

Wabash College
Department of Physics
Acoustics of Musical Instruments (PHY-104)

Term: Spring 2011; TTh ~~8:00am~~

Location: Goodrich 104/201

Instructor: Dr. Martin John Madsen

Office: Goodrich 309

Email: madsenm@wabash.edu

8:15am - 9:30am

Class 1: Course Introduction

The main goal for the class is to learn about how musical instruments produce sound and how the sound travels to a listener. You will learn about different types of sounds, how they are produced, and how they relate to musical instruments. This course is a co-requisite for Music 202. I hope that you can apply the things you learn from this class to that and vice versa.

Course Format and Procedure

The course format will consist of two distinct activities. We will discuss concepts and models as a class on Tuesdays. We will also play the Sound Project game Tuesday mornings (see below). We will meet on Thursdays in the lab where we will get hands-on experience working with the ideas presented on Tuesdays.

Textbook and Reading

Musical Acoustics, 3rd edition, Author: Donald E. Hall

Although this text is not required for the course, it will be the primary source. I will follow many of the chapters pretty closely in describing concepts on Tuesdays. You are welcome to read ahead or follow along if you choose to purchase the book. I recommend that students serious about designing and developing instruments purchase and study the book- it is a very good introduction to acoustics. Those of you that are interested in acoustics, but not in purchasing the book, might consider renting it.

Tuesdays

On Tuesdays we will work on the following:

1. Sound Project Presentations
2. Introduction to new material
3. Discussion of material, demonstrations, and questions
4. Prepare for Thursday activities

Thursdays

Thursdays will be mainly devoted to hands-on activities exploring the key concepts in acoustics. We will be doing a variety of activities including:

1. Collecting and analyzing data from a variety of instruments
2. Exploring physics models related to acoustics
3. Weekly in-class Quizzes (see below).

Attendance Policy

Your participation grade will be based on your attendance and participation. Because in-class activities are the major component of the course, **unexcused absences** will result in a 3% reduction of your **final grade** for each absence. Each **excused absence** must be made up with a 5 page paper reviewing the concepts and activities missed in the session. The other component of the participation grade will be based on your engagement in class. Students that are frequently asleep in class or not participating will do poorly on their participation grade.

Notebooks

Successful people keep an organized accounting of their work. You will need to purchase a 3-ring binder to organize the materials and notes from this course. I recommend a 3-ring binder with loose leaf paper because we will have a number of handouts and printouts from our work. You will need to keep them organized in your binder.

I will grade your notebooks every other week on Thursdays. I will grade your notebook based on the following items:

1. The notebook is neat and organized.
2. All course handouts are included (in numerical order).
3. Data from experiments has been printed out, labeled, and included in the notebook.
4. Every data printout has a brief description written on it describing the experiment and meaning of the data.

Sound Project

One team of 2-3 people (rotating around the class) will record 5 sounds due Tuesday morning before the start of class. Sounds must be original (not used previously in the semester- see the list on Moodle) and must NOT be created digitally (no computers, electronics, or any sound coming from a speaker). Do not label the sounds for what they are, rather label the files by group last names and a number. Take a picture of your sound producer so that you can show us what you did and how you made the sound. Each recording should be a minimum of 1 second long, a maximum of 30 seconds long. The idea is to record a single sound not a collection of sounds: i.e. record a single note played on a violin, not a violin duo playing a piece.

We will play the sounds at the start of class on Tuesday. Bonus points will be awarded for sounds that we cannot determine what they are, based on the recording. Sound Project grades will be tabulated as follows:

1. Did the group present 5 unique sounds?
2. Did the sounds fit into the time limits?
3. Were the sounds single (isolated) or were there multiple sounds playing together?

4. Was the recording high-quality (no background noises, pops, hisses, etc.)?
5. Did the team provide pictures of all 5 of their sound producers?
6. Was the class able to determine the source? Bonus points for stumping us!

Week 1 Sound Project

Let's play the Sound Project Game! I will go first. I will play each of the sounds and you guess what made them.

Your Guess	Actual Sound
1.	
2.	
3.	
4.	
5.	

Thursday Quizzes

There will not be any formal exams in this course. However, each Thursday I will give you a short, in-class quiz. If you regularly review your notebook and understand the material, you should do just fine on the quizzes.

Grading

Course grades will be determined by your total point score as follows:

- Participation: 40%
- Notebook: 20%
- Sound Project: 20%
- Quizzes: 20%

Anyone who receives 90% of the total points will receive at least an A-, 80% will receive at least a B-, etc.

Academic Support Services

Students with disabilities, whether physical, learning, or psychological, who believe they may need accommodations in this class, are encouraged to contact Academic Support Services as soon as possible to ensure that such accommodations are implemented in a timely fashion. Please meet with Julia Rosenberg (ext. 6024) to verify your eligibility for any classroom accommodations and for academic assistance related to your disability. You may also discuss your disability with the professor if you wish. All discussions will remain confidential.

If you have a hidden or visible disability which may require classroom or test accommodations, please see me as soon as possible during a scheduled office hour. If you have not already done so, please visit

Academic Support Services (Armory 101) which is responsible for coordinating accommodations and services for students with disabilities.

Emergency Procedures

In case of a fire, we are to proceed from the classroom out the nearest exit and toward the Chapel. You should join the instructor and the class at the Chapel to make sure that everyone got out of the building ok. In the event of a severe weather storm, we are to proceed to the basement and shelter in the basement hallway.

Now on to Acoustics!

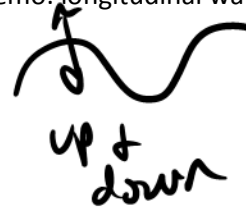
Sound Waves


Hall, Chapter 1

What is a wave?

Motion of patterns - continuous
 ↳ not particles - displacement

What are different types of waves? (Demo: longitudinal waves)

Transverse →  wave → spring/string

Longitudinal →  wave

Measuring Waves

How do we measure sound waves? (Demo: vortex canon)

Pressure changes → Sound = change in air pressure

What does a microphone do? (Demo: microphone and oscilloscope)

Measures changes in sound pressure

General Sound Classifications

Hall, Chapter 3

Sounds can be classified as being either in the first column or the second column for each row. For example, sound produced by striking a timpani drum is Natural, Original, Transient, with Clear tone.

Natural	Artificial
Original	Reproduced
Transient	Steady
Clear tone	No clear tone

Sounds are also classified as being at some point along a range from the first column to the second column. A timpani drum struck hard could be closer to Loud and typically has a Low pitch.

Loud	Soft
High pitch	Low pitch

Sound is created when a vibrating object sets the air around it vibrating. The vibrational wave then propagates outward as sound. Sound vibrations in musical instruments are created in one of the following ways. Note that the initial vibrations are often spread and amplified. At this point we are only interested in the cause of the initial vibrations.

Initial Vibration	Example
Membrane	Drum head
Metal	Bell
Wood	Xylophone
String	Guitar
Edgetone	Recorder
Reed	Clarinet
Lip	Trumpet
Vocal chord	Voice (singing)

Practice

Let's practice classifying the Sound Project game sounds I presented today.

Sound	Classification
1. Mongol bell	natural, original, transient, clear tone, loud, high pitch, metal
2. Tibetan bowl	natural, original, steady, clear tone, soft, high pitch, metal
3. Floor vibration	" " , transient, not clear, loud, low, wood
4. metal door	" " , transient, not clear, quiet, high pitch, metal
5. furnace	" " , steady, not clear, loud, low pitch, ?

edgetone?