6.003 Signal Processing

Lecture #1A: Introduction, Signals, Signal Processing
What is 6.003?

• 6.003 is about *signal processing*.

• Abstractly, a *signal* is a function that conveys information

• *Signal processing* is about extracting meaningful information from signals, and/or manipulating information in signals to produce new signals.
Signals

• **Signals** are functions that contain and convey information.

• Examples:
  • medical (EKG, EEG, MRI, . . .)
  • speech signals
  • music
  • seismic signals
  • images
  • video
Signals: independent variable

• Signals may have 1 or 2 or 3 or even more independent variables.
Signals: dependent variable

• Dependent variable can be a scalar or a vector.
Signals: dependent variable

- Dependent variable can be real, imaginary, or complex-valued
Signals from physical systems are often of continuous domain:
- continuous time – measured in seconds
- continuous spatial coordinates – measured in meters

Computations usually manipulate functions of discrete domain:
- discrete time – measured in samples
- discrete spatial coordinates – measured in samples
Signals: Periodic vs Aperiodic

- Periodic signals consist of repeated cycles (periods).
Signals: Symmetric vs Antisymmetric

- Signals can be **symmetric** or **antisymmetric**.

**Symmetric**:
\[ x(t) = x(-t) \]
\[ x[n] = x[-n] \]

**Antisymmetric**:
\[ x(t) = -x(-t) \]
\[ x[n] = -x[-n] \]

Or can be not symmetric at all! (Asymmetric)
6.003: Notation

• Sometimes, we will want to talk about an entire signal as a single entity. Other times, we will want to talk about individual values of the signal. In 6.003, we will use the following notation to differentiate these cases:

1D, CT, whole signal: $f(\cdot)$
1D, CT, single value: $f(t)$

2D, CT, whole signal: $f(\cdot, \cdot)$
2D, CT, single value: $f(x, y)$

1D, DT, whole signal: $f[\cdot]$  
1D, DT, single sample: $f[n]$  

2D, DT, whole signal: $f[\cdot, \cdot]$  
2D, DT, single sample: $f[n_x, n_y]$
Check yourself

- Before listening to the manipulated signals, can you think what should \( f(2t) \), \(-f(t)\) and \( \frac{1}{3}f(t) \) look and sound like?
Signal Processing

Signal Processing is **widely used** in science and engineering to ...

- **model** some aspect of the world,
- **analyze** the model,
- **interpret** results to gain a new or better understanding.

**Signal Processing** provides a common language across disciplines.
Transform

• Signals are functions that convey information. Sometimes, though, the straightforward way of representing a signal may not expose important properties of the signal.

• It is often useful to have multiple different ways of looking at a signal.

• Consider the following two representations of a speech signal:
Transform

• We achieve such an alternative view of a signal through a **transform**.

• In 6.003, we will primarily focus on a family of transforms referred to as **Fourier transforms**, (e.g. a periodic signal is represented as sums of sinusoids):

\[
f(t) = \sum_{k=0}^{\infty} \left( c_k \cos k\omega_0 t + d_k \sin k\omega_0 t \right)
\]
Get the most out of 6.003!

- **Please check course website:** [http://mit.edu/6.003/](http://mit.edu/6.003/)

- **Lecture:** pre-recording, two 1-hr session each week, >1 day before recitation
  - **Questions after lecture:** issued together with each lecture, required to be completed before the beginning of the next recitation (8am session) (10%, based on correctness)

- **Recitation:** Tuesday/Thursday 1 hr each
  - **Live questions in recitation** (10% graded based on effort)

- **Office hours:**

- **Homework:** issued Monday 8am, due the following Monday 10pm
  - **Drills:** focus on facts, definitions, and simple concepts – online with immediate feedback (not graded)
  - **Psets:** focus on developing problem solving skills – simple computational extensions to real-world data (20%)
  - **Labs:** focus on applications of 6.003 to authentic problems – more open-ended, multiple approaches, multiple solutions – issued Mondays, required check-in (15%) Friday, due following Monday (20%)

- **Two in-class Exams** (10% +15%)