Engin. 100: Music Signal Processing Introduction and Lab #1

- Overview of Engin 100: What's coming? What's in store for you in this course?
- Technical part: Digital Signal Processing. What is it and why is it worth doing?
- Tech Comm part: Significance to Engineers. Introduction to Tech Comm next lecture.

Lab and Lecture Materials Location:

- Ctools website: http://ctools.umich.edu
- Log on with UM ID and Kerberos password.
- Tabs at the top. Click on "Engin 100" tab.
- Labs, lectures, *assignments* all online 24/7.
- May wish to *print out lectures ahead of time*. Save paper-select "handouts" when printing.

Course Overview

- 50% of course is *technical* (signal processing).
- 50% of course is *technical communication.*
- BOTH are equally important to your *grade* and to your future *career* in engineering (more later).
- 3 labs and 3 projects (2 small, 1 large).
- Large: simple music synthesizer and transcriber.
- 2 exams; memos; oral & written presentations.

Engineering 100.300-Introduction to Engineering-Music Signal Processing-Fall 2009

Faculty
Prof. Andrew E. Yagle
Dept. of Electrical Engineering and Computer Science (EECS)
4114 EECS Building aey@eecs.umich.edu
Office Hours: Thursday 3:10-5:00

Ms. Pauline Khan, BSME, MSE
Technical Communications Program
308 Engineering Programs Building
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Office Hours: Tuesday 1:30-2:30 in EECS (confirm location with me) or by appointment

Schedules:
Lectures: Tuesday AND Thursday, 10:40-Noon, 133 Chrysler Center
Discussion: Tuesday, Wednesday, Thursday, Friday, 12:40-1:30, in rooms:
EECS Rooms: 1003 3427 1003 1008
Labs: Tuesday, Wednesday, Thursday, Friday, 1:30-3:30, Pierpoint Commons, room B521.

Required Course Materials:
Reading material will be posted on the CTools website for the course:
www.ctools.umich.edu Sign in with your UM ID and Kerberos password

Book: 'A Practical Guide to Technical Reports and Presentations,' Pearson Publishers, Bary-Khan, Hildinger, & Hildinger, 2008

WEEK	TUESDAY LECTURE	THURSDAY LECTURE	READ CHAP	LAB / PROJ	LAB TOPIC	DISCUSS TOPIC	ASSIGN DUE NEXT WEEK	DUE
Sep. 7-11	Goals, overview & Sampling	Intro to Tech Communic	Chap 1	Lab 1	Matlab and sampling	Introduction	Personal Essay	
Sep 14-18	Measure freqs. & semilog plots	Memo Writing	Chap 2	Lab 2	Measuring Music freqs.	Teamwork	Lab #2 result; Team Contract	Essay
Sep 21-25	Project 1 specs: tone synthesizer and transcriber	Oral Pres Basics	Chap 8	Proj 1	Synthesizer Transcriber	Memos	Project 1 oral presentations	Memo (Lab#2 Resu
Sep 28-Oct. 2	Matlab's fft and spectrogram I	Content Development	App B	None		Proj 1 OP	None	OP#1
Oct. 5-9	Matlab's fft and spectrogram II	Progress Reports & Writ Strategies	Chap 2	Lab 3	spectra and spectrogram	Client-Consult	Lab #3 result due Thur. 15	Memo (Summary of research)
Oct 12-16	Ethics in Engineering	Teamwork Skit (CoE)		Lab 3	spectra and spectrogram	Engin. ethics situation	Studying for midterm exam	
Oct 19-23	FALL BREAK	EXAM #1		None	None	None	None	Exam#1
Oct 26-30	Project 2 specs: touch-tone phone	Graphics	App C	Proj 2	Touch-tone project work	Graphics Presentations		Lab 3
Nov 2-6	Project 3 specs: music synthesizer and transcriber	Oral Pres Advanced	Chap 8	Proj 3	Synthesizer project work	Writing Strat Email Etiquette	None	Memo (Proj 2)
Nov 9-13	Synthesizer hints and help	Persuasive Final Reports	Chap 6 App F	Proj 3	Transcriber project work	Writ Strategies Exec Summary review		
Nov 16-20	Transcriber hints and help	Transcriber hints and help		Proj 3	Transcriber project work	Proj 3 OP Draft Review		Draft OP & Progress Report
Nov 23-27	Transcriber hints and help	None THANKSG.			Transcriber project work	None THANKSG.		
Nov. 30-Dec. 4	Transcriber hints and help	Executive Summary & OP Slide peer review		Proj 3	Transcriber project work	Presentation Rehearsals	Peer evaluat Final Report	Draft Exec Summary
Dec. 7-11	Transcriber presentation	Transcriber presentation		None	Transcriber presentation	Transcriber presentation	Studying for Second exam	Peer Eval Final OP
Dec. 14	EXAM #2		Turn in	Final	Report			Final Report Exam#2

*Topics for lectures and discussions subject to change at the discretion of the instructors.

Complete schedule for Engin. 100, Fall 2009.

Available on Ctools website under heading "Introduction." We suggest you print this out and keep it handy!

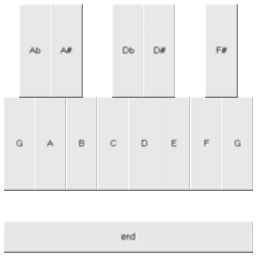
Engin 100 Lab Schedule

- **GOAL**: (1) To learn skills for use in projects; (2) To learn fundamentals of musical signals.
- **#1**: Introduction to Matlab and sinusoids.
- **#2**: Measure frequencies of music tones with DSP; visualization using semilog and log-log plots.
- **#3**: Compute spectra of signals using Matlab; filtering noisy signals; spectrogram (visualization).

Engin 100 Project Schedule

- **GOAL**: (1) To design & build simple music systems; (2) To apply tech comm principles to present results.
- **#1**: Build music tone synthesizer and transcriber.
- **#2**: Reverse-engineer touch-tone phone signal:
- (a) Compute freqs; (b) Build synthesizer; (c) Build transcriber; (d) Study transcriber behavior in noise.
- **#3**: Build simple music synthesizer and transcriber:
- (a) Generate musical staff-like notation from signal;
- (b) Report results using tech comm principles.

Project #1: Tone Synthesizer GUI

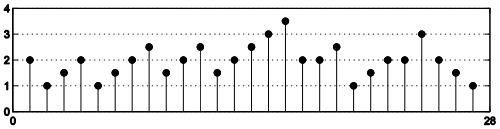


Mimics single octave of a piano keyboard: black keys above (for accidental notes); white keys below (for whole notes).

You can jazz this up (add colors & labels) if you desire to do so.

Clicking on key with mouse plays that note

Project #1: Tone Transcriber Output



Crude musical staff notation of "The Victors."
Musical notes: uses stems instead of ♫ or ♪.
No interval info.-all notes have same duration.

But *heights* against 5-line background correct.
Computing these heights from sampled signal from your synthesizer is the point of project.

Project #2: Touch-Tone Synthesizer GUI

Touch-Tone Phone: Synthetic keyboard. Click on key with mouse makes tones.

Transcriber Output like: "8 6 7 5 3 0 9" Computing this from sampled sound from keyboard is point of this project. Also: performance in noise.

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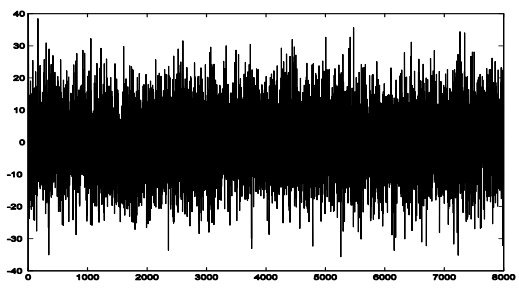
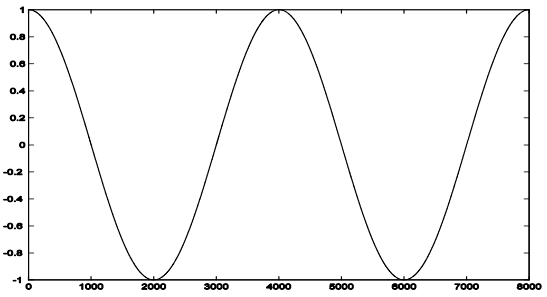
Plotted below is a signal-plus-noise. Can you figure out what the signal is?



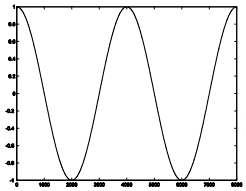
This is the signal without noise.
How to get it? Wait for Lab #3.



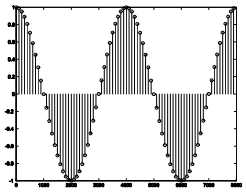
Applications of Digital Signal Processing (DSP)

- Digital storage of real-world analog signals.
  Analog storage: vinyl, cassette tapes, wire.
  Digital storage: hard drive, CD, DVD, ipod.
  Allows compression (digital vs. analog TV).
- Analysis of signals: What is frequency of note? What is its spectrum? What type of instrument?
- Filtering of signals: Removing noise (previous); removing interference (known undesired signal).
- Listen: What's happening? What can we do?
- Lab #3: Analysis (spectrogram) Filter it out.

What IS DSP? How do we do it?
Sampling: Convert analog to digital



SAMPLE analog to get digital (sequence of discrete numbers).

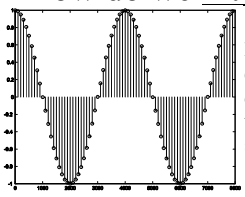


Analog (continuous-time) x(t)

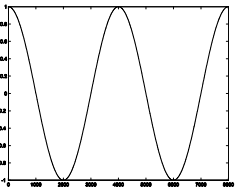
Digital (discrete-time) x[n]

Once have sampled signal x[n], can process it on a digital computer!

Issue: Can we recover x(t) from x[n]?
Can we convert digital back to analog?
How do we interpolate x[n] to x(t)?

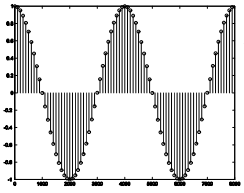


How do we connect the dots to get the correct smooth x(t)

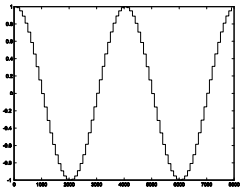


You do need an analog signal output for your speakers or earphones!
If we can't interpolate, then we are just playing with numbers here!

Real-World Digital-to-Analog Conversion:
This is called "0th-order sample-and-hold"



Digital to analog. "stairs" effect is exag-gerated.



In fact, we can reconstruct x(t) from x[n] perfectly if the sampling rate exceeds twice the maximum frequency of the original signal! We will derive this for periodic (but arbitrarily large) signals in Lab #3 lecture.

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WARNING!

- How you report results is just as important as the technical merit of results themselves!
- A technically good transcriber that is poorly presented will NOT get a good grade!
- A technically inferior transcriber that is well presented WILL get a good grade!
- A technically good transcriber that is well presented will get a REALLY good grade.

Why is Presentation so Important?

- This is **absolutely** how the real world works.
- True in both industry and academia (oh yes!)
- Only difference: *grades* in Eng. 100 become *salary*, *jobs* and *careers* in the real world.

- But you don't have to take my word for it.
- Take the word of UM engineering alumni:

So you want to be an EE... (same holds for any other type)

- Most important: To know math & physics
- Employers look for: Technical competence (good grades in your engineering courses)
- What you will do: Apply directly what you learned in all of your engineering courses
- Your job: Electrical Engineer, obviously.
- **ALL** of the above statements are **WRONG!**

U-M EE Alumni Say That:

- Most important in their professional experience

1 Ability to function on a team
2 Oral communication skills
3 Written communication skills
4 Engineering problem-solving ability
5 Math, science,and engineering skills (yes, 5th)
6 Professional and ethical responsibility

What U-M EE Alumni Do:

- 62.5%: Engineer
- 14.6%: Manager
- 6.3%: Marketing
- 16.7%: Other
- Source: U-M College of Engineering Alumni Surveys for classes 00-01, 01-02, 02-03, 03-04

Conclusions from this data:

- Nerds can't be engineers!
- Team and communication skills are more important on the job than technical competence.
- You're not smarter than everyone: Someone else is smarter (in India?)