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Sinusoidal Tones as an Acoustical Measuring of a College Auditorium and Recording Studios

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Abstract

Acoustical measurements in college auditorium were carried out using an empirical version of Sweep Sinusoidal Response given satisfactory results from a previous study. The measures took place where typically the audience seats. The same sort of measures were also carried out in two more rooms. Sinusoidal techniques can be used as a standard for this sort of measurements. And the rooms measured can be more efficiently used for live acts or recording productions.

Keywords: *Sinusoidal acoustical measurements, room acoustics, live rooms, recording environments.*

1. Introduction

Auditoriums and performing venues need a good acoustical environment for the audience to have a better understating and enjoyment pf the performance. More than often, changes on its walls, floors, and ceilings are needed. Following previous works on acoustical measurements (Alonso & Franco-Galván, 2022) and (Franco-Galván et al., 2023), researchers in the Department of Arts (Facultad deArtes) at the Autonomous University of Puebla BUAP, Mexico decided to study the acoustical response of the *Auditorio Cuicacalco.*

An experiment was carried out where amplitude was measured at different frequencies (80, 250, and 1500 Hz). The first stage was measured on strategic sites in the auditorium. Such data were obtained by checking the amplitude of sine waves played back at the frequencies.

The document is organized as follows: After this introduction, section 2 describes the background in this sort of experiments. Section 3 describes the room to be measured. Section 4 contains the experiment procedure. The experiment results are described in section 5 and section 6 discusses the conclusions.

2. Background

Measuring the acoustical response of a building has become a standard in building industry, recently (Tenutta et al., 2019) used this technique to refurbish audiometer cabins. The same technique was applied in the construction of a university auditorium (SALVADOR GIL SANCHIS, 2020). A similar method was used during the remodeling of public auditoriums in Valencia, Spain (Javier & Guzmán, 2020).

Among the different techniques to measure acoustical responses, the Sweep Sinusoidal is one of the most notorious ones (Bjor & Nikolic, 2004) It is based on directly obtaining the venue´s impulse response which is necessary to know the reverberation time at different frequencies.

The current text documents an experiment, in which, the authors used a method based on Sweep Sinusoidal technique. The main difference is that three discrete points in frequency instead of using a continuous sinusoidal wave. This method was applied in a previous study (Alonso & Franco-Galván, 2022) when investigating the acoustic response of an auditorium, not particularly different to the one used on the present study. In this case frequencies at 80, 250, and 1500 Hz were chosen to measure the sinusoidal response. The choice of frequencies is based on their importance in the human hearing range.

3. Room Description

The room to measure is an auditorium which is part of the Benemérita Universidad Autónoma de Puebla. It is in the city center in 8 oriente 406, where a building from the XVII century hosts part of the music department.

The auditorium is 20.7 m long and 5.5 m wide. The ceiling consists of three domes, the walls are a mixture of cement and rock, they are about 50 cm thick. The floor is covered with ceramic tiles and chairs are spread in a 15x4 m area. There is

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a stage of 6 x 5.5 m with wooden floor where normally musical performances take place.

4. Procedure

The proposed method for sound measuring is the following: Set a sound source, which is placed at the center of the stage, producing a sine wave at three frequencies (80, 250, and 1500 Hz). Its amplitude was measured using a SPL-meter at different distances from the source 5, 8.5 and 15 meters, which are the distances where usually the audience seats from the stage when attending an event in that room.

The measuring spots A, B, and C are shown in figure 1, the sound source was a Bose Soundlink speaker and the meter used is a D525 RadioShack Sound meter.

5. Obtained Results

The resulting data measured in the auditorium can be seen in table 1. Frequencies at 80 Hz are considerably attenuated by 10 dB if compared to high frequencies at 15000 Hz. This situation happens in all the room. It might be of little importance considering that such frequencies are not the most relevant when listening to music or speech. In a previous study measuring in another room, similar size and conditions to the current auditorium (Franco, et. al., 2022) those frequencies around 80 were also elusive even after conditioning the building with anti-reflective materials. Something found in a previous study to measure a recording studio acoustic response (Franco-Galván et al., 2023) was that: the only way to preserve 80 Hz frequencies over 80 dB was using a bass-trap.

High frequencies at 1500 Hz can be well appreciated since anywhere in the auditorium they attain over 80 dB. In practice, these frequencies are not the strongest in either music or speech, most of them consist of harmonics in voice and instruments.

Middle Frequencies at 250 Hz are around 80 dB from the first two measuring points. At point C which is the farthest from stage, they decrease 10 dB.

Measuring Point A. Distance (5 m)	
80 Hz	73
250 Hz	81
1500 Hz	82
Measuring Point B. Distance (8.5 m)	
80 Hz	70
250 Hz	81
1500 Hz	82
Measuring Point C. Distance (15.83 m)	
80 Hz	70
250 Hz	72
1500 Hz	86

Table 1 "Obtained Data in three measuring points"

Results in Table 1 can be graphically reviewed in Figure 3. Should the reader need a visual perspective on where the main power of the different sound waves at the established frequencies, figure 2 offers a color representation. Such images were obtained using a sound wave spread simulation software, therefore they represent an approximation of the physical results. Spots in Red show where the sound is stronger, yellow areas where it becomes weaker, and green and blue areas show where it is weakest.

Acoustical response of two more rooms in the same building was obtained using the method here described, using the same frequencies. One of them was a small room of 20 x 5 m and a dace studio of 50 x 10 m. Both rooms will be used as recording studios. Their acoustical responses are shown in figures 4 and 5 respectively.

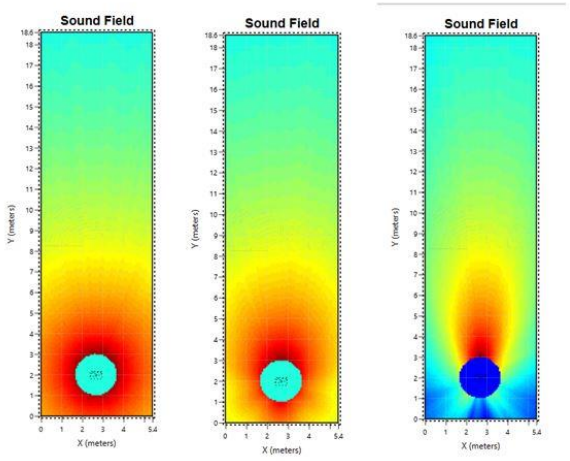

Figure 2 "Color Representation of Soundwave energy. The pictures correspond respectively to 80, 250, and 1500 Hz"

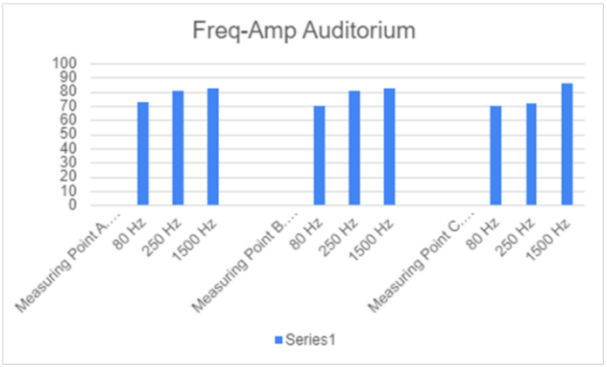

Figure 3. "Graphic Results in from data in Table 1"

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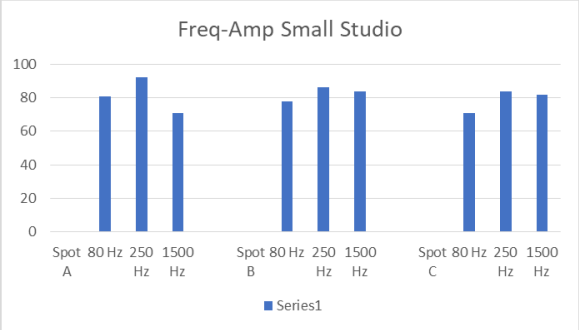

Figure 4 "Measures in Small Recording Studio"

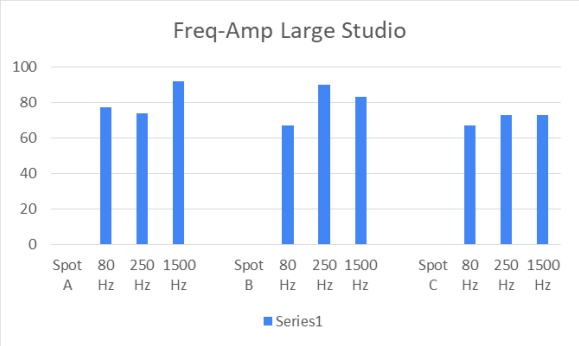

Figure 5 "Acoustical Response in Dance Studio"

6. Final Discussion

The ultimate effectiveness of the values here shown relates directly to human sound perception. This evaluation demonstrates the strength of certain sounds within the auditorium but that does not mean the building is not suitable to perform music or speech that is rich in low and medium frequencies.

A problem to address in the future are the three domes that conform the ceiling. They produce large reverberations and make difficult to understand speech. Therefore, conferences and other events related to oratory will be better heard in different venues of the music department.

The acoustical response found in the smaller room shows that the room is suitable for recording music as figure 4 shows is more stable in medium and high frequencies, particularly on the back side of the room. The measurements taken in the Dance studio show large response o medium and high frequencies on the back side of the room but poor low frequency response. The room in question will be used for recording live performances in audio and video, high quality sound capture is not sought for.

The sinusoidal method here used will be applied in further venues in the university´s music department to document acoustical response of all the stages where music is produced for either live events or recording productions.

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