'Music': What it means?

Introduction

Read following conversation between Rahi and her music teacher.

Teacher: For the annual programme, I need one person from your class to sing national anthem from the stage.

Rahi: All of us like our national anthem. So you can select anyone of us.

Teacher: True. But I will take an audition and select the student who can sing it 'properly'.

Rahi: What you mean by properly? All of us know the exact words of anthem.

Teacher: Yes. But you don't have to just 'recite' it, you should be able to 'sing' it.

Rahi: But all of us also know the tune of the national anthem. So all of us can sing it.

Teacher: Singing is not just knowing the tune. You should sing with exact 'सुर'.

Rahi: I know the seven सुर(Sur) . They are सा(Sa) , रे(Re), ग(Ga), म(M), प(P), ध(Dh), नी(Ni).

Teacher: Correct. Singing properly means each sound from your vocal chord should hit correct position of the respective सुर.

Rahi: Correct position? What is that? Are they standing somewhere?

Q1. What do you think the teacher is trying to say? Do you understand what she means by 'correct position'?

_____

_____

Q2. Let us take an example of a harmonium. You heard it just now. What did you notice?

_____

_____

_____

Q3. Do you know other examples or instruments where you can produce different sounds?

_____

You know from the science textbooks that sound is carried to us in form of some kind of waves.

Q4. When we say a uniformly moving 'wave' what all quantities would we need to describe it?

_____

_____

For the following tasks, we will need a smartphone. There are many smartphone apps which show you frequency of the sound played in the vicinity of the phone. We will use one of those apps.

Task 0 – Familiarization with the 'Aurdino Science Journal' app

We will be using 'Aurdino Science Journal' app throughout this LU to measure the frequency of different musical notes.

Here's how to use the app:

Aurdino Science Journal

1. Download from Play store (it's a free app)
2. Open the app. Click on the '+' (plus) sign on the bottom right, and it'll start a new experiment.
3. This will open an 'Untitled experiment' page. Use the pencil icon on top right to name your experiment and add description if you want.
4. Next you'll have to chose the sensor which will be used for the experiment. This can be done by clicking on the 'Sensors' button from the toolbar at the bottom of the screen.
5. Now you'll see the list of all sensors available on your phone. Choose the 3rd sensor which has the icon of a musical note. This will allow you to measure the frequency of the sound produced.
6. Now you are ready to begin the experiment. You'd be seeing a live graph with frequency on the y-axis and time on the x-axis. You can also look at the exact values of the frequency produced on the top right of the graph.

Note: This app is quite sensitive and it will pick up background noise as well.

Just to test the app, we will need some volunteers. Use a smartphone with permission of your teacher. One of you can try producing the sound 'AAA'(Hindi vowel 'आ') in an extended way and see what frequency gets displayed. Tell the frequency to the entire class and the pass the phone to next group.

Task 1 – Understanding the relation between different notes on a harmonium

Teacher will play different keys on Harmonium and you have to note frequency of those keys in the table below. For convenience, let us agree to a convention. On the harmonium, you will see a pair of black keys and then a set of three black keys. The white key just before the black pair (first key in the figure) will be called White 1 (W1).

Illustration 1: *Arrangement of black and white keys in a harmonium.*

As you proceed rightwards from this key, next key will be called Black 1 (B1), the next one is W2 and so on. Note that B3 comes after W4.

Note: Since the app shows you live data, it might be difficult to note down the relevant frequencies very quickly. Use the 'record' button to record the relevant part, save it and then use it later.

Once you are done playing the different सुर and done with the recording, open the recording and it'll show you the graph of the entire recording. You can zoom in and find out the frequency of the various सुर you played.

While noting down frequencies for each सुर, you may note only one digit after the decimal point.

Table 1: Frequency Table

Key	Freq.	Key	Freq.	Key	Freq.
W1		W8		W15	
B1		B6		B11	
W2		W9		W16	
B2		B7		B12	
W3		W10		W17	
W4		W11		W18	
B3		B8		B13	
W5		W12		W19	
B4		B9		B14	
W6		W13		W20	
B5		B10		B15	
W7		W14		W21	

Q5. Do you see any patterns or relationships among numbers in this frequency table? List them down and discuss with the class.

_____

_____

_____

Try finding out the ratios of 2 consecutive frequencies, for eg. B1/W1, W2/B1and so on.

Typical value of the ratio (r) is = _____

Let our first frequency (White 1) be f. Then second frequency (Black 1) will be f × r. Third freqeuncy (White 2) will be (f × r) × r = f × r^2.

In this notation, freqency of White 8 will be f × r.

Find ratio of the frequencies of White 1 and White 8. Ratio = _____

Hence value of r can be expressed as a power of 2 as _____

Task 2 – Understanding the seven सुर for any given scale

In the beginning, Rahi spoke about seven सुर in Indian music. Following table gives a relation between 'सुर' and harmonium keys (in a particular scale). Refer to the table above and note down the frequencies of these keys. Now find ratio of each frequency in this table with the frequency of the first key (W1). Note down the ratios as a fraction instead of converting them into decimals, as it'll be helpful later.

Table 2: Finding ratios

सुर	सा	रे	ग	म	प	ध	नी	सा
Key	W1	W2	W3	W4	W5	W6	W7	W8
Freq.								
Ratio	1							

Harmonium or piano uses pre-defined frequencies which are set to a fixed frequency ratio. This is called 'equi-tempered scale'. However, one may note that there are other ways of defining scale, which give almost same frequencies. Looking at the ratios obtained from the table above, one may notice that these ratios can also be expressed as fractions where both numerator and denominator are both integers less than 20. Write the ratios in that form.The sequence of ratio you get is known as 'Ptolemaic Sequence'.

Task 3 – Finding the frequency of seven सुर in any scale

Different scales in piano or harmonium just mean starting your first सुर at another key. Now suppose your first सुर (i.e. सा) is starting with B1 instead of W1. Use the ratios you found above and the table on the previous page, decide which keys will correspond to other सुर. Here B1 is taken just as an example, you may choose any other key instead of B1.

Table 3: Finding a different scale

सुर	सा	रे	ग	म	प	ध	नी	सा
Ratio								
Freq.								
Key	B1							

Play this sequence on harmonium to see if you get similar sequence of sounds as playing W1-W7.

Try to represent these ratios that you got by simple fractions, where the numerator and denominator are fairly small integers.

Usually when converting decimals to fractions, it is useful to look out for certain decimals: 0.125 = 1/8, 0.25 = 1/4, 0.75 = 3/4 , 0.33 = 1/3, 0.66 = 2/3, 0.5 =1/5 and so on. For eg. if one of the ratios is 1.12, then 0.12 is close to 0.125. So it can be fractionalized as 1 + 1/8 = 9/8.

Task 4 – Understanding Jaltarang

Have you heard the sound made by water while filling up a glass or a water bottle? The sound made by the vessel keeps changing as it gets filled. This tells us that we can adjust the frequency heard from a vessel by changing the amount of water level inside it.

Jaltarang literally means 'waves in water'. It is a traditional musical instrument used in Indian classical music. You might have seen Jaltarang being played by a musician. It is played by striking a set of bowls

which have varied amount of water in them, producing melodious music. Let us understand how it works and then make Jaltarang of our own.

Take ceramic/metallic/glass vessels of different kinds (bowls/beakers/measuring cylinders/drinking glasses) and a measuring cylinder.

Picture 1: *Setting up for Jaltarang*

Q1. Place the side by side and tap them with a pencil and note down the frequency in each case. Which bowl has the highest frequency?

Table 4

Description of the vessel	Frequency observed

Q2. Repeat the same exercise with a glass stirrer / rod. Is there any difference in the resulting frequency.

Table 5

Description of the vessel	Frequency observed

Q3. Now take the largest beaker, keep adding a fixed amount to water to it (say 25 ml each time) and note the frequency.

Table 6

Volume of water added	Frequency observed

Q4. What happens to the frequency as the volume of water increases?

_____

_____

_____

Q5. Is it possible to change the frequency of this bowl/beaker to match that of the smallest bowl/beaker and at what water level will that occur?

_____

_____

_____

Q6. What all parameters are important in deciding vibrating frequency of the beaker?

_____

_____

_____

Task 5 – Making of Jaltarang

Take a number of cups/glasses/bowls/small vessels (not just 7). Try out cups of different shapes, sizes and materials (metal, glass, ceramic). Strike them with a glass rod/stirrer/pen and note down their frequencies. Repeat the same procedure when it's almost full with water.

Table 7: Frequency of vessel when empty and filled

Description of the vessel (shape, material etc.)	Frequency observed (Hz)	
	Empty	Filled with water

As we have seen in the previous tasks, musical notes are multiples of base frequency. Using the range of frequencies available to you, choose your base सा. Note that your upper सा will have twice the frequency of your base सा, so make your decision wisely. Now using this base सा frequency and the ratios of the सुर you got previously, complete the table below:

Note: It might be helpful to number your vessels as 1,2,3... This will make it easier to identify them if all of them are similar.

Table 8: Setting up the Jaltarang

सुर	Frequency ratio (in fractional form)	Actual frequency after choosing your base सा	Which vessel can be used to play this frequency?	Amount of water in the vessel (Empty/partially full, almost full)
सा (Base)				
रे				
ग				
म				
प				
ध				
नी				
सा (Upper)				

The frequency table for your Jaltarang is ready!

Now using this table, arrange the vessel based on their सुर, and add water to them accordingly. Adjust the water level to get your desired frequency. To make minor adjustments in the frequency, you can use a dropper or a spoon to add or remove water in small quantities.

After you are done checking the frequency for each vessel, your Jaltarang is ready! As mentioned earlier, musical notes are just multiples of base frequencies. Strike the vessels in the musical octave order (base सा to upper सा) and listen to it. Does it 'sound' right?

Enjoy playing melodious music using your self made instrument!

Note: Do not keep Jaltarang for too long because frequencies will change as water evaporates, so you may have to retune it before using.