

EE-2200

Spring-99

LECTURE #1

Sinusoids

2-April-99

INFORMATION

LABS

- Room 309 in CoC Building
- MATLAB based computer projects
- MATLAB Help: W 6 pm (VL-456)**

RECITATIONS

- Problem Solving

GRADING ?

4/1/99

EE-2200 Spring-99 jMc

2

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

4/1/99

EE-2200 Spring-99 jMc

3



Introduction to Discrete Systems

Autumn 1998

Lecture Time: M & F 11:05-11:55

Room: W200 Van Leer (Auditorium)

Instructor: [Dr. Jim McClellan](#)

Email: jim.mcclellan@ece.gatech.edu

Office: E475-C Van Leer, or 363 GCATT **Phone:** (404) 894-8325

Office Hours: Tu-Th 12:00-2:00p; F 12:00-1:00p, or by appointment

For Recitation instructors and TAs, please refer to the [Course Information and Help](#) page below.



information

[Course Information and Help](#)



bulletins

[Bulletin Board](#)



lab

[Laboratory Information](#)



resources

[Resources](#)



mail

[Private Mail](#)



calendar

[Calendar of Course Events](#)

[Grader Student Management](#)



quiz

[Online Quizzes and Surveys](#)



tools

[Course Tools and Other Useful Links](#)

READING ASSIGNMENTS

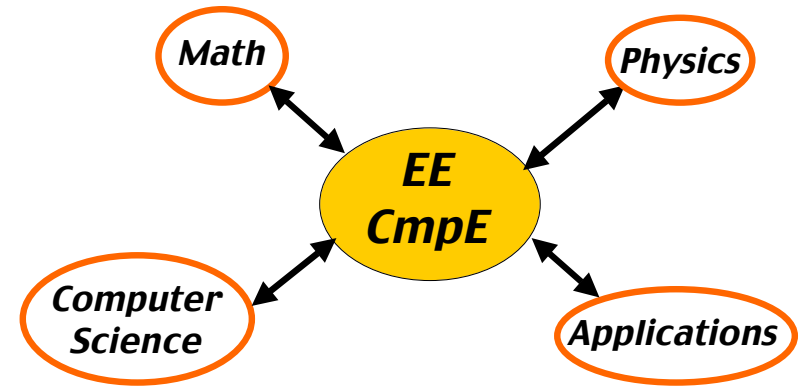
- This Lecture:
 - Chapter 2, pp. 9–17
- Appendix A: Complex Numbers
- Appendix B: MATLAB
- Chapter 1: Introduction

4/1/99

EE-2200 Spring-99 jMc

5

CONVERGING FIELDS



4/1/99

EE-2200 Spring-99 jMc

6

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?

4/1/99

EE-2200 Spring-99 jMc

7

WHY USE DSP ?

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

4/1/99

EE-2200 Spring-99 jMc

8

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 via D/A hardware (at F_{samp})

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
 - $2 \times (16/8) \times 60 \times 44100 = 10.584$ Mbytes

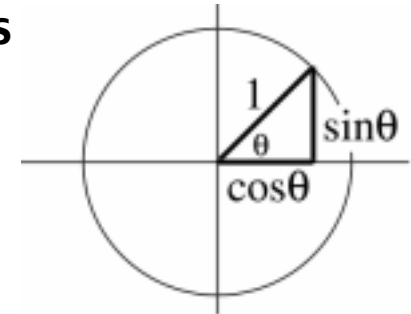
4/1/99

EE-2200 Spring-99 jMc

13

TRIG FUNCTIONS

■ Circular Functions



■ Common Values

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

4/1/99

EE-2200 Spring-99 jMc

14

SINES and COSINES

- Always use the COSINE FORM

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

- Sine is a special case:

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

4/1/99

EE-2200 Spring-99 jMc

15

SINUSOIDAL SIGNAL

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

- FREQUENCY ω

- Radians/sec
 - Hertz (cycles/sec)
- $$\omega = (2\pi)f$$

- AMPLITUDE A

- Magnitude

- PERIOD (in sec)

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

- PHASE φ

4/1/99

EE-2200 Spring-99 jMc

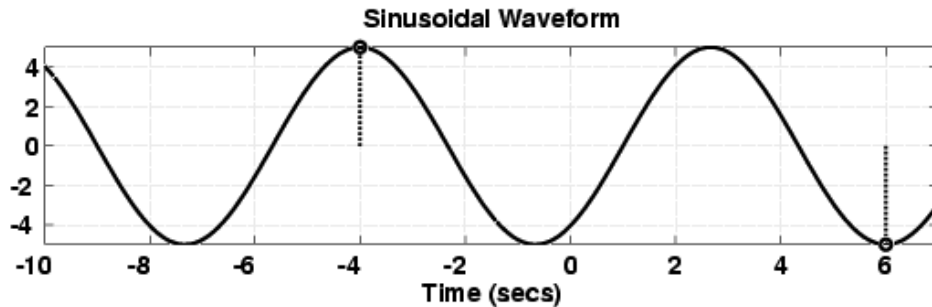
16

EXAMPLE of SINUSOID

- Given the Formula

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

- Make a plot



PLOT COSINE SIGNAL

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

- Formula defines A, ω , and ϕ

$$A = 5$$

$$\omega = 0.3\pi$$

$$\phi = 1.2\pi$$

4/1/99

EE-2200 Spring-99 jMc

18

PLOTTING COSINE SIGNAL from the FORMULA

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

- Determine **period**:

$$T = 2\pi / \omega = 2\pi / 0.3\pi = 20/3$$

- Determine a **peak** location by solving

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

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

4/1/99

EE-2200 Spring-99 jMc

19