Nick Bitzis

Measurement of Room Reverberation Time Using The ISO 3382 Standard

ECE 602 - Engineering Acoustics
Project 2
Partners: Brian Manolovitz

Project Description

Brief:

"The reverberant properties of a room have strong influence on the sound pressure level from noise sources, the intelligibility of speech, the perception of privacy and the quality of musical performance, and it can be used to determine the correction for room absorption and insulation. Reverberation time is defined as the time it takes the space-averaged sound energy density to decrease by 60 dB after source activity has stopped. The goal is to measure the reverberation time of an unoccupied regular room at the University of Miami. The method will follow the ISO 3382-2 (2008) standard provided in the course notes on Blackboard. The volume of the selected room must be at least 300 m3 (medium to large room.)"

Our Procedure:

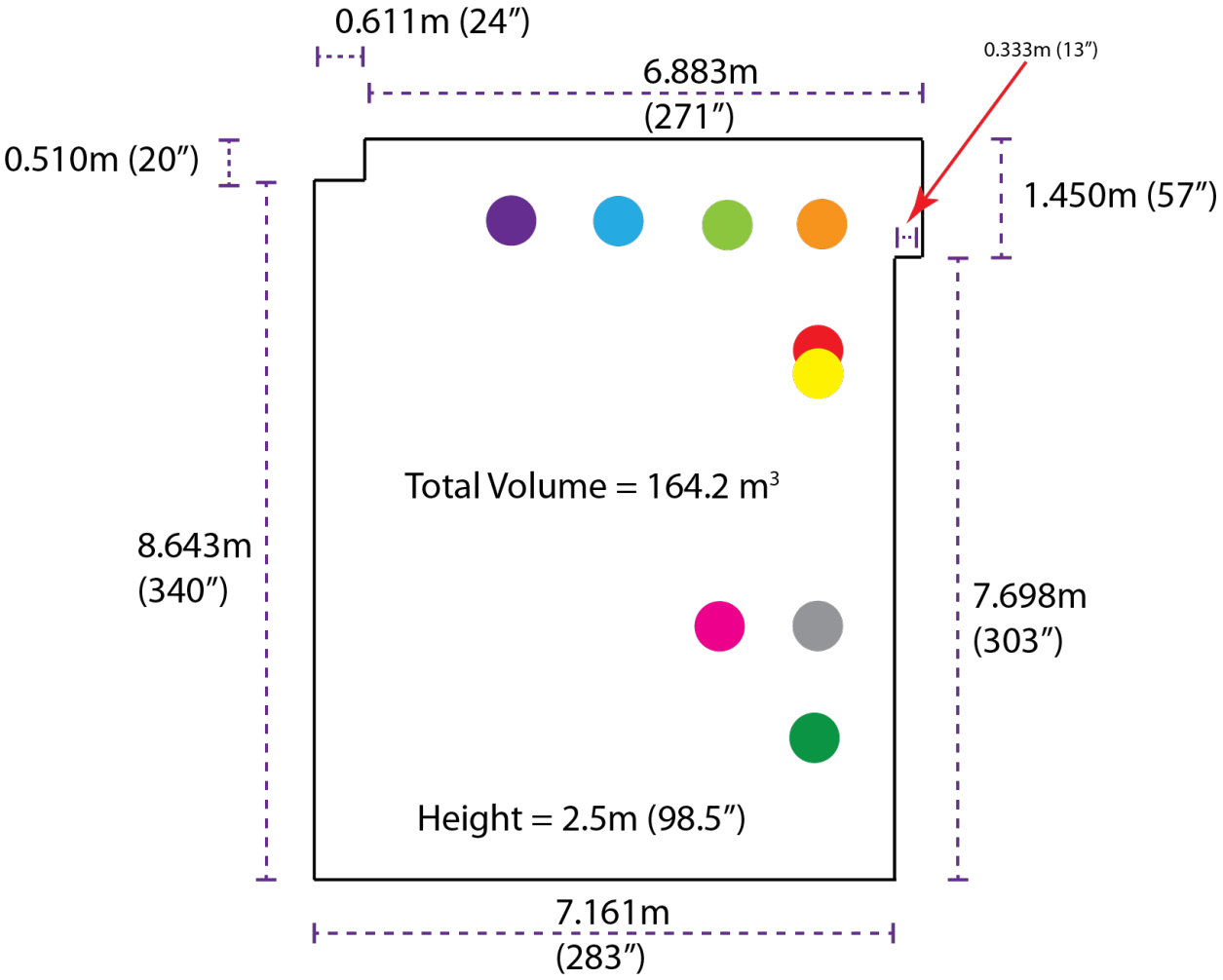
To accomplish the tasks required for this project, we will be measuring the reverberation time, commonly referred to as "T60 or RT60", of our lecture classroom, the Dooly Memorial Building Room 109. We will be using the ISO 3382- 2 (2008) standard, which defines T60 as the time it takes for a noise to drop 60 dB.

Our procedure includes making use of a room excitation, in our case, popping a balloon. To properly approximate the room's response to the excitation, we selected 9 source-microphone combinations, with located sources at least 1 m from any surface and microphone at least 3 m from source on a tripod. Additionally we avoided symmetric positions to avoid redundancy in our recording. We used 16 bit precision and a sampling rate of 44.1 kHz.

In order to properly average the results, we superimposed the amplitude normalized and time synchronized traces of the squared sound pressure recording and computed the average sound energy decay waveform. Because it was difficult for us to record T60, we used linear regression to model the decay curve and determine T20 and T30 of the averaged sound decay waveform so that we could extrapolate T60.

Lastly, we simulated the standard octave bands using a Fourier analysis (FFT) in Matlab, thereby computing the average sound energy decay waveform corresponding to each octave band. We then used linear regression, once more, to model the decay curve and determine T20 and T30 and calculate T60 for each octave band.

Room Layout



Trial	X	Y	Z
1	2	1	1
2	3	1	1
3	4	1	1
4	5	1	1
5	5	2.5	1
6	5	2.5	1
7	5	6	1
8	5	7	1
9	4	6	2

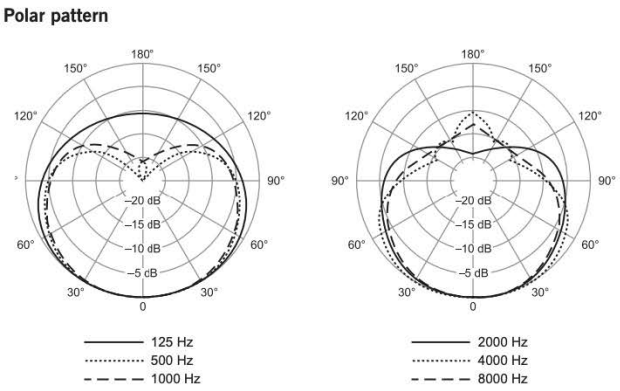
This table shows the location of the mic set during each recording. The top left of the room is (0m, 0m).

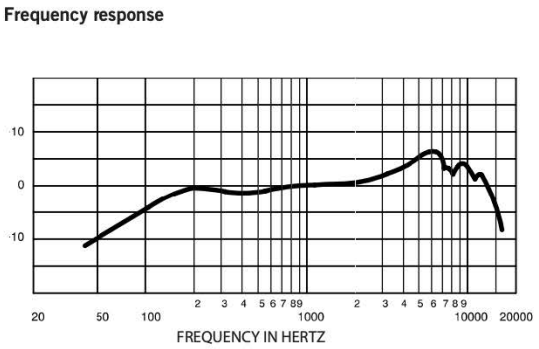
Dooly Memorial Building Room 109 is a primarily shoe-box shaped room. It has 29 free standing student desks and a large podium style desk in the front of the classroom; all desks appear to constructed of mostly wood and some metal. The walls are constructed of painted dry wall on 3 sides, with one wall made mostly of glass windows with metal framing on the fourth side starting at approximately 1m off the ground. A large paneled white board is on the front wall of the room. Other than the three people performing the tests, the class room was unoccupied at the time of testing. The room was approximately 20° Celsius (68° F), with 70% humidity on the day of testing (Nov. 30th).

The sound source used to generate the impulse was a balloon, due to logical campus constraints limiting cap-guns. The popped balloon, however, was an adequate room excitation to capture an impulse. The balloons were popped in the same location on a desk located in the middle of the room for all nine trials.

Recording

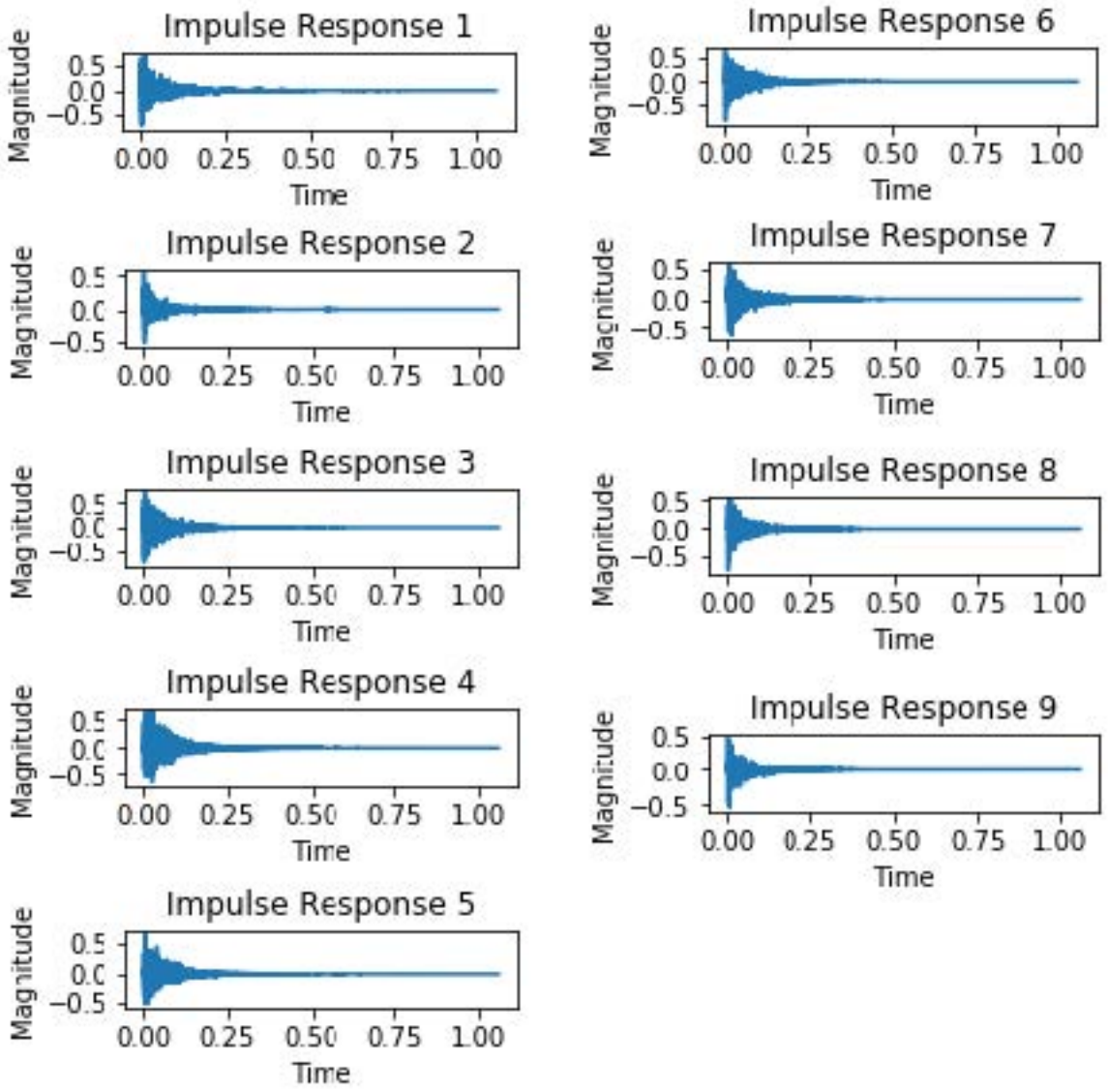
The nine test impulses where recorded by two Shure SM57s pointing in opposing directions (one facing up and one facing downward), which were acquired with the help of our classmate Josh Stoller. They were held next each other in order to approximate a 360° polar pattern. No microphone can handle this on its own, thus the need for two identical recording microphones. The Shure SM57 is an industry standard microphone utilized for its reliability and durability. It is a dynamic cardioid mic with a frequency response from 40 to 15,000 Hz. Signals from both mics where recorded into a borrowed Focusrite Scarlett 2i2 audio interface connected to a MacBook Pro running Ableton Live 9.5. They were recorded at as 16-bit .WAV files with a sampling frequency of 44100Hz. Below is a graphic representation of the mic's polar pattern and frequency response, as well as a simplified representation of our setup.





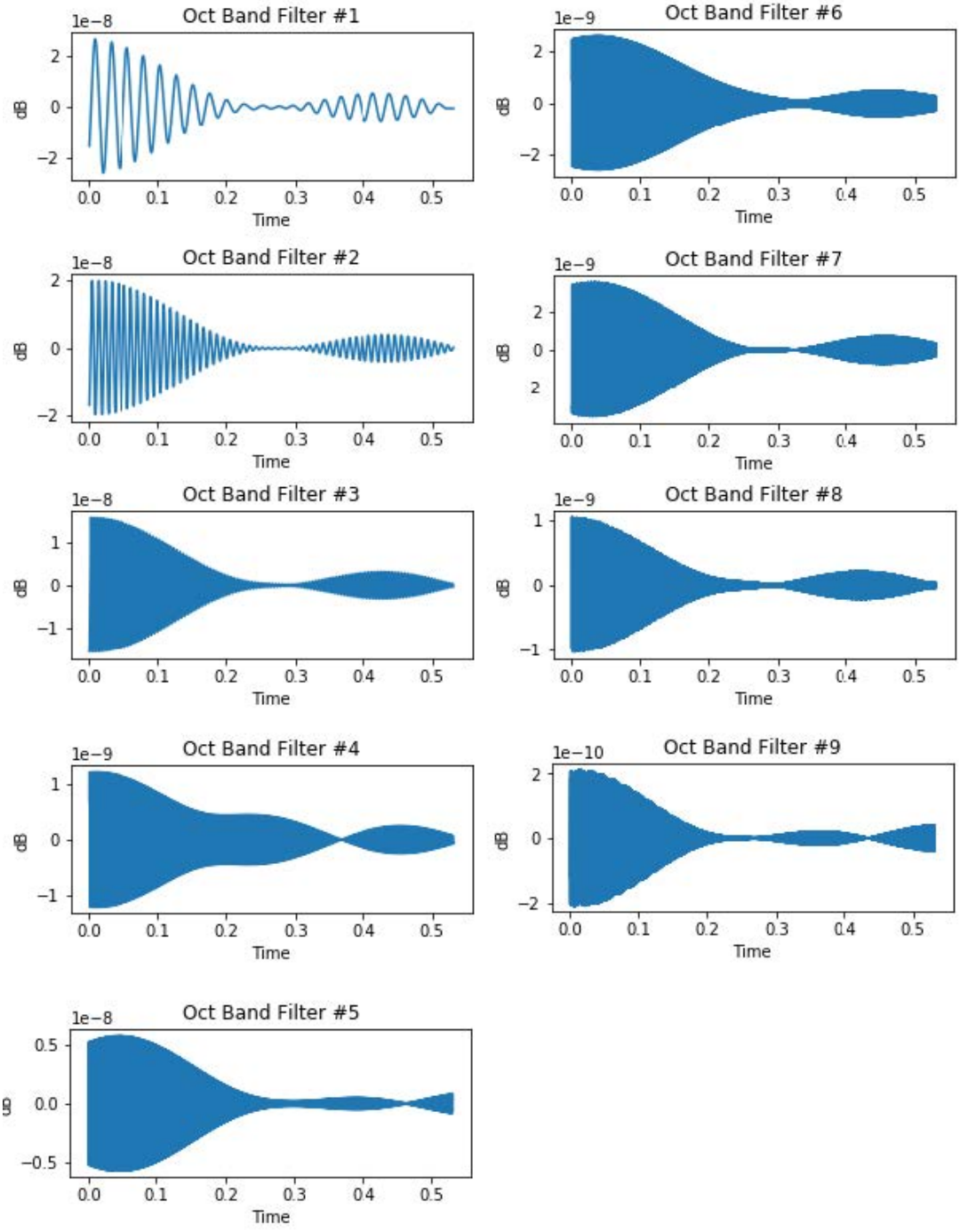


Measurements

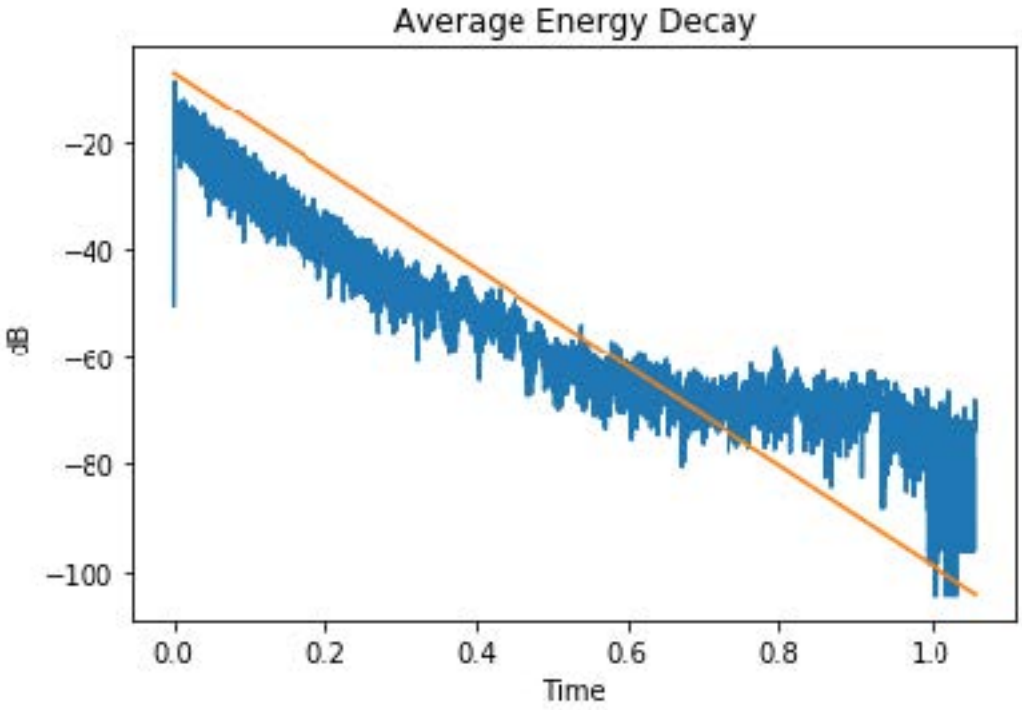


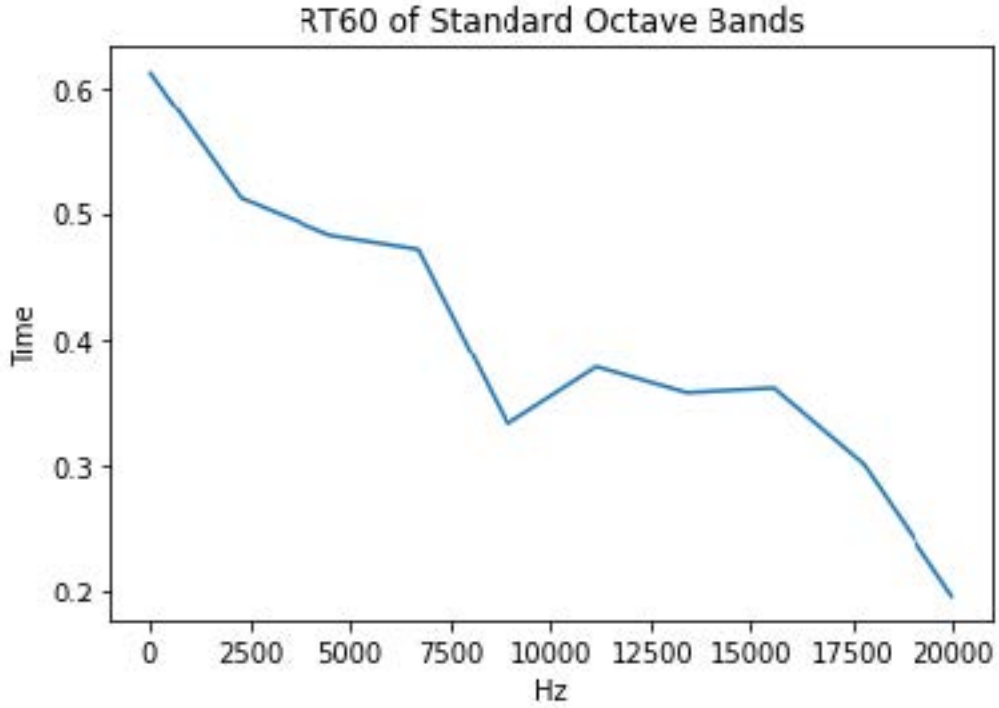
Measurements were taken on Wednesday, November 28, 2018 in the Dooly Memorial Building Room 109 from 9 source-microphone combinations.

Measurements (cont.)



Measurements (cont.)





Conclusion

In conclusion, this project gave an excellent look into the real-world application of the concepts and theories that we learned over the course of the semester and especially in Unit 3. Over the course of this project, we took a look at the room reverberation time of an average classroom in Dooly Memorial Room 109 at the University of Miami using the ISO 3382 Standard. By popping a balloon repeatedly, we were able to calculate T60 with the given impulse, through the use of two opposing Shure SM57 microphones. Once the recorded impulses were filtered into the different octave bands, the average energy decay and the T60 was simple to calculate.

By utilizing the calculated T60 that we found, we were able to approximate the reverberation response of the very same classroom where we conducted the class. With relatively simple recording techniques, a low-tech impulse (popping a balloon), and the use of MATLAB, we were able to understand the acoustics of a room the same way that professionals in the industry would. Our methods were not perfect by any means, but I feel we can accurately represent the room with the data we collected and the calculations made. Ideally, if we were to conduct the experiment again, I would recommend the use of an omnidirectional microphone to limit an discrepancies when averaging the impulse recordings done with the mic pair. Lastly I would also like to use a slightly more consistent impulse if possible, however, the balloon was certainly suitable for the accuracy level necessary for our report. All in all, I would say this was a project that turned out nicely in terms of execution and results, as well as offered a great deal of practical experience.

Citations

- Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements, Copyright by ASTM Int'l (all rights reserved); Wed Nov 4 12:16:01 EST 2015
- “Instrument Microphone | SM57 | User Guides | Shure Publications.” Shure Publications | User Guides | KSM313, SHURE, pubs.shure.com/guide/SM57/en-US.