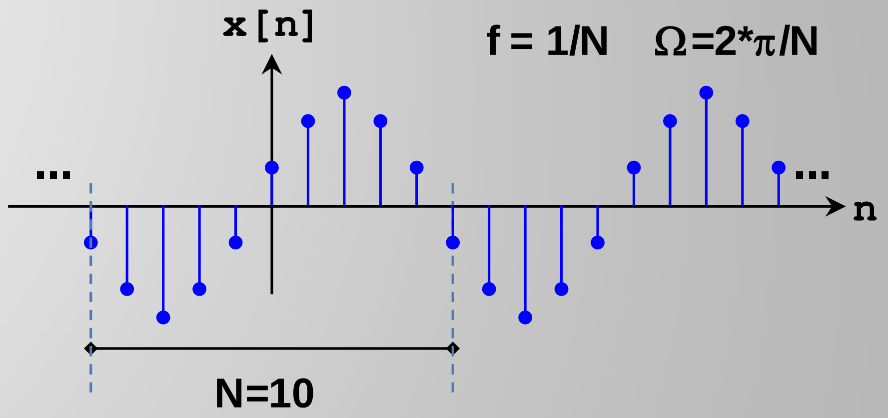
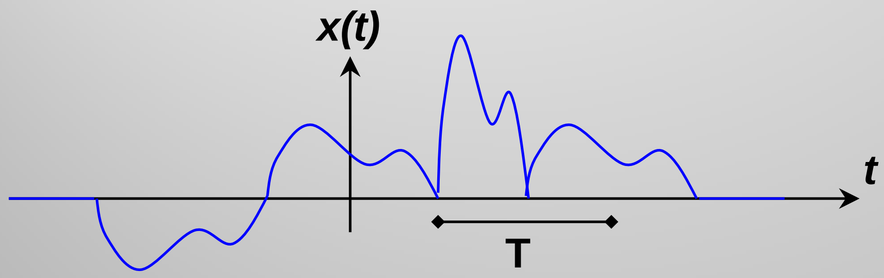
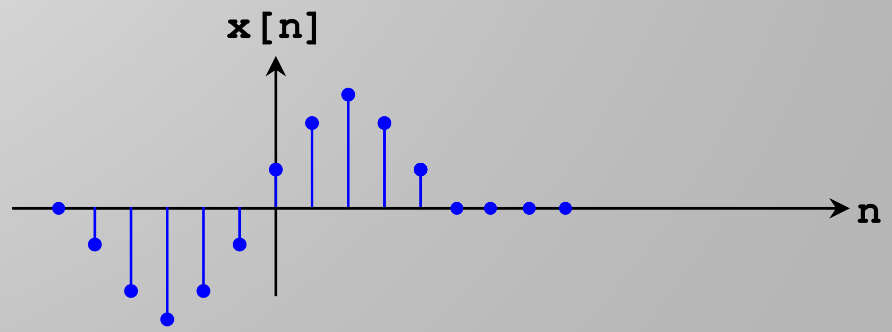
- Periodic signals:





- Nonperiodic (aperiodic) signals





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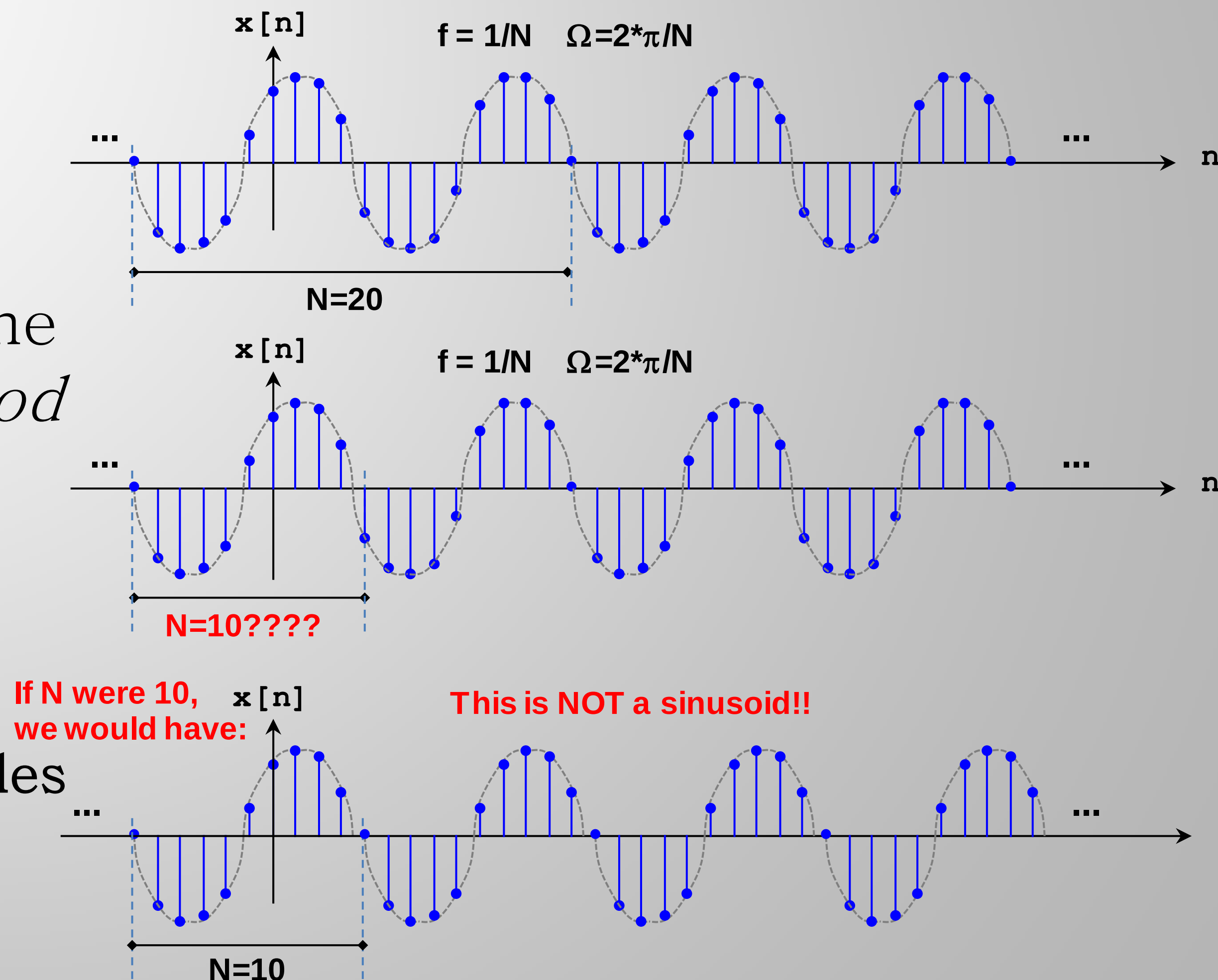
- Example of discrete-time periodic signal, where the period does not match the *fundamental period* of the original continuous time signal:
    - N = 20 amounts to two sinusoidal cycles (of the original continuous-time signal)



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- Basic operations on signals:
- On the independent variable (not on t)
  - Amplitude Scaling
  - Addition
  - Multiplication
  - Differentiation
  - Integration
- On the Dependent variable (on t):
  - Reflection (Examples with addition)
  - Time scaling (MATLAB)
  - Time shifting (MATLAB)
  - Precedence rule for time shifting and time scaling

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