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# Effect of air volume in musical drums on the quality of sound produced

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## ABSTRACT

**Aim:** ***To find if there is any correlation between the quality of sound produced and the volume of air present in the membranophones.***
**Materials and methods:** ***The experiment was conducted in an anechoic room with proper sound insulation. The drums were placed on the stands and were marked with a circle of radius 3 cm for accuracy of strikes. In total 15 strokes were recorded to decrease the uncertainty in the force. The data was recorded through a microphone and transferred to a system. The data were analysed and plotted using Audacity's in-built function.***
**Results and conclusion:** ***With an increase in the depth, the air has more room to move around and when a sound is produced, the increased volume allows the air to lose energy easily to the surrounds and maybe clash around with each other to decrease its frequency and producing multiple unique sounds at the same time.***

***Keywords***— *Membranophones, Sound, Drum*

## 1. INTRODUCTION

Music is considered as a food for the soul that rejuvenates it and fills it with energy and vitality. Howbeit, scientifically music is analysed based on a variety of its elements, including pitch, timbre, volume, texture, duration and form. It can be vocal, instrumental or a combination of both in a manner that produces the beauty of form, harmony, and expression of emotion. Amongst instrument, percussion instruments are probably the oldest musical instruments in the world. Unequivocally, instrumental music has played an essential part in the cultural richness of ancient India. Numerous references to the instruments of various kinds have been made in Sanskrit literature [1].

There are innumerable instruments in the percussion family. They can be classified into four subgroups as idiophones, membranophones, aerophones and chordophones [2]. Alternatively, they are divided into instruments having a definite pitch and those that do not possess any definite pitch. Membranophones, more commonly known as drums, are universal musical instruments [2]. There are more than 1500 entries in the New Grove Dictionary of Musical Instruments for drums alone [3].

The quality of sound is dependent on different factors like the type of membrane in the drums, diameter and depth of the drums and the amount of tension given [4]. Drumhead must be tightened to produce the same tone when struck in different places. The top head and bottom heads are also tuned to different tensions. If both the top and bottom heads are given the same tension, the musical tone is sustained for long, but the volume is low [5].

We hereby speculate that the quality of sound produced might change with change in the air volume in closed drums keeping other variables constant. We aim to find if there is any correlation between the quality of sound produced and the volume of air present in the membranophones.

## 2. MECHANISM OF SOUND PRODUCTION

When the head of the drum is struck with sticks, the membrane on it changes its shape and compresses the air inside the drum. This compressed air from the top presses against the bottom head and changes its shape. Again, from the bottom, it hits the walls of the drum and reflected. This action is repeated and again producing a vibration which finally becomes sound [6]. The tone of the drum will change depending on where the drum is struck so it needs uniform tightness of the head in order to produce uniformity wherever the head is struck.

Both membranes of the head and bottom should be tuned to different tensions. Same tension will make the tone long with low volume. If the tension in the bottom head is tighter than the top head, then the tone becomes longer and louder. However, if the bottom head is looser, the tone does not ring so long, and the tone is flatter [5]. We decided to take tension as a constant using a method mentioned later, as including tension would complicate this experiment and tension can be studied in a different experiment as our current topic is only related to the volume of air.

Drummers use drums of different diameters and depths in order to match the style of music they perform. The reason behind the selection of variable size is the quality of tone they produce when drums are struck. The tone sustains (ringing of drum), and projection (strength of sound) of a drum is affected by the shape of the shells of the drum. Larger the diameter or the deeper the shell, the thicker and heavier the tone, and the smaller or shallower the shell, the brighter and lighter the tone is [4]. (Fig 1.1)

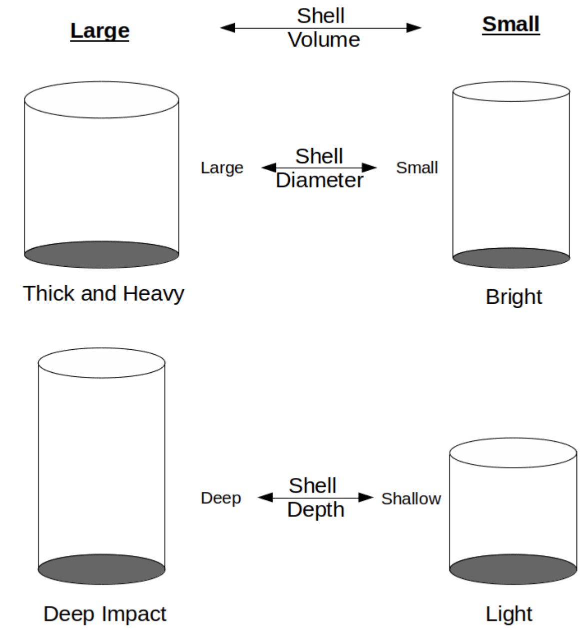


**Fig. 1.1: Shell characteristics affecting the tone**

## 3. QUALITIES OF SOUND

- **Pitch:** It is measured in units called hertz (Hz) which show the number of vibrations per second. It tells us the difference between a high sound and a low sound [9].
- **Duration:** It is measured in seconds (sec.). It tells for how long the sound wave lasts until it fades out. It helps to differentiate between a short sound and a long sound [10].
- **Amplitude:** It is measured in units called decibels (dB). It characterizes between a loud sound and a soft sound (commonly known as volume) [11].

## 4. AUDIO LINGO [7]

Before understanding sound and its nature, we need to understand basic words which audio engineer, as well as daily listeners of music, tend to use and need to be explored in relation to the visual representation of these set of words.

- **Warm–** A warm sound is considered as a sound whose frequency is between 60 Hz to 2000 kHz (Generalized into the lows and low mids). Sometimes this sound can be called a dull or a low sound if it is in the around 60Hz.
- **Cool–** A cool sound is a sound with a frequency between 2000 kHz to 4000 kHz (Generalized into the mids and high-mids). Sometimes this sound can also be called a bright or a joyful sound.

## 5. CONSTRUCTION OF A DRUM

A drum in a basic drum kit used in music production and in live performances is, generally, made of wood while the drumhead choice can differ from person to person. The most common material used, though, is polyethene terephthalate [8]. As we are limited to a wood-based drum kit with a polyethylene terephthalate surface, we will have to narrow down our research based on these conditions.

## 6. RESONANT FREQUENCY [12]

Resonance is the phenomena when the tension of both, the upper and the lower head, are the same [5]. The resonant frequency is the frequency which a sound tries to achieve when it is produced but sometimes is unable to because of natural damping (caused by air). It presents us with a unique frequency which dominates other frequencies and can be heard very distinctly. Hence resonant frequency is what we will try to determine through this experiment.

## 7. CONTROLLING TENSION

To make sure tension wasn't a variable which wasn't under control, we utilized a basic method to control tension. Using a thin layer of fine plastic, we covered the drum and made sure that there wasn't any air between the plastic and the drum. By pouring droplets of water onto the plastic, we examined whether the droplets moved towards the centre. To control the tension, we kept on repeating this process until the droplets remained at their original position. To make sure that the friction from the plastic wasn't hindering with this, we specifically used a refined layer of plastics which is used in shrink wrapping. The use of plastic was necessary to make sure that water didn't make the membrane moist or hinder with the readings in any form. This process was repeated for both the membranes of each drum.

## 8. FORCE OF STRIKE AND AREA OF STRIKE

The force applied in every drum hit affects the initial pitch of the sound alongside an increase in the amplitude of the sound, but the sound always tends to settle around the resonant frequency. So, an increase in the strike force will not change our reading drastically. Whereas, the area of the strike of the force will affect our reading intensely. As a drum stroke moves away from the centre of the drum itself, the frequency starts to increase because of a decrease in the tension of the membrane. Therefore, to control this possible human error, the hits were directed towards the centre of the circle. The drum was marked with a circle of radius 3 cm to make the hit as precise and accurate as humanly possible while maintaining the same force.


## 9. EQUIPMENT USED

Drums with following dimensions (in Inches):

| Name | Diameter | Height |
|---|---|---|
| High Tom | 10” | 7” |
| Mid Tom | 12” | 8” |
| Floor Tom | 16” | 15” |
| Snare Drum | 14” | 5” |

- A pair of drumsticks
- A stand to hold the drums in the air

 

- An Anechoic Room
- A microphone (with a large range of measurable frequencies)
- Software to analyse the data (Audacity)
- A microphone

## 10. METHODOLOGY

The experiment was conducted in an anechoic room with proper sound insulation to make sure that the experiment wasn't affected by echo and noises produced outside the system. The drums were placed on the stands one by one and were marked with a circle of radius 3 cm to make sure that the strike was accurate and towards the centre. A drummer was asked to strike the drum with the same force in the circle marked on the drum. A total of 15 strokes were recorded to decrease the uncertainty in the force applied by the drummer. The data was recorded through a microphone and transferred to a system. Using Audacity's in-built function to figure out the dominating frequency, the data was analysed, and the results were plotted. Due to limitations on the number of drums, the date was only recorded for 4 drums and the results were plotted.

## 11. RESULTS

### a) SNARE

The spectrogram of the snare drum in Fig. 2.1 depicts the nature of the sound produced by the snare drum. The X-axis plots time while the Y-axis plots frequencies in the spectrogram while the X-axis plots frequencies and the Y-axis plots the amplitude of the sound in the second figure. The white area symbolizes the loudest frequencies followed by red and then magenta. The strip of white near the value of 170Hz supported by Fig 2.2 demonstrates that the resonant frequency was near about 170 Hz. Notice the curve before the resonant frequency, it appears to be very steep and a trend can be discovered in the volume of the air inside which is discussed later.

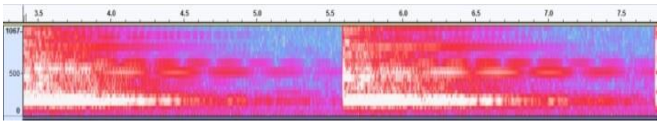

**Fig. 2.1: Snare drum spectrogram**

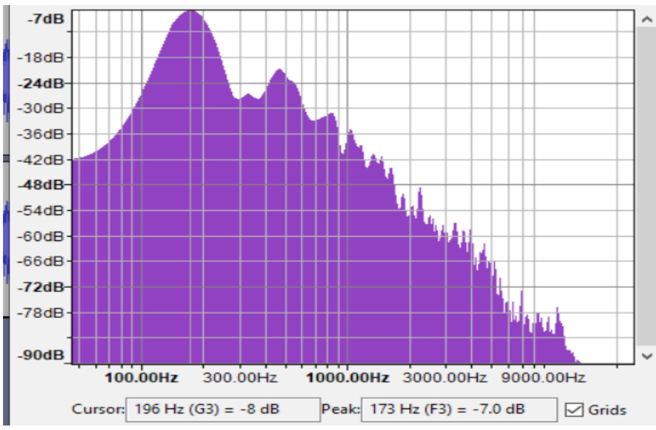


**Fig. 2.2: Resonance-frequency graph**

### b) HIGH TOM

The High Tom displays less white in Fig 3.1 compared to Fig 2.1, which indicates another trend which will be discussed later.

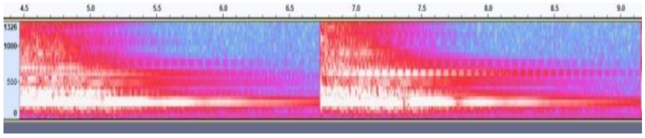

**Fig. 3.1: High tom spectrogram**

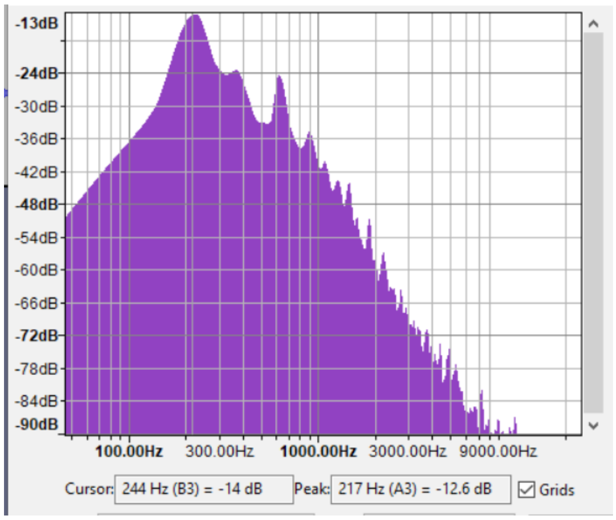


**Fig. 3.2: Resonance-frequency graph**

### c) MID TOM

The mid tom displays an increase in the white and determining a resonant frequency is difficult with an increase in the volume of air. Even in Fig 4.2 the graph before the resonant frequency appears to be less steep and is about to meet the resonant frequency.

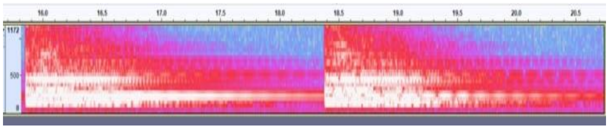

**Fig. 4.1: Mid tom spectrogram**

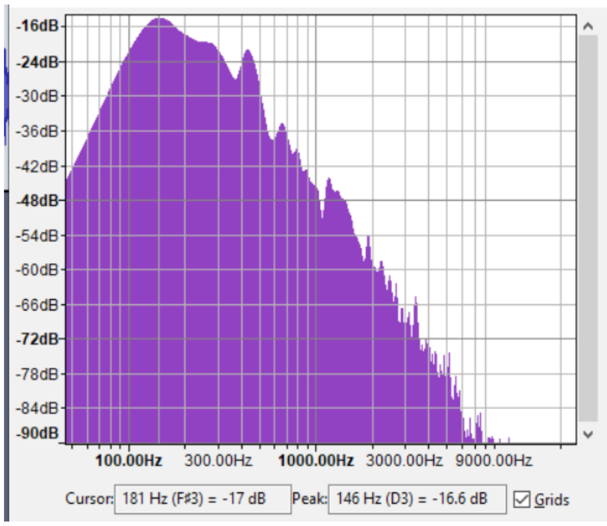


**Fig. 4.2: Resonance-frequency graph**

### d) FLOOR TOM

The resonant frequency is impossible to determine as there is no distinct or unique frequency which dominates the others (Fig 5.1) Hence, the floor tom has a quality which will be discussed later.

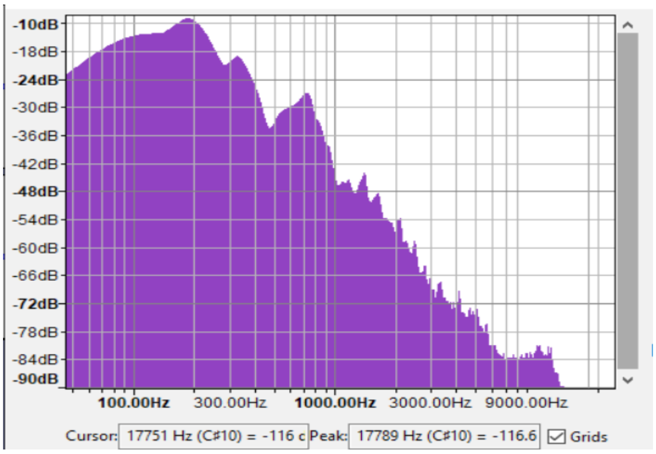


**Fig. 5.1: Resonance-frequency graph**

## 12. TRENDS DISCOVERED

With an increase in the size of the drum, the resonant frequency tends to merge with the frequencies below it and hence, deducing a specific frequency becomes impossible. Hence, the sound produced is warmer and feels full because of the number of frequencies with a similar amplitude as the resonant frequency. The gradual increase in the lows can be seen from drum to drum and the decrease in the slope and increase in amplitude is very visible. This gives a valid explanation to the difference seen in the levels of the white present in spectrograms across different frequencies. From this observation, it can be deduced that the smaller the drum is, the sharper the sound is. The possible explanation for such a phenomenon is the increase in the depth of the drum. With an increase in the depth, the air has more room to move around and when a sound is produced, the increased volume allows the air to lose energy easily to the surrounds and maybe clash around with each other to decrease its frequency and producing multiple unique sounds at the same time.

## 13. RESULTS OF RESONANT FREQUENCY

The resonant frequency showed a clear trend of increase in frequency with a decrease in the volume of air.

| Type of Drum | Average resonant Frequency / Hz | The volume of Air / Dm3 |
|---|---|---|
| High Tom | 217.73 | 9.010 |
| Snare | 172.33 | 12.613 |
| Mid Tom | 147.40 | 14.827 |

## 14. ERROR AND UNCERTAINITY

The possible areas of error are listed below with a possible solution for them:

The method used for controlling tension is very basic and has a lot of errors which can affect the flow of water like surface tension or viscosity. Hence a better method is required to control tension. The striking of the drum can include human error as the style of stroke used by a drummer can affect the sound produced. A possible solution for such an error is to use machines and a weight. The weight is dropped by the robot from a height and caught before it bounces for the second time on the drum.

The positioning of the microphone can also give rise to some uncertainty because of the echo. Hence, using an anechoic room is necessary but the room can't make echo non- existent. A possible solution for such an error is to use a small empty room with proper sound isolation to make echo negligible.

## 15. RAW DATA COLLECTED

**Table 1: Snare Drum**

| Frequency | Decibels |
|---|---|
| 172 | -8.1 |
| 173 | -7.0 |
| 172 | -7.4 |
| 172 | -6.6 |
| 172 | -6.3 |
| 173 | -6.2 |
| 172 | -5.9 |
| 172 | -6.8 |
| 172 | -6.0 |
| 173 | -7.1 |
| 172 | -7.2 |
| 172 | -7.4 |
| 172 | -7.1 |
| 173 | -6.0 |
| 173 | -5.9 |

**Table 2: High Drum**

| Frequency | Decibels |
|---|---|
| 216 | -17.7 |
| 217 | -11.8 |
| 216 | -12.8 |
| 218 | -11.8 |
| 219 | -11.9 |
| 218 | -10.3 |
| 218 | -11.4 |
| 218 | -10.9 |
| 218 | -10.7 |
| 218 | -11.5 |
| 219 | -11.6 |
| 218 | -12.2 |
| 217 | -12.4 |
| 219 | -11.5 |
| 217 | -11.6 |

**Table 3: Mid Drum**

| Frequency | Decibels |
|---|---|
| 145 | -17.5 |
| 148 | -16.3 |
| 145 | -16.9 |
| 145 | -16.5 |
| 146 | -16.6 |
| 149 | -16.8 |
| 149 | -16.4 |
| 148 | -15.8 |
| 149 | -16.5 |
| 147 | -16.1 |
| 149 | -17.0 |
| 147 | -15.8 |
| 146 | -15.7 |
| 150 | -15.8 |
| 148 | -16.2 |

 

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