EE-2200

Lecture 1

Sinusoids

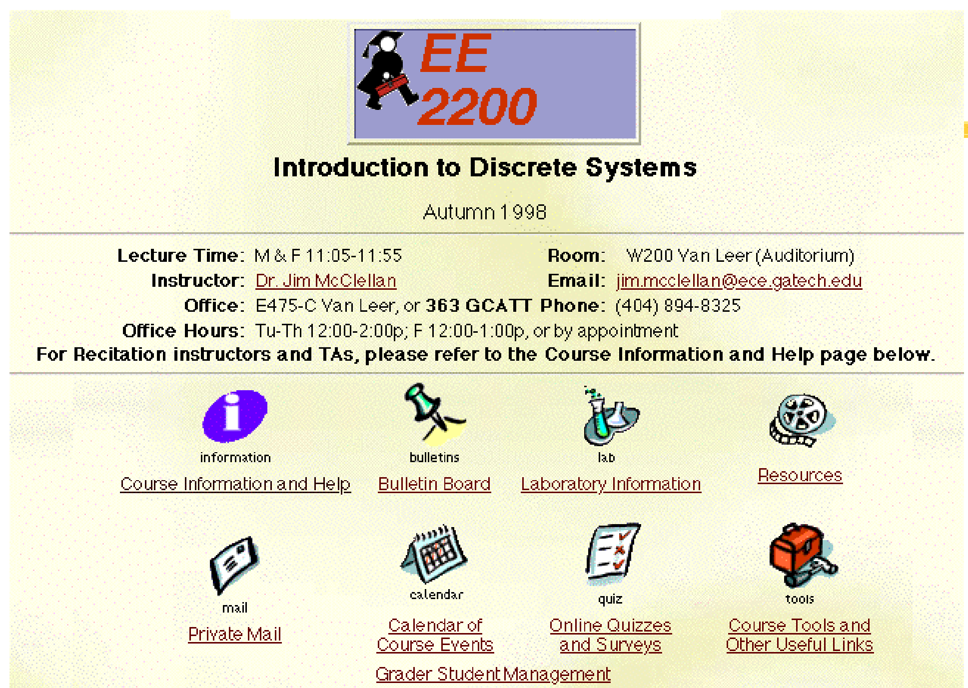
25-Sept-98

INFORMATION

- LABS
  - Room 309 in CoC Building
  - MATLAB based computer projects
- RECITATIONS
  - Problem Solving
- GRADING ?

REMINDERS

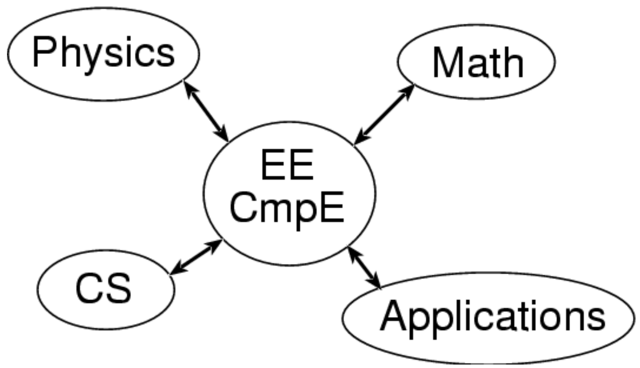
- Web–CT Password:
  - SSN(4:8), 4th thru 8th digits of SSN
- Activate your ECE Computer Account
  - in room 309 of CoC Building
  - Monday (or at least before Lab)
- Hard copy of Instructor Verification Sheet
  - get PDF file of Lab#1 from WebCT



READING ASSIGNMENTS

- This Lecture:
  - Chapter 2, pp. 9–17
- Appendix A: Complex Numbers
- Appendix B: MATLAB
- Chapter 1: Introduction

CONVERGING FIELDS



COURSE OBJECTIVE

- Students will be able to:
- Understand mathematical descriptions of signal processing algorithms and express those algorithms as computer implementations (MATLAB)
- What are your objectives?

WHY USE DSP ?

- Mathematical abstractions lead to generalization and discovery of new processing techniques
- Computer implementations are flexible
- Applications provide a physical context

LECTURE OBJECTIVES

- Write general formula for a "sinusoidal" waveform, or signal
- From the formula, plot the sinusoid versus time
- What's a signal?
  - It's a function of time, x(t)
  - in the mathematical sense

TUNING FORK EXAMPLE

- CD-ROM demo
- "A" is at 440 Hertz (Hz)
- Waveform is a SINUSOIDAL SIGNAL
- Computer plot looks like a sine wave
- Here is a mathematical formula:

$$A\cos(2\pi(440)t+\varphi)$$

SPEECH EXAMPLE

- More complicated signal (BAT.MAT)
- Waveform $x(t)$ is NOT a Sinusoid
- Theory will tell us
  - $x(t)$ is approximately a sum of sinusoids
  - FOURIER ANALYSIS
    - Break $x(t)$ into its sinusoidal components
  - Called the FREQUENCY SPECTRUM

DIGITIZE the WAVEFORM

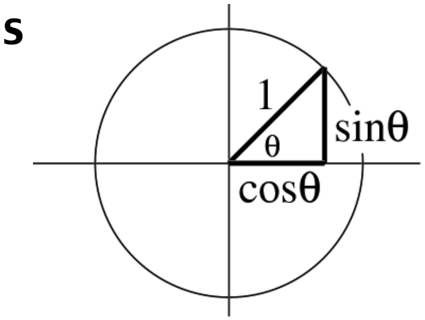
- $x[n]$ is a SAMPLED SINUSOID
  - A list of numbers stored in memory
- Sample at 11,025 samples per second
  - Called the SAMPLING RATE of the A/D
  - Time between samples is
    - 1/11025 = 90.7 microsec
- Output through D/A hardware (at Fsamp)

STORING DIGITAL SOUND

- $x[n]$ is a SAMPLED SINUSOID
  - A list of numbers stored in memory
- CD rate is 44,100 samples per second
- 16-bit samples
- Stereo uses 2 channels
- Number of bytes for 1 minute is
  - 2 X (16/8) X 60 X 44100 = 10.584 Mbytes

TRIG FUNCTIONS

- Circular Functions



- Common Values
  - $\sin(k\pi) = 0$
  - $\cos(0) = 1$
  - $\cos(2k\pi) = 1$ and $\cos((2k+1)\pi) = -1$
  - $\cos((k+0.5)\pi) = 0$

SINES and COSINES

- Always use the COSINE FORM

$$\cos(\omega t + \varphi)$$

- Sine is a special case:

$$\sin(\omega t) = \cos(\omega t - \pi/2)$$

SINUSOIDAL SIGNAL

$$A\cos(\omega t + \varphi)$$

- FREQUENCY ω
  - Radians/sec
  - Hertz (cycles/sec)

$$\omega = (2\pi) f$$

- PERIOD (in sec)

$$T = \frac{1}{f} = \frac{2\pi}{\omega}$$

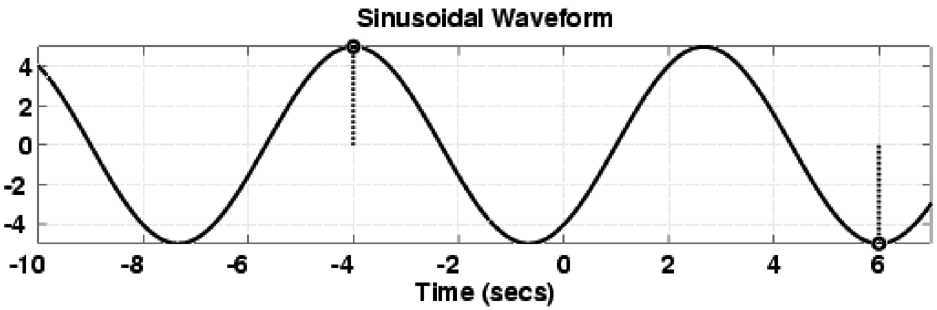
- AMPLITUDE A
  - Magnitude
- PHASE φ

EXAMPLE of SINUSOID

- Given the Formula

$$5\cos(0.3\pi t + 1.2\pi)$$

- Make a plot



PLOTTING COSINE SIGNAL from the FORMULA

$$5\cos(0.3\pi t + 1.2\pi)$$

- Formula defines A, ω, and ϕ
- Determine **period**: $T = 2\pi / 0.3\pi = 20/3$
- Determine a **peak** location by solving

$$(\omega t + \varphi) = 0$$

- **Zero** crossing is T/4 before or after
- Positive & Neg. peaks spaced by T/2