Today	Exam 1 (Ch 1,2,3,4,5,15) Review	Lab 6 Room Acoustics
Thursday	Exam 1	
Friday	**Project Proposals (Give top 3 and rational)**	

Exam 1 Review

Worth: 15% of your course grade

Covered: Ch 1,2,3,4,5,15
Lightly Covered: 3.4, 3.5
Not Covered: 3.6, 4.4, 5.4, 5.5, 15.4, 15.5, 15.6

Format: ½ mathematical problems similar to homework, ½ conceptual questions.

Must know:

- Especially: Anything that you saw in Lab + Lecture + Homework
- What each of the equations on the Equation Sheet means
- Lab: Principles, Techniques, and Math employed in Lab
- Definitions
- A particle level picture of sound propagation
- How a stringed instrument produces music: Impetus, tuning, mechanical amplification

Today:

What questions or topics would you like me to go over?
We can go over homework
We can go over equation sheet
We can go over terminology sheet
We can go over old exam questions

This is a closed book, closed notes exam. Calculators are permitted, but no saved equations may be used. Please let me know if a necessary equation does not appear below. Point assignments are noted throughout the exam. Partial credit is awarded *when work is shown*.

Useful Geometric Relations

For circles: $C = 2\pi R$, $A = \pi R^2$
For Spheres: $A = 4\pi R^2$, $V = \frac{4}{3}\pi R^3$

Physical Relations

Fundamental

$$v \equiv \frac{d}{t} \qquad v_{wave} \equiv \lambda \cdot f \qquad f \equiv \frac{1}{P} \qquad pressure \equiv \frac{Force}{Area} \qquad f_B \equiv \left| f_1 - f_2 \right|$$

$$I \equiv \frac{Power}{Area} = \frac{Energy}{Area \cdot time} \qquad SIL_2 - SIL_1 \equiv 10dB \cdot \log\left(\frac{I_2}{I_1}\right) \Rightarrow \frac{I_2}{I_1} = 10^{\frac{SIL_2 - SIL_1}{10dB}}$$

$$T_r \approx 0.16\, {}^{s}\!/_{m} \cdot \frac{Volume}{Area_{effective}} \qquad I_o \equiv 10^{-12}\, {}^{W}\!/_{m^2}$$

$$Area_{effective} = \alpha_1 S_1 + \alpha_2 S_2 + \ldots \qquad SIL_o \equiv 0$$

Under Certain Conditions

$$v_{sound} = 344\, {}^{m}\!/_{s} + 0.6\, {}^{m}\!/_{(s \cdot {}^\circ C)} \cdot \left(T_C - 20^\circ C\right) \qquad v_{sound} = 344\, {}^{m}\!/_{s} + \frac{1}{3}\, {}^{m}\!/_{(s \cdot {}^\circ F)} \cdot \left(T_F - 68^\circ F\right)$$

$$P = 2\pi\sqrt{\frac{m}{k}} \qquad v_{wave} = \sqrt{\frac{F}{{}^{M}\!/_{L}}}$$

$$L = \left(\tfrac{1}{4} + n/2\right)\lambda \qquad L = n\frac{\lambda}{2} \qquad f_n = n\frac{1}{2L}\sqrt{\frac{F}{{}^{M}\!/_{L}}} = nf_1, \ \text{n} = 1, 2, 3, \ldots$$

$$\frac{I_2}{I_1} = \frac{Area_1}{Area_2} = \frac{r_1^2}{r_2^2} \qquad \frac{I_2}{I_1} = \frac{Power_2}{Power_1} \qquad \sin\theta = 1.22\frac{\lambda}{D} \qquad \sin\theta = \frac{\lambda}{D}$$

Terms

Ch 1
- Speed
- Wavelength
- Force
- Pressure
- Vibration
- Wave
- Amplitude
- Compression
- Rarefaction
- Pitch
- Loudness

Ch 2
- Frequency
- Period
- Simple Harmonic motion
- Equilibrium
- Restoring force
- Inertia

Ch 3
- *No new terms*

Ch 4
- Reflection
- Adsorption
- Refraction
- Diffraction
- Interference
- Beats

Ch 5
- Pressure Amplitude
- Power
- Intensity
- Sound (Intensity) Level
- Decibel

Ch 15
- Reverberation Time
- Direct Sound
- Early Reflections
- Reverberant Sound
- Absorptivity
- Listening Qualities
  - Clarity
  - Uniformity
  - Envelopment
  - Reverberation
  - Free from Echoes
  - Performer satisfaction
  - Free from noise

Ch 1 The Nature of Sound

- 3 components of Acoustics
  - Production
  - Propagation
  - Perception
- Definition of speed: $v = \frac{d}{t}$
- Definition of pressure: $pressure = \frac{Force}{Area}$
- Speed of Sound: $v_{sound} = 344\ {}^{m}\!/_{s} + 0.6\ {}^{m}\!/_{(s\cdot °C)} \cdot (T_C - 20°C)$
- Speed of Sound: $v_{sound} = 344\ {}^{m}\!/_{s} + \frac{1}{3}\ {}^{m}\!/_{(s\cdot °F)} \cdot (T_F - 68°F)$
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Lab 1 Oscilloscope

- Reading Amplitude, Period, and Frequency off Scope screen.

Ch2 Waves and Vibrations

- **Amplitude**
- **Wavelength**
- **Period**
- **Frequency**
- **Wave speed**
- $v_{wave} = \lambda \cdot f$
- $f = \frac{1}{P}$
- **Simple Harmonic Resonator**
  - Equilibrium
  - Restoring Force
    - Linear in displacement
  - Inertia
- $Y(t) = Y_{max} \cos\left(2\pi \frac{t}{P}\right)$
- **Period for mass on Spring:** $P = 2\pi\sqrt{\frac{m}{k}}$
- **Wave speed in string:** $v_{wave} = \sqrt{\frac{F}{{}^{M}\!/_{L}}}$

Lab 2 Speed of Sound

$$v_{wave} = \lambda \cdot f = v_{sound} = 344\ {}^{m}\!/_{s} + \frac{1}{3}\ {}^{m}\!/_{(s\cdot °F)} \cdot (T_F - 68°F)$$

Ch3 Sources of Sound

- **Frequency – wavelength relation for wave on string:** $v_{wave} = \sqrt{\frac{F}{M/L}}$

  $v_{wave} = \lambda \cdot f$ **,** $L = n\frac{\lambda}{2}$
  - $f_n = n\frac{1}{2L}\sqrt{\frac{F}{M/L}} = nf_1$**,** harmonic series: n = 1, 2, 3,…
- **Sound Production**
  - **Impetus**
  - **Tuning**
    - Construction
    - Pre-performance
    - Performance
  - **Amplification**

Lab 3 Vibrating String

- $f_n = n\frac{1}{2L}\sqrt{\frac{F}{M/L}} = nf_1$**;** Vary tension, F, and vary driving frequency, fn.

Ch4 Sound Propagation

- **Reflection**
  - Equal angle of incidence and reflection
  - Adsorption, Transmission
- **Rarefaction**
  - Different temperatures results in different speeds
- **Diffraction**
  - Angle of diffraction depends on ration of λ/D.
  - Larger ratio, diffracts more
- **Beats**

Lab 4 Resonance in tube & jug

- **Given frequency, different lengths meet the condition** L= (¼ + n/2)λ, n = 0,1,2,3…

- **Ch5 Sound Intensity and its Mesurement**
- $I = \frac{Power}{Area} = \frac{Energy}{Area \cdot time}$
- $\frac{I_2}{I_1} = \frac{Area_1}{Area_2} = \frac{r_1^2}{r_2^2}$ for same source & spherical propagation
- $\frac{I_2}{I_1} = \frac{Power_2}{Power_1}$ for same detector and different sources
- $S.I.L._2 - S.I.L._1 = 10dB \cdot \log\left(\frac{I_2}{I_1}\right)$

Lab 5 Diffraction and Attenuation

- $S.I.L._2 - S.I.L._1 = 20dB \cdot \log\left(\frac{r_1}{r_2}\right)$

Ch15 Room Acoustics

- **Listening Qualities**
  - Clarity
  - Uniformity
  - Envelopment
  - Reverberation
  - Free from Echoes
  - Performer satisfaction
  - Free from noise
- **Sound Components**
  - **Direct, early reflections, reverberation**
- **Reverberation time $T_r = T_{-60dB}$**
- $T_r = 0.16\, {}^{s}\!/_{m} \cdot \frac{Volume}{Area_{effective}}$

  $Area_{effective} = \alpha_1 A_1 + \alpha_2 A_2 + \ldots$

Speed of sound in air

1) (10 points) Feeling stir crazy, you decide to bust out of Redlands. Say you go to watch a professional Baseball game. It's a pleasant 73.4 °F = 23 °C. You're about 200 m from home plate (in the cheap seats). How long does it take the sound of bat striking ball to reach you?

Pressure

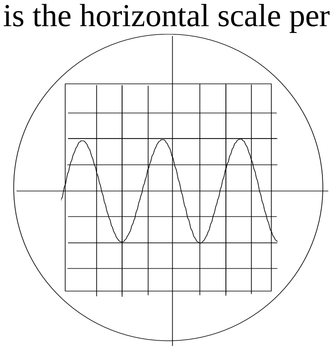
2) The Threshold of Pain is about 2 N/m^2 at 1 kHz. If your eardrum has an area of about 0.8 cm^2, what is the force, in N's? (To understand just how sensitive the eardrum is, an apple weighs about 1 N).

wavelength and frequency

3) The range of frequencies that we can hear is roughly 20 Hz to 20,000 Hz. So if the speaking length of a C_5 (f = 524 Hz) is 30 cm, then what would be the speaking length of the shortest useful pipe?

Reading oscilloscope, frequency & period

4) (8 points) Imagine you are back in lab and you hold an E 659Hz tuning fork up to the microphone, that is plugged into the oscilloscope. It produces this picture. Roughly, what is the horizontal scale per division?



Standing Waves on a String

Say a middle C (f = 261.6 Hz) piano string has $m/L = 7 \times 10^{-3}$ kg/m and is tightened with F = 100 lbs = 462 kg $*m/s^2$. Based upon these values, about how long is the middle C string?

Reverberation Time

Your group is setting-up in a studio to record an album. You'll record a wide range of pieces; there are some intimate ones, traditionally performed in the parlors of private homes, and there are some written for concert hall performance. You'd like the recording to suggest the appropriate environments for the different pieces. What effect might the engineer adjust to achieve this; in which case would you want more and in which case less?

SIL & The Inverse Square Law

Say you're performing in an acoustically dead studio (negligible reflected sound).
How much lower is the SIL about 10 m away than just beyond your instrument (say 0.25 m)?

If a SIL detector is set up near your instrument, and it reads 80 dB, what is the intensity (in W/m^2) at this point?

beats

(8 points) Consider the complex, combined motion of the second, minute, and hour hands of a clock? With what frequency do the second and minute hands align?

Room Acoustics

Given the dimensions and materials of a room, be able to approximate the reverberation time. More qualitatively, be able to discuss how redesigning a space in different ways (changing materials, changing dimensions, changing orientations of surfaces) change the listening qualities (uniformity, clarity, envelopment,…)

Propagation Effects

Be familiar with sound's *reflection, refraction,* and *diffraction.*