

# EE-2200

# Winter-99

## LECTURE #1

### Sinusoids

### 8-Jan-99

# INFORMATION

## LABS

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

## RECITATIONS

- Problem Solving

## GRADING ?

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# 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

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## 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](mailto: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.



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lab

[Laboratory Information](#)



resources

[Resources](#)



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calendar

[Calendar of Course Events](#)

[Grader Student Management](#)



quiz

[Online Quizzes and Surveys](#)



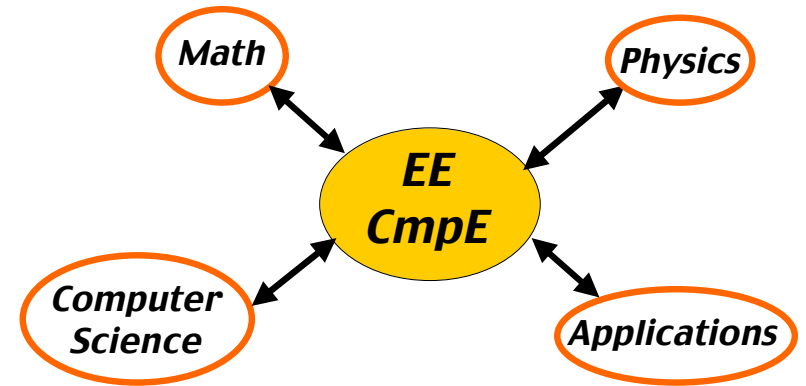
tools

[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

# 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  $F_{\text{samp}}$ )

# 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

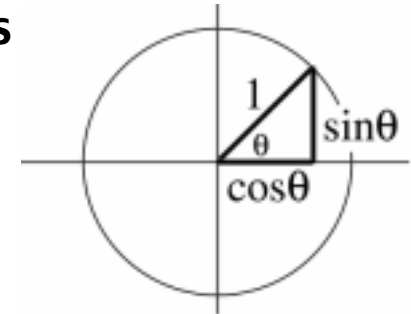
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# TRIG FUNCTIONS

## ■ Circular Functions



## ■ Common Values

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

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# SINES and COSINES

- Always use the COSINE FORM

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

- Sine is a special case:

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

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# SINUSOIDAL SIGNAL

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

- FREQUENCY  $\omega$ 
  - Radians/sec
  - Hertz (cycles/sec)
  - $\omega = (2\pi)f$
- AMPLITUDE  $A$ 
  - Magnitude
- PERIOD (in sec)  $T = \frac{1}{f} = \frac{2\pi}{\omega}$
- PHASE  $\varphi$

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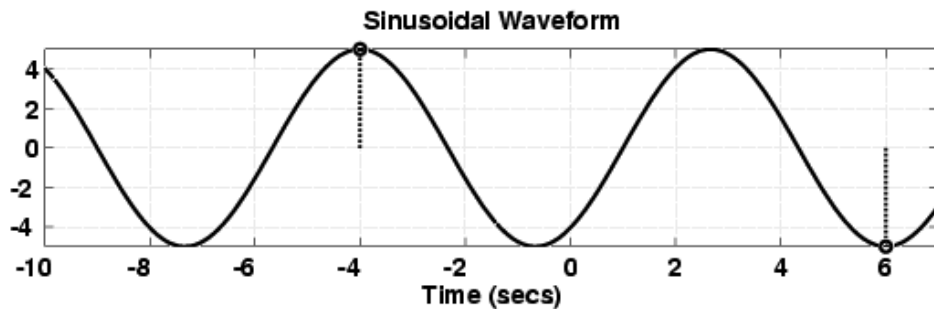
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## EXAMPLE of SINUSOID

- 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,  $\omega$ , and  $\phi$

$$A = 5$$

$$\omega = 0.3\pi$$

$$\phi = 1.2\pi$$

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## 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  $T/2$

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