

ECE-2025

Fall-09

LECTURE #1
Sinusoids
17-Aug-09

INFORMATION

- LABS
 - Room 2440 in Klaus Building
 - MATLAB based computer projects
 - MATLAB Help: in the evenings
 - Tentative Times this week:
 - Klaus-2440: Wed & Thurs at 6pm
 - Next week: ???
 - RECITATIONS (always in VL-361)
 - EMPHASIS on Problem Solving
 - GRADING ?

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Computer Ownership

- Hardware
 - All students own laptops
- Software
 - MATLAB is part of the required suite
- **ECE-2025 Lab**
 - **Bring your own laptop, if you like**

REMINDERS

- T-Square Login:
 - GT username & password
- ECE Computer Account
 - Login with GT usname/passwd via AD domain
 - www.ece-help.gatech.edu/faq/index.html
- HW #1 posted, get the PDF from **t-square**
 - Due next week

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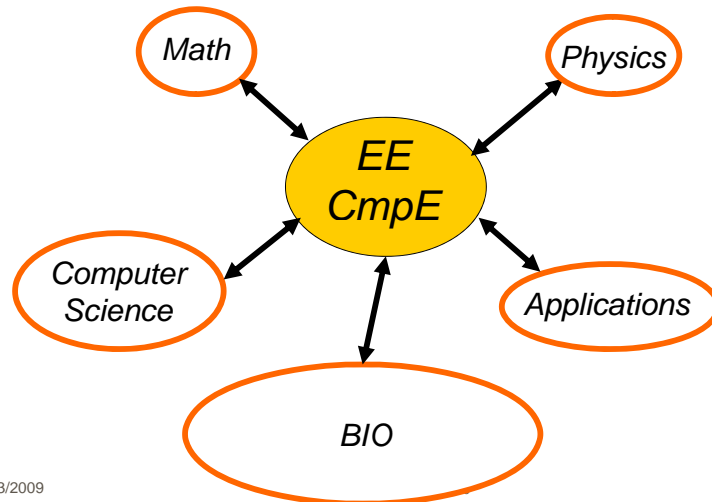
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The screenshot shows the T-square website interface. The top navigation bar includes tabs for 'My Workspace', 'DSP UG-VIP Res', 'ECE-2025-A SPR08', 'ECE-2025-A SPR09', 'ECE-2025-A SLIM09', 'ECE-2025-A,B', and 'My Active Sites'. The 'ECE-2025-A,B' tab is selected and circled in orange. Below the navigation bar, there are three main sections: 'COURSE TOOLS', 'MY WORKSPACE INFORMATION', and 'RECENT ANNOUNCEMENTS'. The 'COURSE TOOLS' section on the left has a vertical menu with items like Home, Syllabus, Announcements, Assignments, Resources, Email Archive, Gradebook, Site Info, Site Stats, Section Info, Blogs, Chat Room, Email, Roster, Tests & Quizzes, Wiki, and Help. Several items in this menu are circled in orange. The 'MY WORKSPACE INFORMATION' section features a 'Quick Links ECE-2025 (Fall-09)' table with links for Lecture Slides, Lab Projects, Problem Sets, Quizzes/Exams, INFO, FAQ, MATLAB Movies, Prof/TA Office Hrs on the Wiki, SP-1st Errata, SP-1st CDROM, and SP-1st Toolbox. A 'RECENT ANNOUNCEMENTS' section on the right shows a 'Matlab Tutorial Sessions this Week' announcement. Below the quick links is a 'RECENT CHAT MESSAGES' section. A 'CALENDAR' section at the bottom contains a link to old ECE-2025 quizzes and a notice about the latest SP-First Toolbox M-files, with a 'JUMP' button. The page footer shows the date 8/13/2009, the user 2009 CJR, jMc, and the page number 5.

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


Fourier Everywhere

- Telecommunications
- **Sound & Music**
 - CDROM, Digital Video
- Fourier Optics
- X-ray Crystallography
 - Protein Structure & DNA
- Computerized Tomography
- Nuclear Magnetic Resonance: MRI
- Radioastronomy
- Ref: Prestini, "The Evolution of Applied Harmonic Analysis"

LECTURE OBJECTIVES

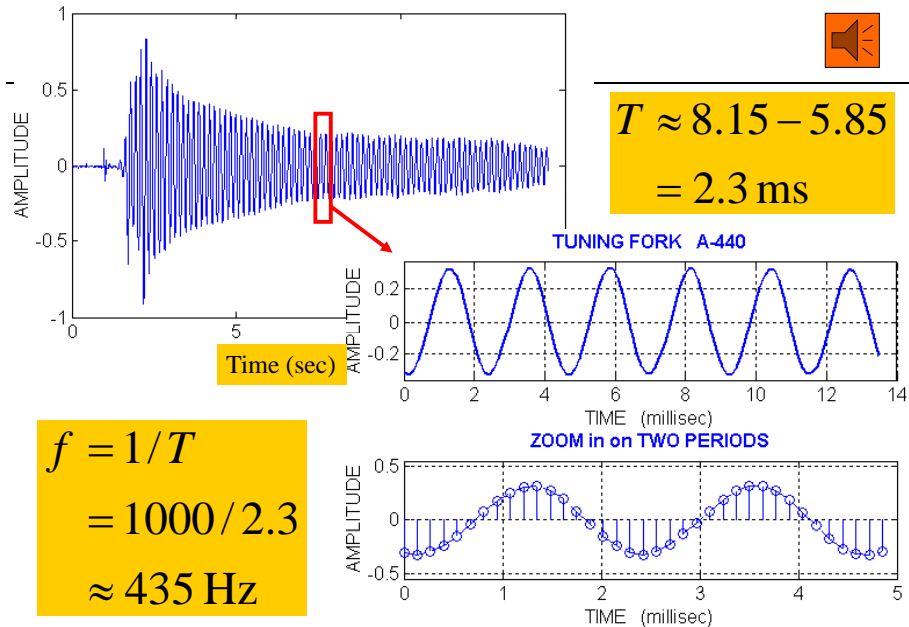
- Write general formula for a "**sinusoidal**" waveform, or signal
- From the formula, plot the sinusoid versus time
- What's a **signal**?
 - It's a **function** of time, $x(t)$
 - in the mathematical sense

TUNING FORK EXAMPLE

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

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

TUNING FORK A-440 Waveform



SPEECH EXAMPLE

- More complicated signal (BAT.WAV)
- 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

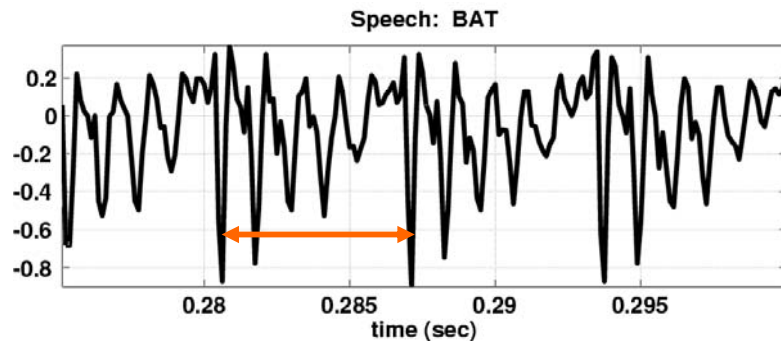
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Speech Signal: BAT

- Nearly **Periodic** in Vowel Region
 - Period is (Approximately) $T = 0.0065 \text{ sec}$



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
 - $1/11025 = 90.7 \text{ microsec}$
- Output via D/A hardware (at F_{samp})

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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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SINES and COSINES

- Always use the COSINE FORM

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

- Sine is a special case:

$$\sin(\omega t) = \cos(\omega t - \frac{\pi}{2})$$

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SINUSOIDAL SIGNAL

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

- **FREQUENCY** ω
 - Radians/sec
 - Hertz (cycles/sec)
- **AMPLITUDE** A
 - Magnitude

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

- **PERIOD** (in sec)

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

- **PHASE** φ

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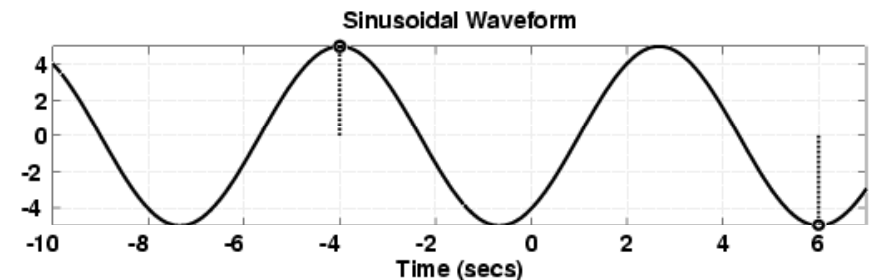
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EXAMPLE of SINUSOID

- 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, ω , and ϕ

$$A = 5$$

$$\omega = 0.3\pi$$

$$\phi = 1.2\pi$$

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

$$(\omega t + \phi) = 0 \Rightarrow (0.3\pi t + 1.2\pi) = 0$$

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

PLOT the SINUSOID

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

- Use $T=20/3$ and the peak location at $t=-4$

