Developing Smartphone Apps for Laboratory Instruction in Acoustics

SCOTT H. HAWLEY

DEPARTMENT OF CHEMISTRY & PHYSICS

BELMONT COLLEGE OF SCIENCES & MATHEMATICS

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Overview

- General comments on App-writing in for Instructional Purposes
- Necessity: Lab for Study Abroad Gen Ed
- Development
- Trial Lab with Students
- More Development & Measurement @ OmegaLab
- Writing Journal Paper
- The future: PHY2010 Lab, Fall 2016!

They say you don't really know something...

...until you try to ~~teach it~~ write a teaching 'app' about it!

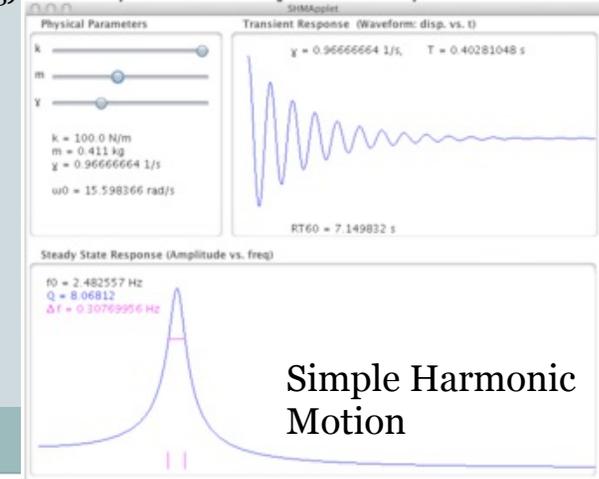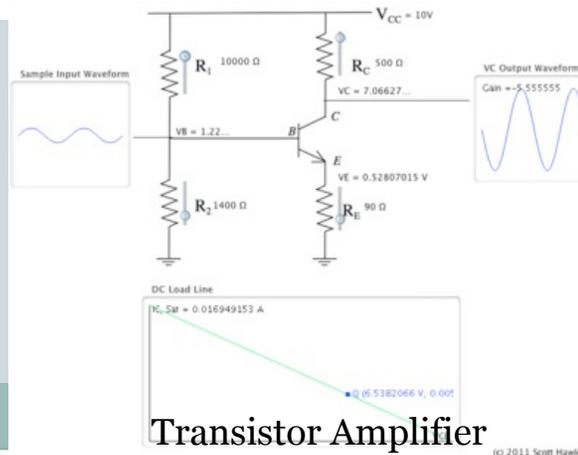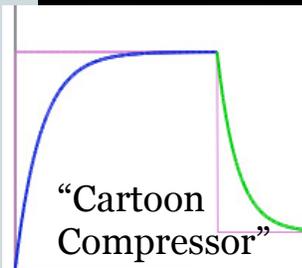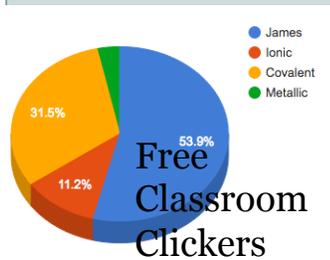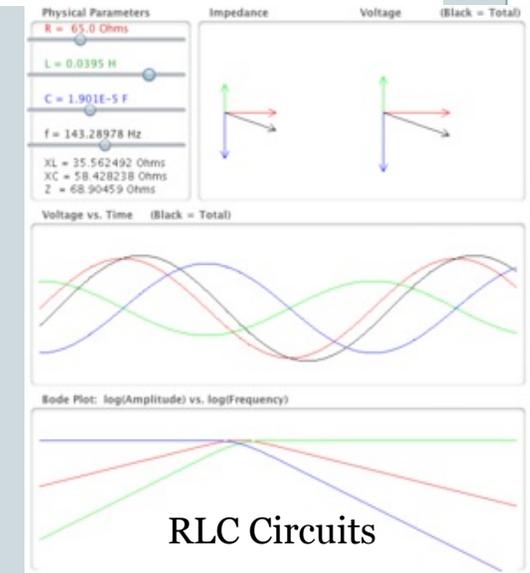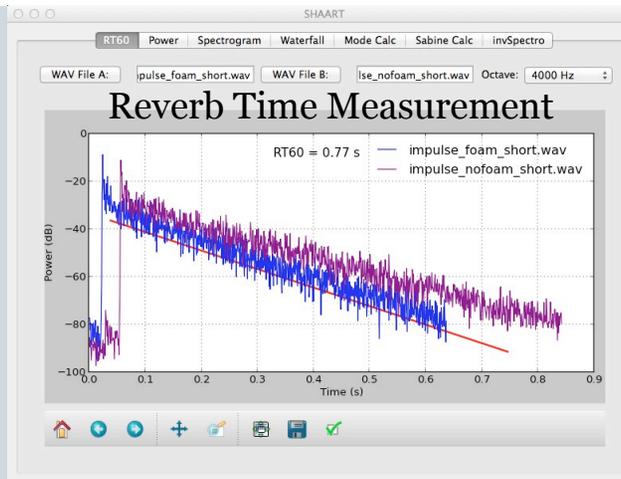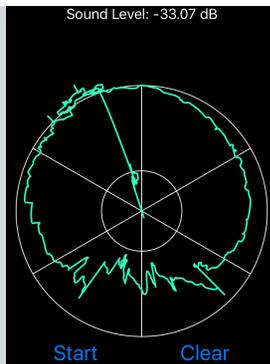Instructional Tech apps are created to help students, and yet...

The 'app' writing process *also* benefits the instructor:
- builds depth of comprehension
- clarifies understanding / illuminates misunderstanding
- offers opportunities for discovery

Sample of 'Apps' Developed While at Belmont

Languages: Python, JavaScript, PHP, Swift (none of which I knew before starting)
Platforms: Web, Mac & iOS

3D Audio Player

Sound Level: -33.07 dB

Start   Clear

Reverb Time Measurement

RT60 = 0.77 s

impulse_foam_short.wav
impulse_nofoam_short.wav

SHAART

RT60   Power   Spectrogram   Waterfall   Mode Calc   Sabine Calc   invSpectro

WAV File A: pulse_foam_short.wav   WAV File B: lse_nofoam_short.wav   Octave: 4000 Hz

Physical Parameters   Impedance   Voltage   (Black = Total)
R = 65.0 Ohms
L = 0.0395 H
C = 1.901E-5 F
f = 143.28978 Hz
XL = 35.562492 Ohms
XC = 58.428238 Ohms
Z = 68.90459 Ohms

Voltage vs. Time   (Black = Total)

Bode Plot: log(Amplitude) vs. log(Frequency)

RLC Circuits

James
Ionic
Covalent
Metallic

53.9%
31.5%
11.2%

Free Classroom Clickers

"Cartoon Compressor"

RhymeLink

Rhyming Thesaurus (Songwriting)

Session 9/13/2015

KNOBILITY

Audio Session Documentation

V_{CC} = 10V

R_1 10000 Ω R_C 500 Ω

Sample Input Waveform

VC Output Waveform
Gain = -5.555555

VC = 7.06627...

VB = 1.22...   C

B

R_2 1400 Ω   E

VE = 0.52807015 V

R_E 90 Ω

DC Load Line

IC, Sat = 0.016949153 A

Q (6.5382066 V, 0.005...

Transistor Amplifier   (c) 2011 Scott Hawley

SHMApplet

Physical Parameters   Transient Response (Waveform: disp. vs. t)

γ = 0.96666664 1/s,   T = 0.40281048 s

k
m
γ

k = 100.0 N/m
m = 0.411 kg
γ = 0.96666664 1/s
ω0 = 15.598366 rad/s

RT60 = 7.149832 s

Steady State Response (Amplitude vs. freq)

f0 = 2.482557 Hz
Q = 8.06812
Δf = 0.30769956 Hz

Simple Harmonic Motion

Why Write Instructional Tool Apps?

- Necessity
  - e.g., Acoustic toolkit, for measuring reverb times & other lab tasks
- Convenience – 'there ought to be a way…'
  - e.g., Clicker system, Polar Pattern Plotter
- Control / Customization
  - e.g., Physics Problem Parser & online HW, for randomizing questions
- Enrich & accelerate the learning experience
  - Provide visualization, interactivity & 'tactile' learning experience
  - Emphasize concepts over (math) details
    - e.g., Transistor Amp demo, RLC Circuit demo
- Comprehension
  - e.g., Compressor demo
- Service
  - e.g., Knobility, for Audio II documentation (which I don't teach)
- Help Stay Current on Latest Tech
  - Convolution Reverbs, WebAudio, Spatial Audio, Neural Networks

The App: Polar Pattern Plotter
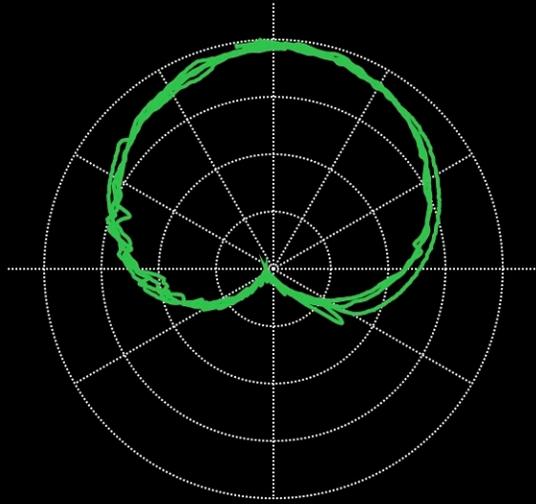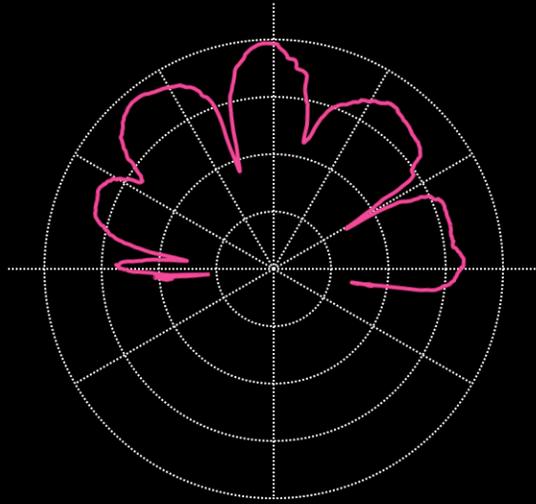
The Story of PPP

- Teaching Gen Ed Electro-acoustics class for Study Abroad, needed labs for us to do!
  - Issues: student preparation, and "morale"
    - Not too math- or Excel- intensive
    - "Fast" and reliable
    - Should be related to SA trip: speaker & mic manufacturers
  - Idea: automated data acquisition & visualization?

Story p 2

- Manufacturers use "robot" systems for polar pattern measurement (Neumann HQ):

- Had idea for app: Mic input + Compass data -> Polar Pattern! Asked online ("Audio Educators Forum"), no such thing. ...Yet!

- Wrote beta app in a couple days, students used my phone for lab
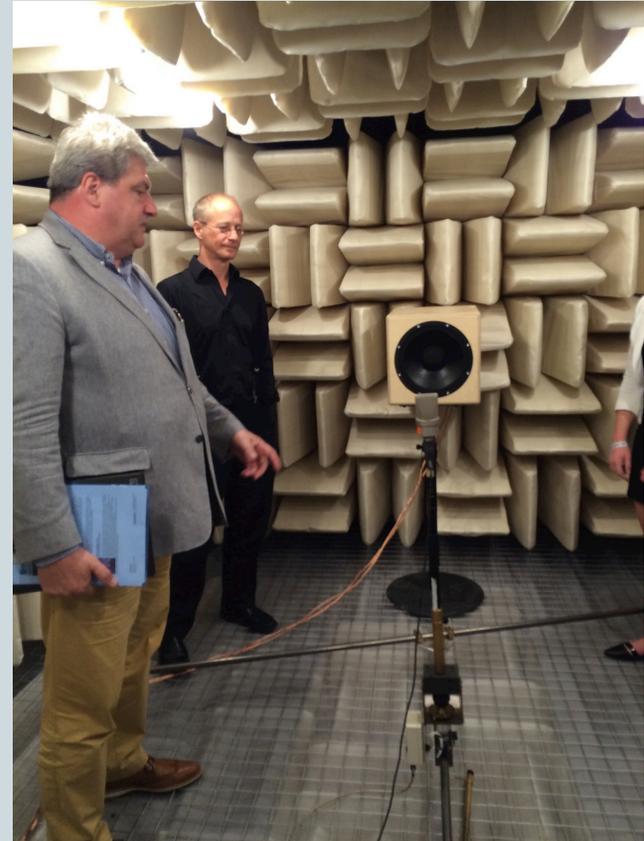
The Story of PPP, cont'd

- Study Abroad bought Y-Adaptors for Phone Jack
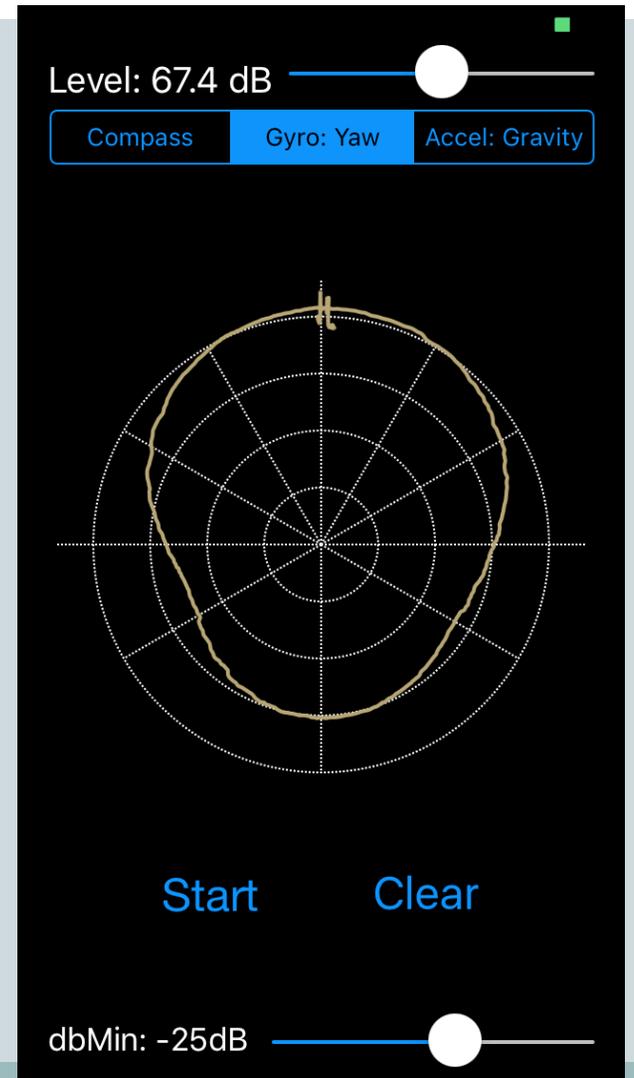- Lab setup:

App queries compass to get rotation info

Note: Compass near large permanent magnet!

Education Outcomes

- ## Students got graphs!
- ## Students reported:
  - Enthusiasm for teacher's effort
  - Appreciation for visual representation
  - Appreciation that it was directly relevant to trip / mic-mfg

  - Note: Dr. Yang-Hann Kim, in his Rossing Prize in Acoustics Education speech, identified visualization as *key* component for acoustics education.

Continued App Development

- Partnered with Rob McClain of OmegaLab Studio for measurement

- Offers "free field" / anechoic space

- Measured mics & multi-speaker setups

- Found gyroscope is more reliable than compass

- Identified need for more UI elem's: meter, graph scale
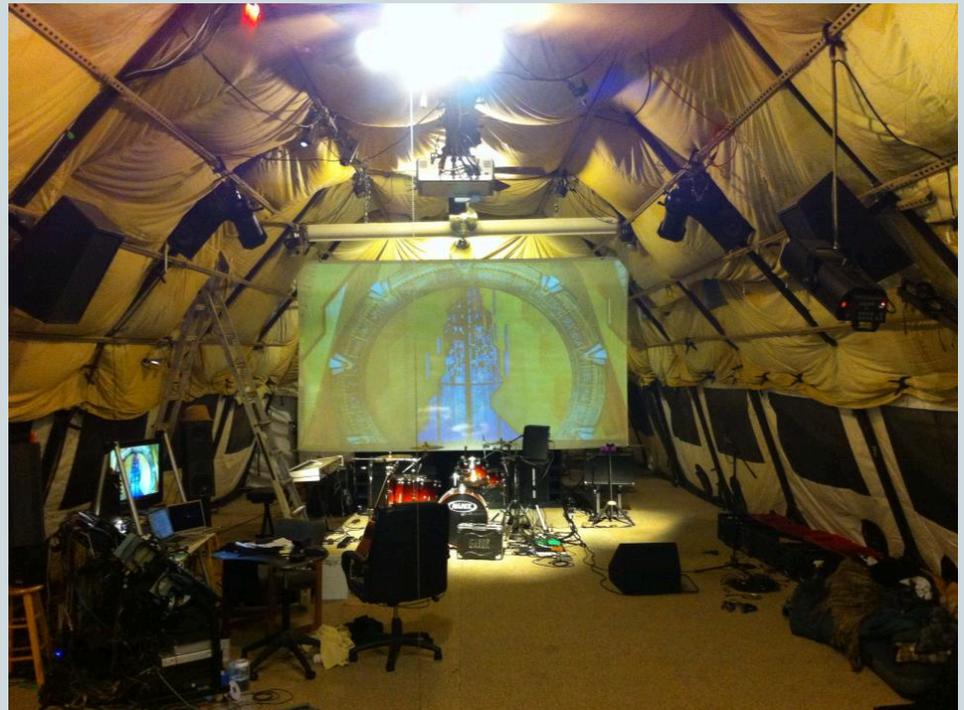
Paper for *The Physics Teacher*

- *The Physics Teacher* journal, features a running "iPhysics" section on labs using smartphones
- Samples from submission by Hawley & McCain:
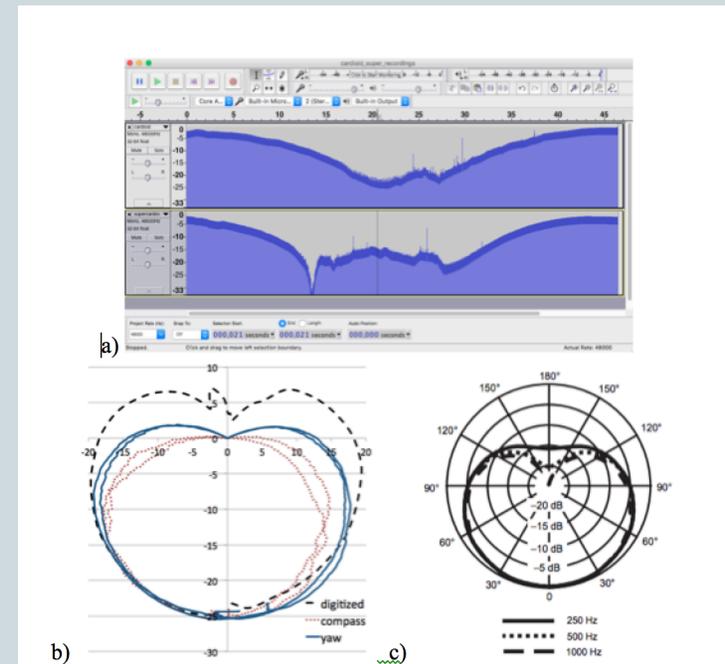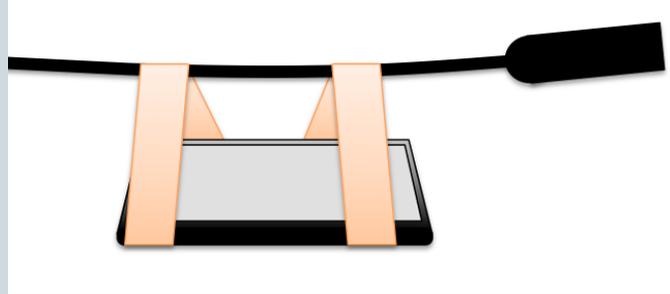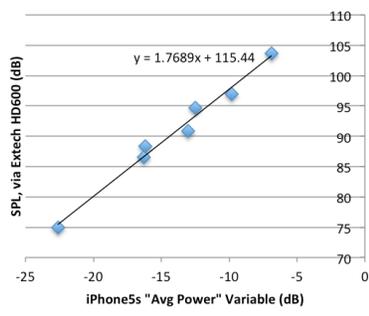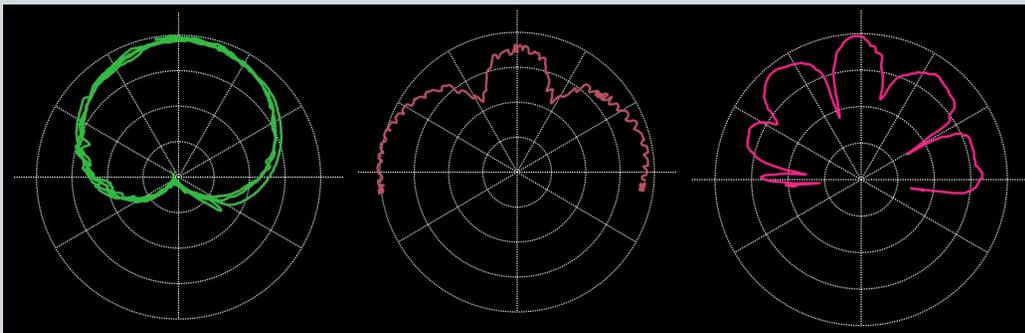
Future Work

- Use in PHY2010 labs, Fall 2016!
- Study Fraunhofer Diffraction (using accelerometer):
- Re-submit app (to App Store) with better frequency response
- Find out how others (AET?) may use app!
- Get paper published
- 3D Sound Viz! w/ Nathan Adam (Gibson Foundation Grant?)