CogSci 109: Lecture 4

Tuesday Oct 3, 2006

Discretization and filtering

Announcements

- Office hours are finally posted
- Homework correction/clarification- download again
- Look to the web site for new reading assignment and new assignment posting either tonight or tomorrow, will be due Thurs of next week

Announcements II

- Class data forms - please fill in the info and submit the form, we'll use the data for our class homeworks
  - No personal info linked to you at all
- Homework - generally I would like matlab code included (we can give you strategic suggestions then), but this is the first HW and I didn't require it

Topics today

- Announcements
- Little math review/elaboration
- Concept of analog and digital signals, digitization
- Discretization concepts, sampling
  - Supersampling/subsampling
- Aliasing
- Filtering
  - Low pass
  - High pass
- Two simple easy effective filters
- Matlab functions

A matrix operation which is important

- Transpose
  - Interchange rows and columns
  - Denoted conventionally by a superscript ‘T’
    - i.e. A^T

$$A = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix} \longrightarrow A^T = \begin{bmatrix} 1 & 3 \\ 2 & 4 \end{bmatrix}$$

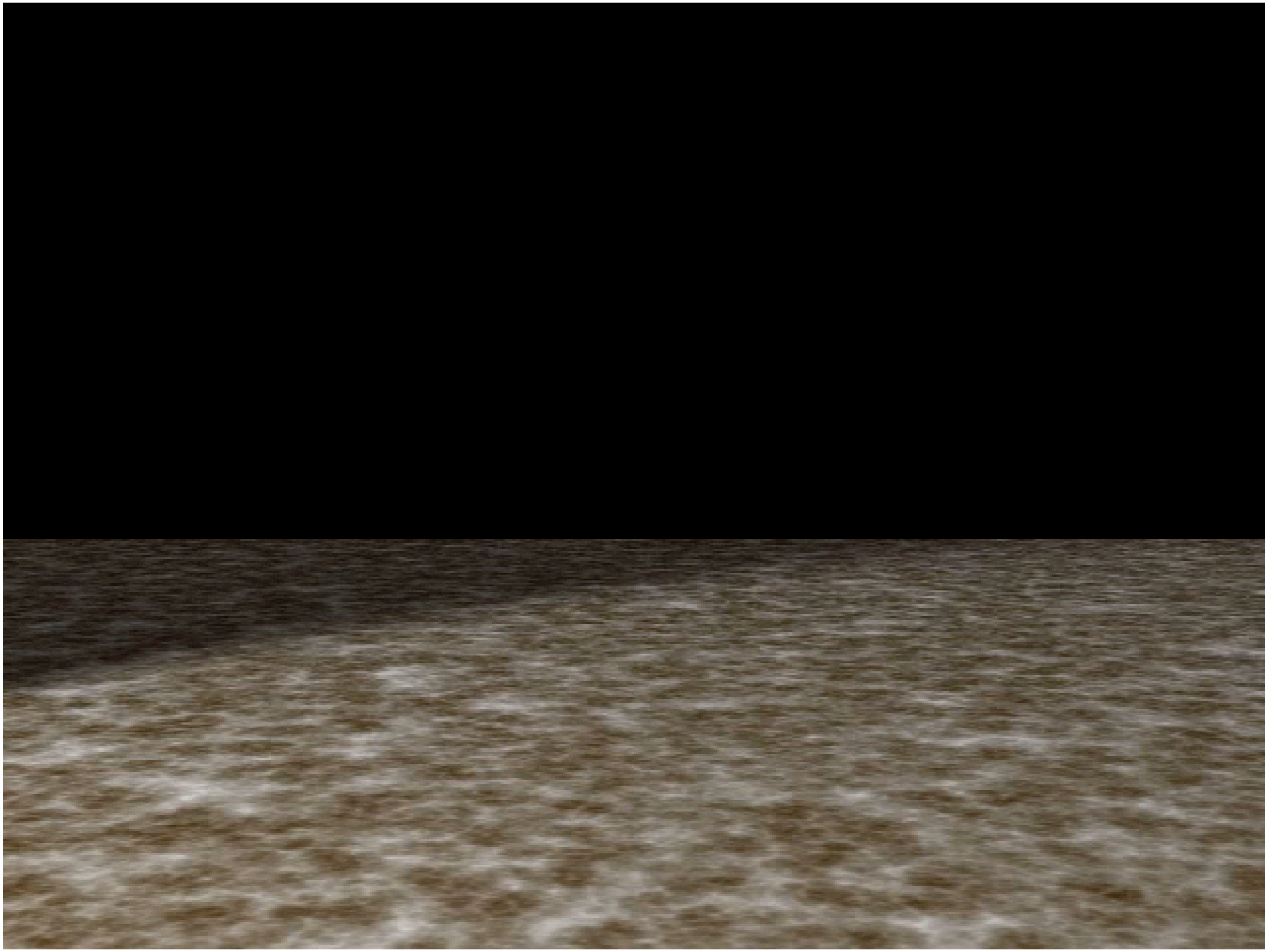
More on transposes

- Important transpose rules

$$(ABC)^T = C^T B^T A^T$$
$$(A^T)^T = A$$
$$(A+B)^T = A^T + B^T$$

- A square matrix is symmetric if

$$A^T = A$$

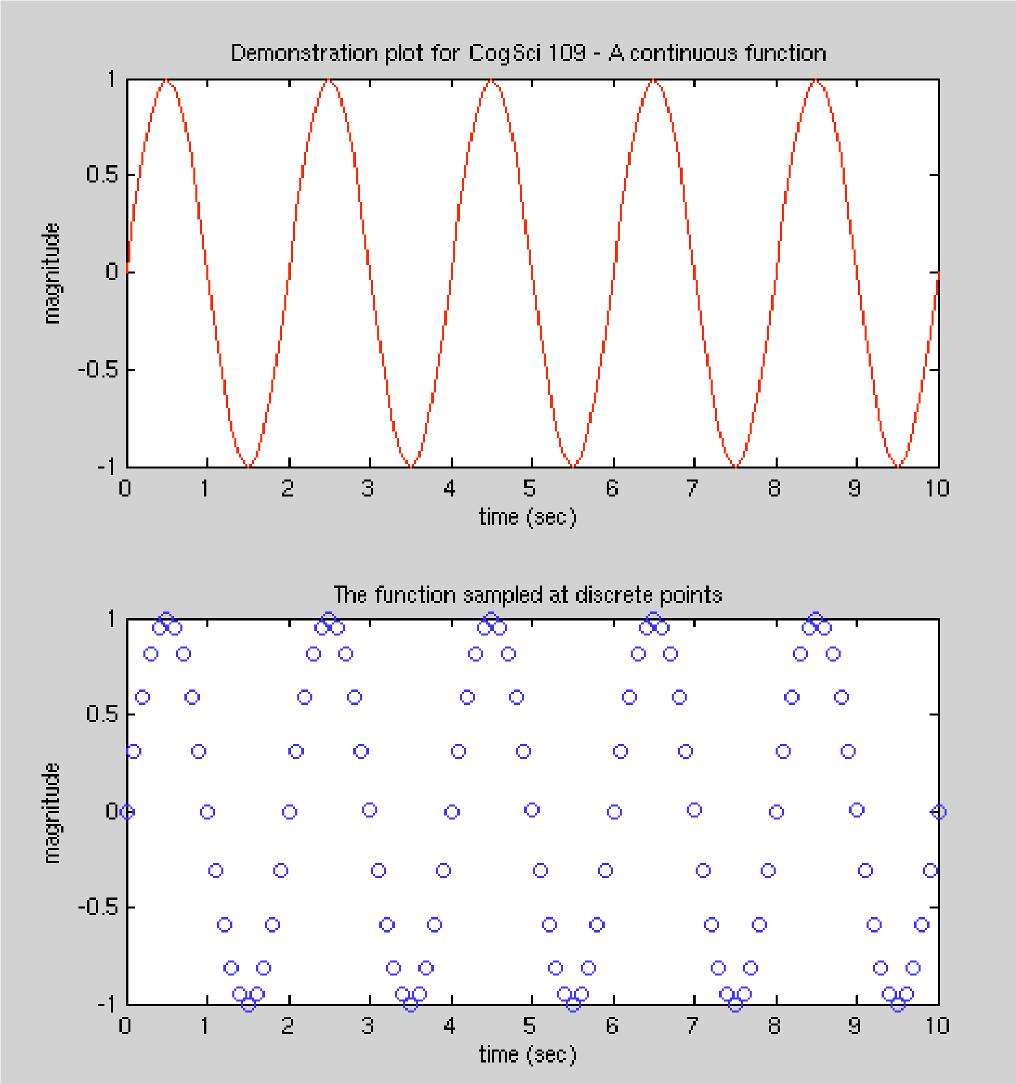


Little calc/precalc review

- Domain and Range
  - Consider domain to be the input, range to be the output
  - Important in terms of space
- About plotting functions in Matlab which have discontinuities

Continuous vs. Discrete quantities

- Information storage
  - **Continuous** signals have information at every point in time
  - **Discrete** signals have info only at specified intervals (fixed or variable)



Examples of continuous and discrete systems

- Continuous or discrete?
  - # of people in this class
    - Discrete
  - # of Time zones
    - Discrete
  - Time
    - Continuous
  - Answers on multiple choice tests
    - Discrete
  - A Sound
    - Continuous
  - Body temperature
    - Continuous

Analog vs. Digital quantities

- Information storage
  - Analog contains infinite information
  - Digital contains limited information, depending on the number of bits of information the digital value can store
    - 0 or 1 in each bit means each bit multiplies the possible combinations of numbers by 2
    - 2^4 = 0-15 (a 4-bit number, 16 different values)
    - 2^8 = 0-255 (an 8-bit number, 256 different values)
    - 2^{16} = 0-65535 (a 16-bit number, 65536 different values)

More on digital quantities

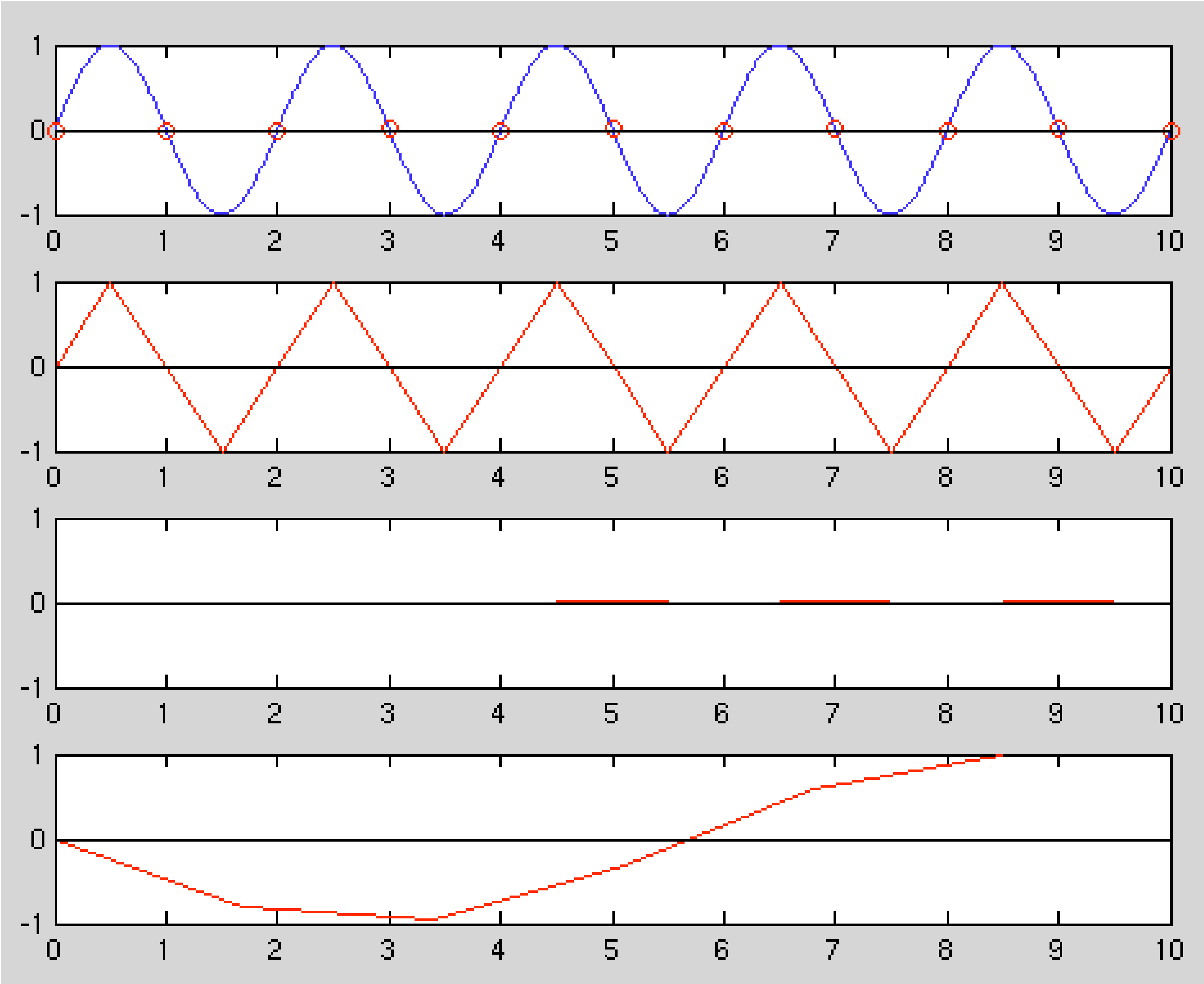
- Measuring an EEG boils down to recording a sequence of numbers into computer memory, stored in values of a specific size, such as 8 bit numbers.
  - i.e. signal is 0-5V, digitized with 8 bit ***precision*** would yield a ***resolution*** of 5V/256 = 0.020V, or 20mV (mV = 'milli-Volts')
  - **Resolution -** defined as the smallest quantity which can be reliably measured
  - **Digital Precision -** The number of bits of information contained in a digital quantity
- Also important for computations
  - Round off errors can accumulate
    - Example
      - 2.245+3.432+1.234 = 6.911
      - 2+3+1 = 6, and that's only 3 samples! Imagine 1000/sec (1kHz) !
  - More on this later

Discretization

- Measuring a continuous (analog) signal means capturing a information at specified (fixed or variable) intervals
  - **Sampling frequency -** the frequency at which data is recorded from a signal (Typically in Hz, ie 5kHz)
- When capturing data, or when manipulating data which has been discretized, there are several issues to consider
  - Aliasing (not the TV show:)
  - Sampling rates
  - Post-processing – filtering data to remove unwanted information while retaining desired information

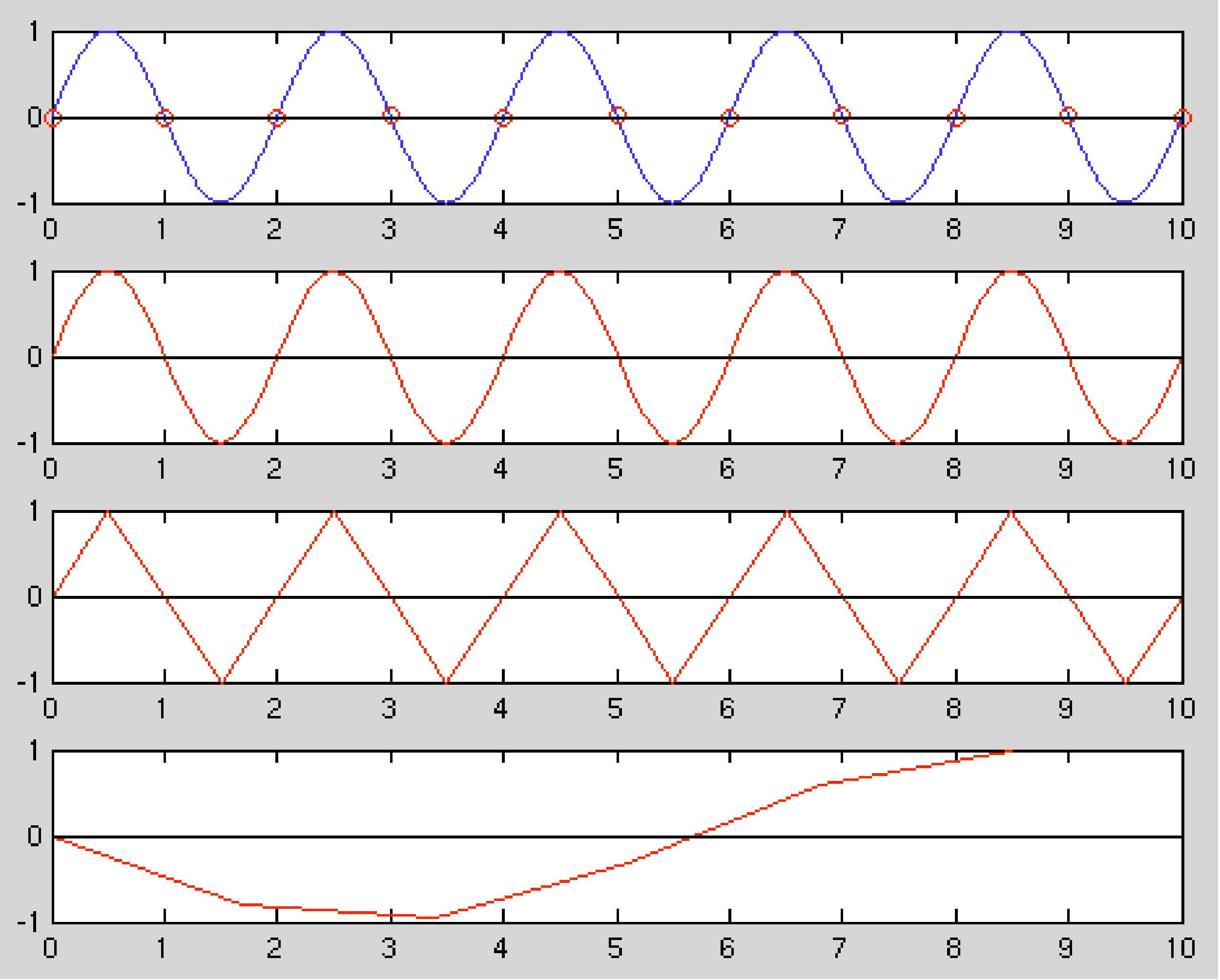
Sampling

- Stories
  - Running in the dark with periodic lights on the ground, with sharp turns
  - Ping pong (no sound, periodic view of the system)
- As a rule of thumb, you must sample AT LEAST twice as fast as the highest frequency you want to measure
  - **Nyquist frequency -** max freq that can be measured
  - **Nyquist rate -** sampling frequency (which is 2x the nyquist frequency) required to sample at the nyquist frequency
  - 20 times as fast is better
  - Filter out higher frequency components


1
0
-1
0
1
2
3
4
5
6
7
8
9
10

What do we see in this picture?

Aliasing - the corrupting of a signal by components of higher frequencies overlapping into the lower frequency



How do we solve this?

- Filter out the frequencies we don’t want
  – Low pass filter
  – High pass filter