The Science of Sound for the Music Technology Student

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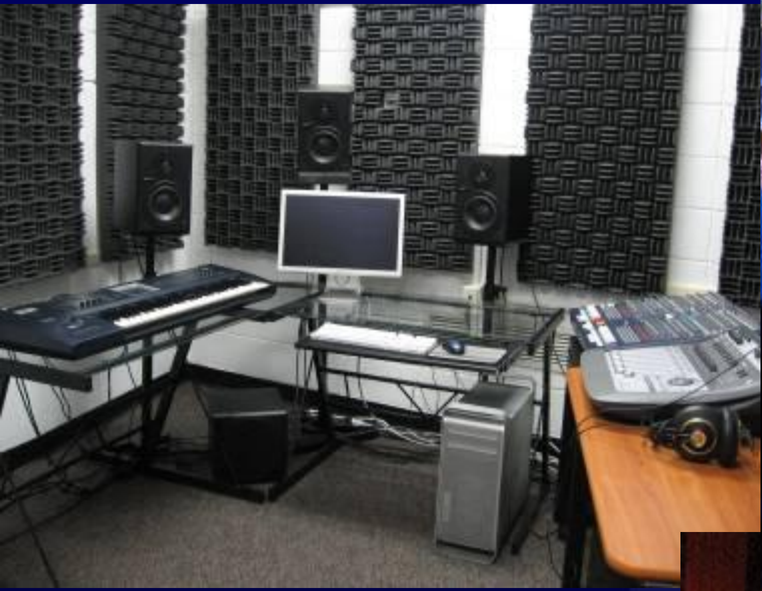
Outline

- Introduction
  - Music Technology degree programs
  - Prerequisites and math/science
  - Science topics of interest to Music Tech
- Lesson Example: source-filter model of musical instruments
- Prospects for future work
- Conclusion

Introduction

- Music Technology degree programs are popular in the U.S. and around the world
- Music Tech degrees typically include
  - music theory
  - audio recording and mixing
  - multimedia production
  - electronic and computer music
  - computer applications in music composition

Music Technology



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College of ENGIN

Introduction (cont.)

- Example: Music Tech Bachelor of Arts
  - Composition
  - Sound Design
  - Audio Technology
  - At least 3 semesters of applied music
  - Interdisciplinary collaboration
- Students fulfill university general ed reqs: but no specific math/science courses

Introduction (cont.)

- Music Tech "Science of Sound"
  - Principles of mass-spring-damper systems
  - Sound waves and sound properties
  - Hearing physiology and psychology
  - Architectural and Environmental acoustics
  - Musical acoustics
  - Audio engineering

Challenges

- Use of mathematical expressions like
  $c = f\lambda$, $\omega = \sqrt{(s/m)}$, $20 \log_{10}(p/p_{ref})$ and $x(t) * h(t)$
  are not initially meaningful
- Sole reliance upon handwaving can be misleading, due to oversimplification
- Time-domain vs. Frequency-domain is initially confusing, but worth emphasizing

What has worked for me?

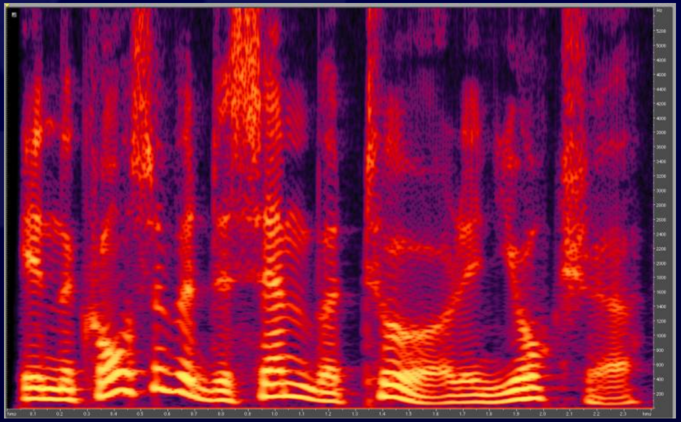
- Graphical views and graphical lookup
- Block diagrams
- Minimal use of arcane symbols

Graphical Representations

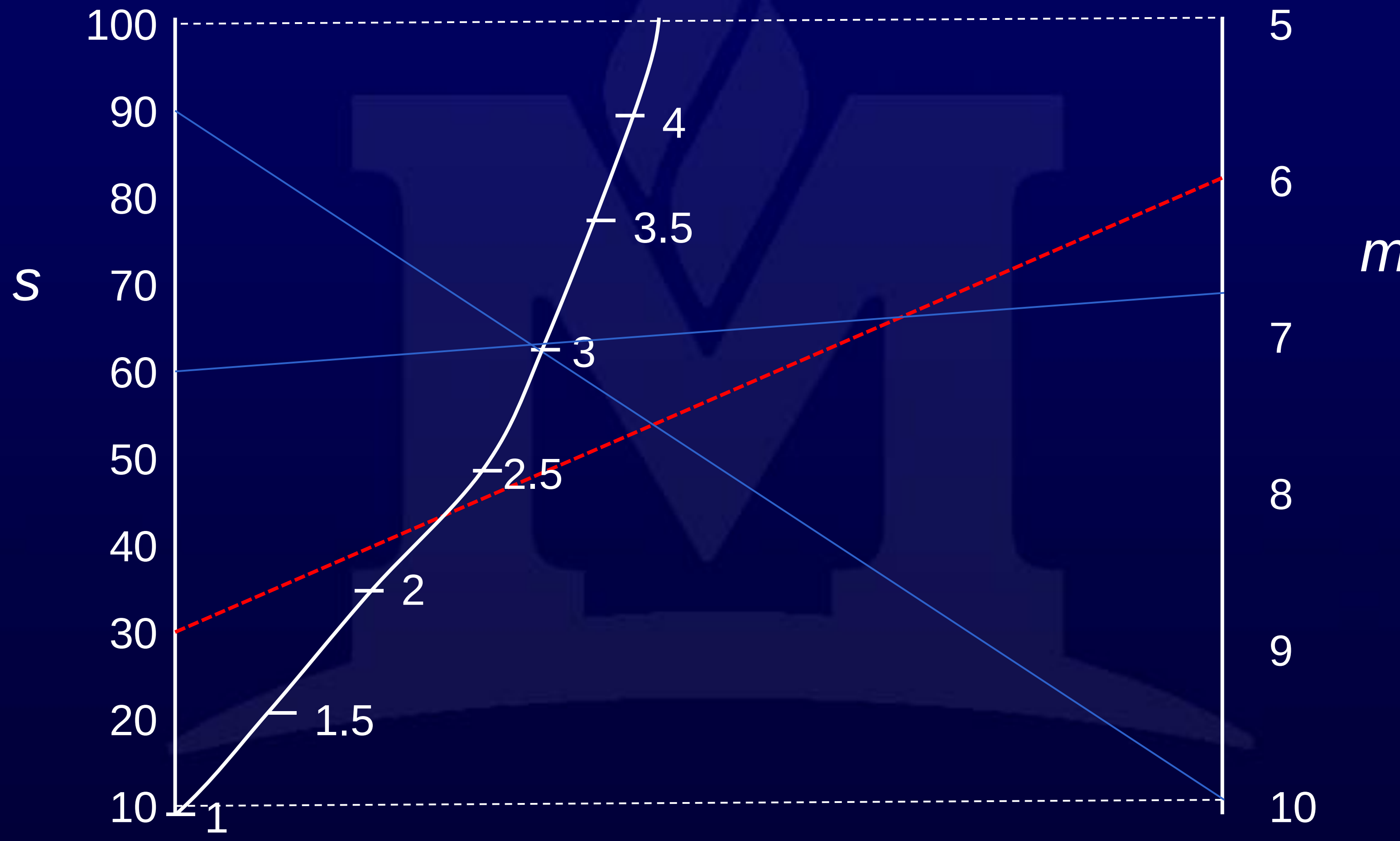
- Time Domain: amplitude vs. time
- Frequency Domain: amplitude vs. freq
- Spectrogram: amp vs. freq vs. time

Musical Notation

- Notation specifies pitches, durations, and time evolution
- Representation is like a spectrogram: frequency vs. time



Nomograms



ω = √(*s*/*m*)

Example

- Interpreting the effect of a filter on a musical signal
- Describing a musical instrument using a lumped model

Bandwidth Examples

- Speech bandwidth (400 Hz – 4kHz)
- Sub-100 Hz bandwidth (very quiet)
- Sub-400 Hz bandwidth
- Above- 4 kHz bandwidth

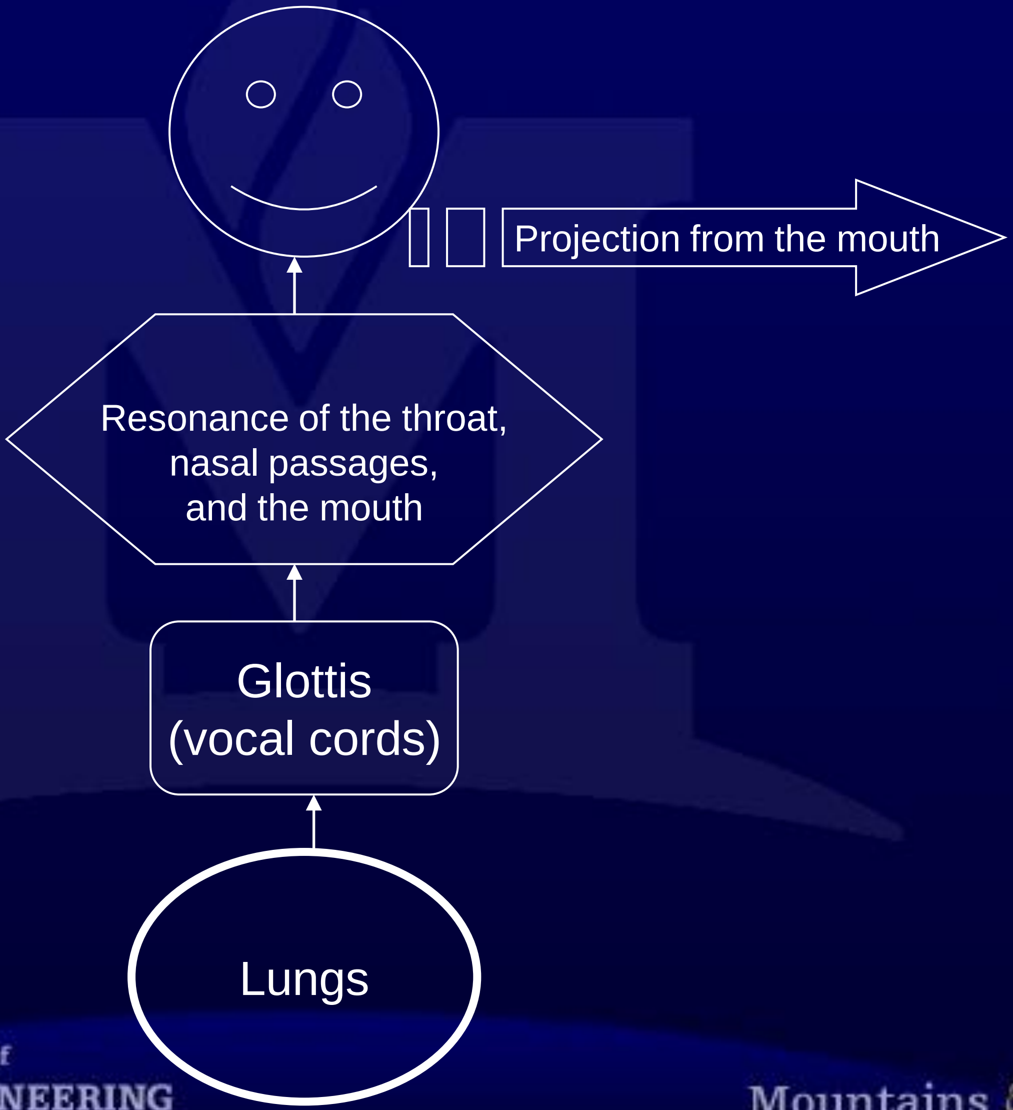
Musical Instruments

- Most *conventional* musical instruments have
  - an *excitation source*
  - a *vibrating element*
  - a *resonant body*
  - a means of *coupling* the vibrations so that they radiate into the air as sound waves

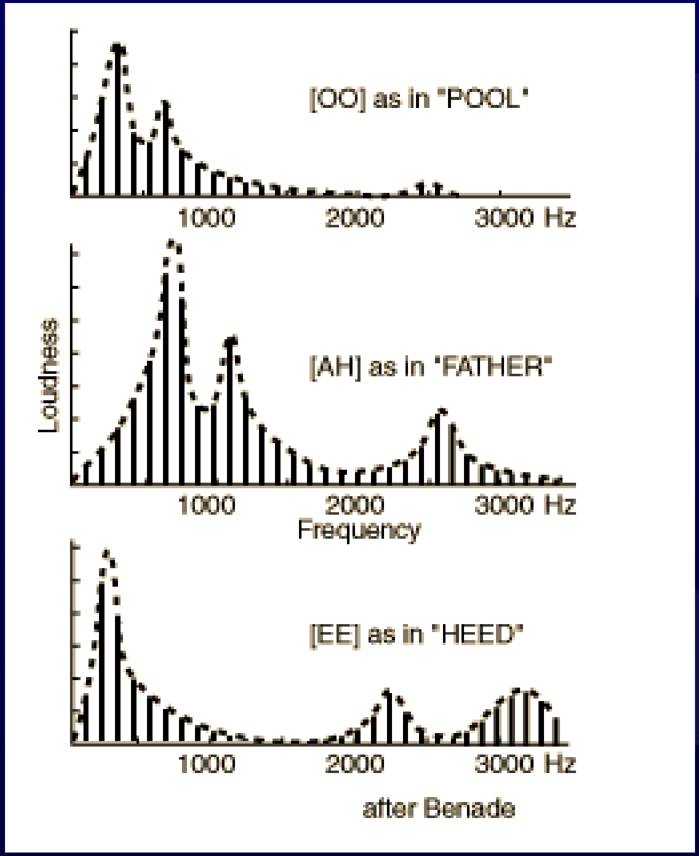
Musical Instruments (cont.)

- The excitation is a motive force
- The vibrating element usually creates many *harmonics*
- The resonant body emphasizes some frequencies and deemphasizes others
- The coupling means takes energy from the vibrating element and “loses” it (radiates) into an acoustical wave through the air

Example: Singing Voice



Formant Example



First three vowel formant frequencies

Vowel	*I*	*II*	*III*
/i/ ("eee")	280 Hz	2250 Hz	2890 Hz
/I/ ("eeh")	400 Hz	1920 Hz	2650 Hz
/a/ ("ah")	710 Hz	1100 Hz	2450 Hz

Conclusion

- Music Technology students can understand acoustical principles with minimal math
- Care must be taken to avoid oversimplification that leads to incorrect conclusions
- Working with mathematically unsophisticated students is *fun*: it reminds us what it was like to learn things the *first* time.