ECE2311—Continuous-Time Signal and System Analysis

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- Course materials: All available on class web site
  - http://ece.wpi.edu/courses/ece2311
  - Homeworks, Class "Guided Notes," exams, …

Print your own copy of "Guided Notes" each day

WPI computer or VPN

login: "ece503"
Pwd: "ted"

- Course schedule subject to change
  - Exam dates, homework due dates → fixed
  - Daily class topics may vary
  - Check your WPI e-mail for class announcements

- YOU ARE RESPONSIBLE FOR ANNOUNCEMENTS MADE IN LECTURE!
  - Get classmate's notes on *rare* days that you miss a class

- Book: ~~Lathi, "Linear Systems and Signals," 2nd ed.~~
  oppenheim, willsky, Nawab, "Signals & Systems," 2nd ed.
  - Best to skim reading material BEFORE class

- MATLAB software: Available on WPI and ECE computers
  - Will be used extensively

- Be sure you have:
  - ECE mail slot (return of all materials)
    - Label ***ALL WORK*** with your ECE mail slot number
  - WPI e-mail (class communication)
  - ECE computer account (Use of AK computers; MATLAB)

Course Content

- Basic theory, practice of processing continuous-time signals
  - "Continuous-time" ➔ Signal not on a digital computer
  - Still use computer as computation, visualization aid
  - E.g.: Sensing most physical systems prior to computer acquisition
    - Physiologic signals (ECG, EEG, etc.)
    - Cell phone transmissions
    - Radar
  - And:
    - Integrated circuits (ICs)
    - Radio

- Linear system analysis
  - Relates "outputs" to "inputs" in "linear" manner
  - Simplest form of system. Many desirable properties.
    - Many complex systems understood as extension to linear systems.

- Frequency-domain representation of signals
  - Signals can be thought of as sum of sine waves of various frequencies, amplitudes and phases

- No hardware laboratory

- Recommended background:
  - ECE2011 (Basic circuits, AC circuits, complex numbers)
  - MA1022 (Differential and integral calculus)
  - ~~Suggested~~ MA2051 (Differential equations)

Course Textbook

- "Signals & Systems," second edition. Oppenheim, Willsky and Nawab, Prentice Hall, 1997. ISBN: 0-13-814757-4.

- Text covers both continuous-time and discrete-time
  - Sometimes in the same section (or even sentence!)

- We will only cover continuous time.
  - Ignore discrete-time (for this course)

- Can easily identify continuous- vs. discrete-time via author's mathematical notation:
  - Continuous time: $y(t) = a \cdot x(t) + b$
    - "t" is the continuous-time variable
    - Time variable encased in round parentheses
  - Discrete time: $y[n] = a \cdot x[n] + b$
    - "n" is the discrete-time index
    - Time functions encased in square brackets

Homeworks

- Due weekly — Wednesday (except for Tues before Thanksgiving)
- Get assignments from class web page
  - Solutions also posted here after due date
- Essential to understand course material; prepare for exams
- Recommend
  - Start homeworks early
  - Get help/tutoring as needed
- ENCOURAGE discussion, study teams
  - But, DO YOUR OWN WORK
    - Try to start each problem
    - Check solution with other; discuss solution method
  - Everything you write down, you should be able to explain
    - Else, may violate academic honesty
- Homework turn in: ECE office on due date, time
  - Generally, NO CREDIT for late work
  - Note: Little flexibility on exam weeks, as must post solutions for class

• MATLAB portions of homework are heavily weighted in grading.

Exams

- In class for full 50 minutes
- Close book. I supply a note sheet.
  - Note sheet is posted on web. Encourage its use for homeworks
- Calculators permitted FOR COMPUTATION ONLY
- NO MAKE-UP EXAMS
  - See me IMMEDIATELY for documented absence

Final Grade Computation

– Homework	20 %
– Exam 1	20 %
– Exam 2	30 %
– Exam 3	30 %
	100 %

Exceptions, Learning Needs

- See me privately, THIS WEEK, if you have any personal learning needs/requests
- During term, inform me IMMEDIATELY of any LEGITIMATE excuses

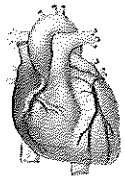
> *If you need course adaptations or accommodations because of a disability, or you have medical information that you choose to share with me, please do so during my office hours THIS WEEK. If you have not already done so, students with disabilities who believe that they may need accommodations in class are encouraged to contact the Disability Services Office THIS WEEK (Daniels Hall, 508-831-5235).*

Academic Honesty

- I expect NO problems
- What you hand in must ALWAYS represent YOUR own work and UNDERSTANDING
- If something you are doing feels wrong — it probably is ➔ STOP !!
- NEVER HESITATE to speak with me about ethics/honesty issues
  - Also available: Prof. Labonte (Academic Ombudsperson), Prof. Looft (Department Head)
- If something bothers YOU PERSONALLY, it is an issue to deal with!

This is YOUR education, take RESPONSIBILITY for it !!

OVERVIEW: Signal Processing Applications



(www.aic.cuhk.edu.hk)

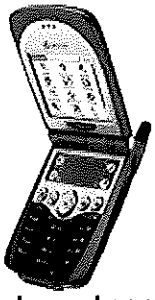
- Physiologic monitoring, imaging
  - ECG (heart), EEG (brain), blood pressure
  - Imaging of bone, tissue (actually, everything in the body)
    - MRI, PET, X-ray
  - Medicine/health care → 15–20% of U.S. economy

(www.cogneuro.ox.ac.uk)

- Aerospace
  - Monitoring aircraft location for air traffic control
    - Passive (radar) and active (beacon) monitoring
  - Electronic monitoring of all on-board systems
  - Automated flight control

(wallpapers.diq.ru)

- Telecommunications (particularly wireless)
  - Cell telephones
  - RFID tags (Radio Frequency Identification)
    - Inventory control and automation



(www.cardsquad.com)

Increasingly, Signal Process in Discrete-Time

- Discrete-time SP advantages
  - More accurate, repeatable, easier to change
- Continuous-time SP advantages
  - Most physical systems/sensors are continuous-values
  - Required at highest speeds
- Often: Continuous-time "front end," followed by discrete-time thereafter

Why Study *LINEAR* Systems?

- Linear systems have many "nice" properties
  - Will study later in course
- These "nice" properties ease the mathematics
  - Allow focus on the major function/workings of a system
- Many systems well-approximated by linear system
  - E.g., R, L, C circuits, transistors in active (linear) region, many physical systems
- Superposition
- Phasor analysis (for linear electronic circuits)
  - GREATLY simplifies steady state response to SINUSOIDS
  - Replaces calculus with algebra
  - Time Domain ⟷ Frequency Domain
  - Sinusoidal Input ⟷ Easier analysis
  - System inputs not always sinusoidal
    - E.g., Voice, ECG, EEG, air speed, distance to transmitter

Fourier Analysis: Treat Signals as Sum of Sinusoids

- **Applet example 1:**
  - **Fourier Transform Demonstration Applet, Zlatko Cajic, University of Maribor, Slovenia**
  - http://colos1.fri.uni-lj.si/colos/Colos/EXAMPLES/FOURRIER_TRANSFORM/index.html
  - **Show that sum of sinusoids produce** general waveforms

- **Applet example 2:**
  - **Fourier Series Applet, Frequency analysis of periodic functions**
  - http://www.falstad.com/fourier/
  - **Show that sum of sinusoids produce** specific periodic waveforms

Big Picture Concept

- Understanding inputs, outputs of linear systems
  - Complex linear system input → Hard problem to determine output
  - Think of input as sum of sinusoids
  - Solve output for each input sinusoid → Many easy problems
  - Superposition: Sum of each output = total solution

- Sine amplitude, phase at each frequency = "Frequency Domain"
  - Many systems easier to understand in frequency domain

Abstraction in Signal and System Analysis

- Signals/systems span many applications, time scales
  - Pico, femtosecond pulses for personnel location systems
  - Radar applications in nanosecond time scale
  - Physiologic systems (0–1000 Hz)
  - Geological periods (millenia)

- Often, discuss concepts without reference to specific applications/examples

- Get used to it!!