## Observing some sources of sound

Take a steel plate. Suspend it nimbly between your index finger and the thumb. If you have a heavy flat plate (e.g. a *tawaa*) which you can suspend by a string, you could use that. Strike it with a spoon. Pay attention to the sound and describe it later. Strike again and watch the plate carefully. Pay attention to the movement of the plate. You could also try touching it very gently. Then describe the motion of the plate.

Take a *dafli* or a *dhol*. Strike the membrane, and listen to the sound. Then later, observe the motion of the membrane like we did for the thali.

Take an *iktara* or a sonometer. Pluck or strike the string and listen to the sound. Then watch the string carefully and closely. You might want to use a hand lens to be able to see clearly. Describe the motion of the string.

Compare the above observations and describe and contrast the sounds produced in each case. Try to identify if there is anything common in the motion of the plate, the membrane and the wire. These are all sources of sound. Try to draw pictures that will indicate the motion of the source.

## Video analysis of a vibrating string

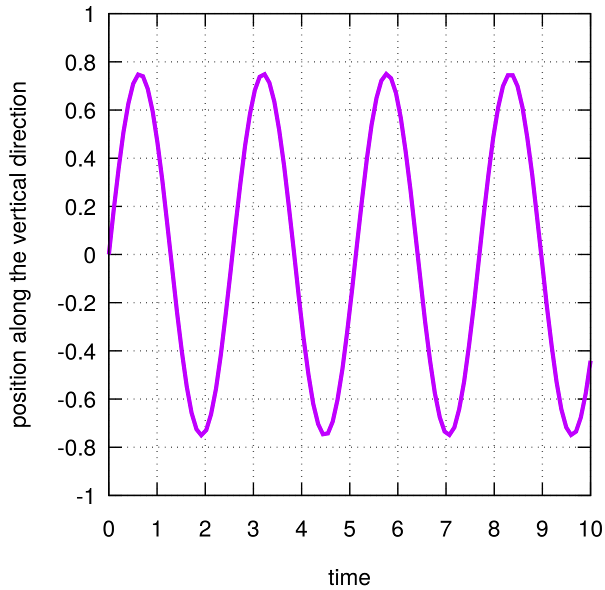
Observe the motion of a stretched vibrating string using video playback. You can pause the video as often as you wish, for better understanding of the motion.
Videos for Vibrating strings:
`https://www.youtube.com/watch?v=vCm7o_r7hbY`
`https://www.youtube.com/watch?v=HPA65zz1FC8`
`https://www.youtube.com/watch?v=_X72on6CSL0`
`https://www.youtube.com/watch?v=-gr7KmTOrx0`

Keep you attention on any one point on the string. On a sheet of paper draw the path of this point as the string continues to vibrate.

Use a graph paper to make the drawing more meaningful. On the $x$ (horizontal) axis we will mark the time and on the $y$ (vertical) axis we will mark the displacement of the point at different times. What is the main feature of the motion of the point?

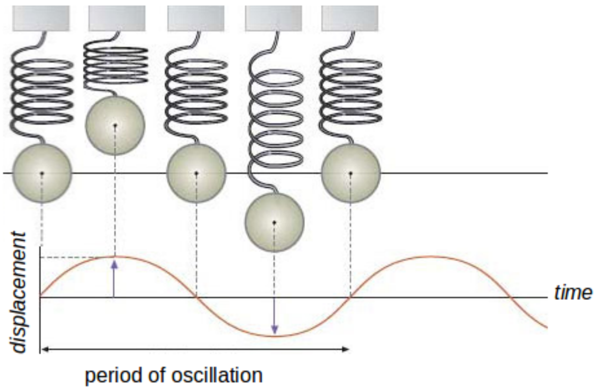
Is the motion of [other] points observed by others similar to the one you observed or is it different? In which way is it different?

The graph of the motion of any point on the string will look something like this, provided the string is plucked gently:



## Analysis of an oscillating mass

Take a small ball or a marble and suspend it vertically by a long spring. Set the ball in vertical motion by giving it a light downward pull or upward push. Plot a graph of its motion and compare it with that of one point of the string.




Understand various terms associated with an oscillation: frequency, amplitude.

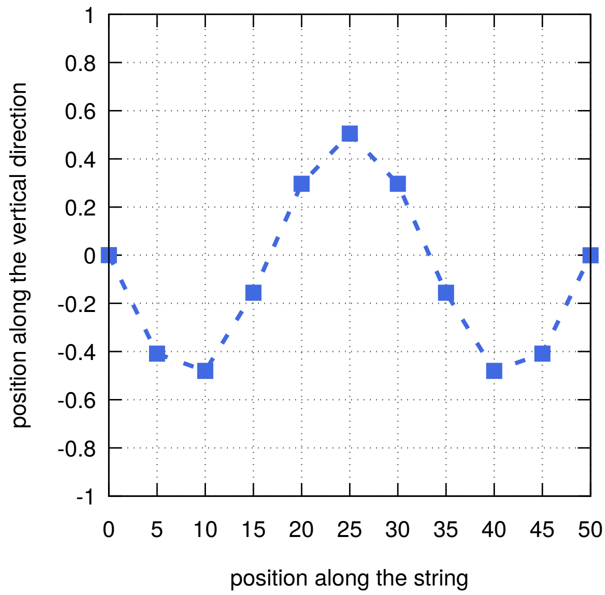
The time it takes for a point to make one complete cycle of motion – starting from its rest position to one extreme, then past the rest position to the other extreme and then back to the rest position – is called the period of oscillation ($T$). The inverse of the period, $1/T$ is called the frequency $f$. Frequency is measured as number of oscillations per second, and this quantity is given a special unit: *Hertz*. 1 Hz is the same as 1 oscillation per second. It is the frequency $f$ of oscillation that is related to the pitch of the sound. High pitch implies higher values of $f$ and vice-versa.

## Vibration of the entire string

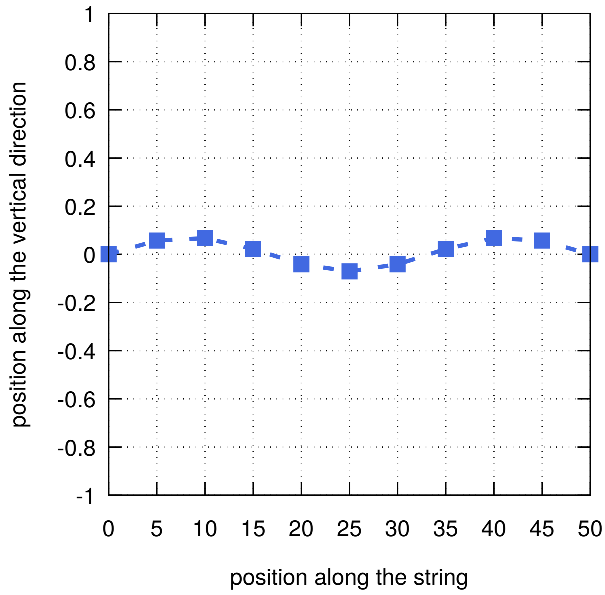
Each person concentrates on one point on the string, and everyone observes the position of their chosen point at a particular instant.

Then plot the position observed by each one at that instant. To plot this graph we will take the location of the point being observed on the $x$ axis and its instantaneous position on the $y$ axis.

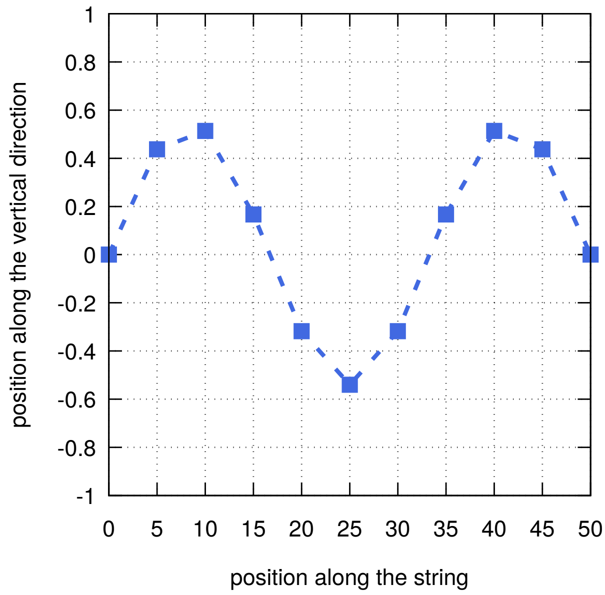
We might get graphs like this one.




If we observe the position some other instant we might get a graph like this one




or this




The motion of a vibrating string is the combined and synchronised oscillation of every point in the string. The difference between the motion of different points is in their speeds. Some points move fast, some slow. The ones that move slowly have small displacements, those that move fast have large displacements, but they all show periodic motion.

## Transmission of Sound

How does the vibration from a string or a membrane reach our ears? In most cases the sources of sound are in air and so is the observer. Let us see what happens if there is no air.

NCERT glass experiment

Video for no propagation in absence of air

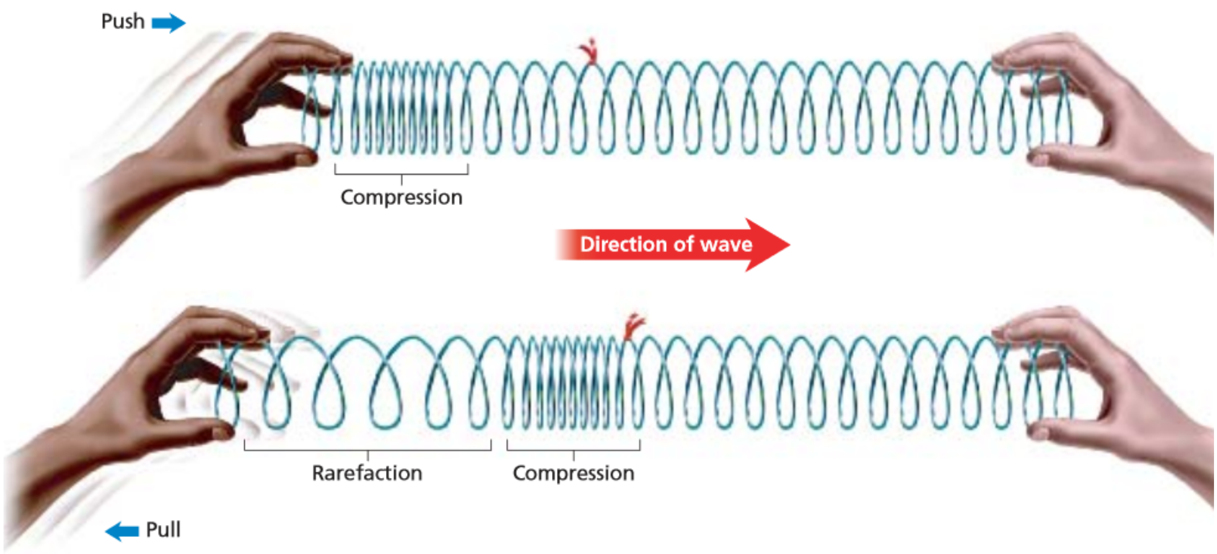
https://www.youtube.com/watch?v=q2pj9k1lrsM

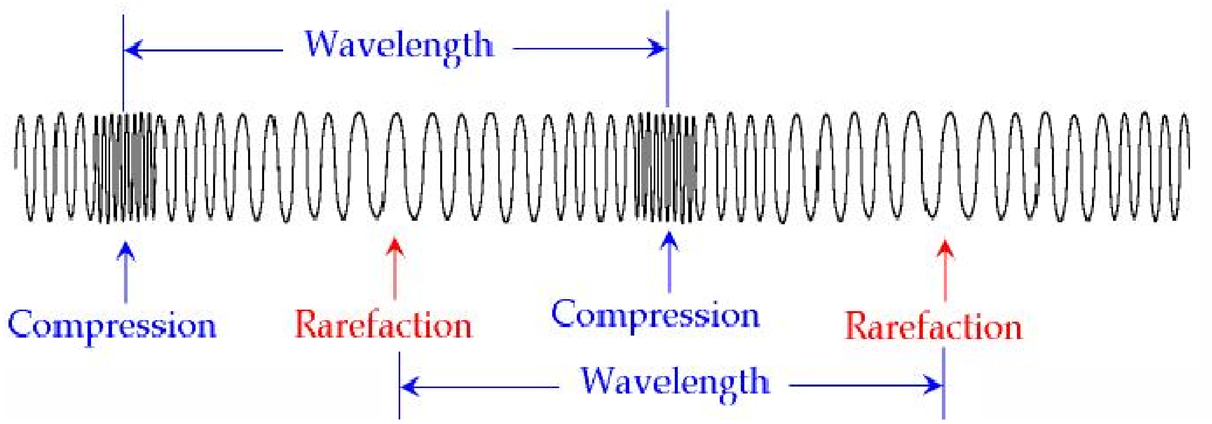
A medium is thus necessary for sound to propagate. How does the medium respond to the vibration of a string or a membrane?

## A model for understanding transmission of sound

A slinky is a long straight coil that can be easily stretched or compressed along its length. Let us place the slinky length-wise and give one end a brief tap. Tapping the slinky compresses it rapidly, and this compression moves along the length of the slinky.

Observe the changes taking place in the slinky, specifically, pay attention to the apparent movement taking place. If you notice carefully, the slinky itself is not moving, it is only the compression that is moving. As the compression moves along, it is accompanied by alternating stretching or rarefaction. There is no movement of the slinky as a whole.

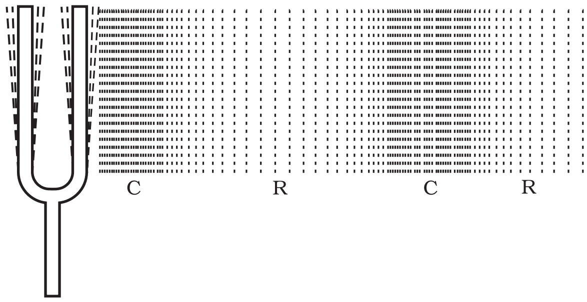


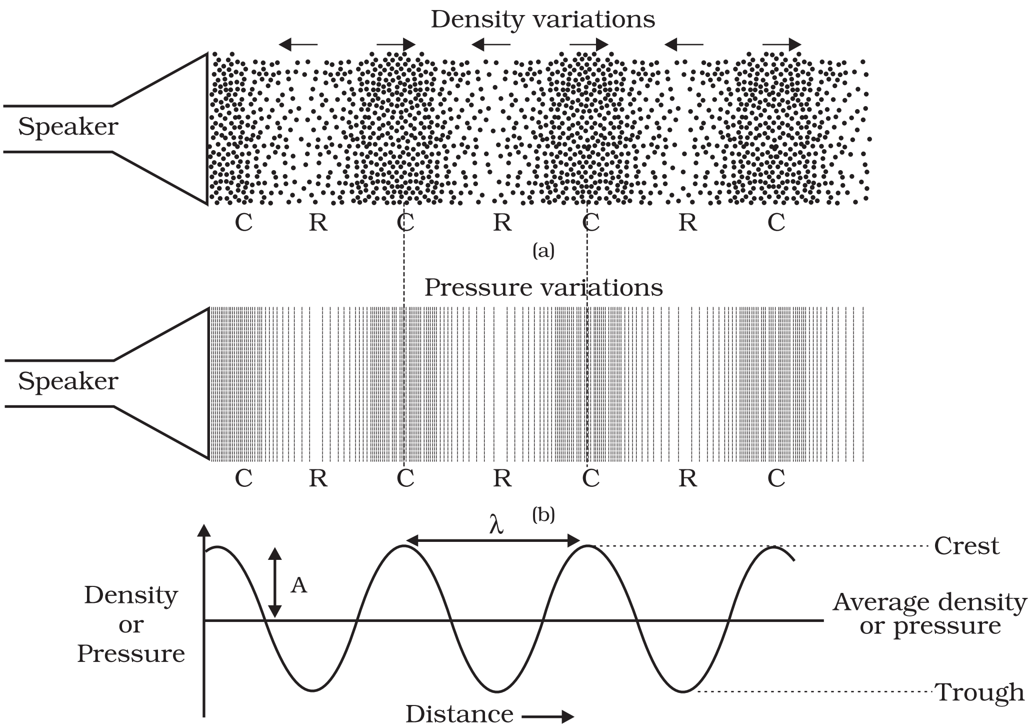



## Transmission of Sound

When a string or a membrane vibrates, it compresses the air near it, similar to the compression created by tapping the slinky. And similar to the compression travelling along the slinky, the compression travels through air (accompanied by alternate rarefactions).

The motion of the string or the membrane pushes the air adjacent to it. This causes the air pressure in that small region to increase momentarily. This compression sets the air that is farther away into motion, thereby transferring the pressure build-up away from the source of sound. Alternate regions of high and low pressure are thus created. It is this transmission of pressure rise and fall pattern that ultimately triggers our hearing mechanism. In the absence of a medium between the source and the listener, nothing will be heard, as there will be no compressions or rarefactions possible.
Diagrams of sound wave emanating from a vibrating fork and a loudspeaker.




Also see pressure wave animations on Dan Russell's website:
`http://www.acs.psu.edu/drussell/demos.html`

## Effect of the medium on the nature of sound

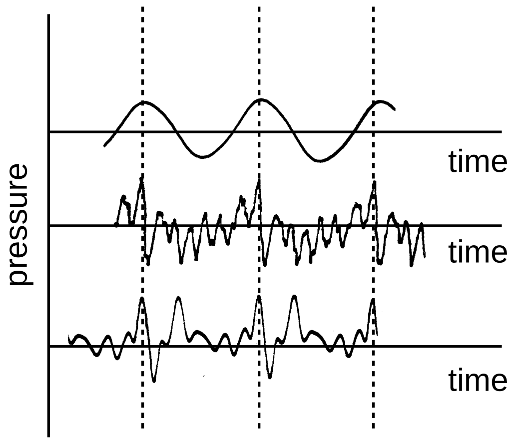
Sound from the same source sounds different when the medium between the source and the listener changes. The experiment with 2 spoons tied to a string and scratching of the surface of the table are pointers to that.

## Qualitative terminology describing sound and technical terms

Most naturally occurring sounds, and sounds produced by musical instruments or voice, are not simple oscillations like the one we saw for small oscillations of aa stretched string. They are usually mixtures (additions) of such basic oscillations. The smallest unit (or entity) of sound is called a note. Any note will in fact have a mixture of frequencies.

So, in addition to pitch, we need a third term, *timbre* which is an indicator of how many different frequencies and with what amplitude are present in the note. A so-called pure note has one dominant frequency and its multiples of smaller amplitudes. Very often, what distinguishes two notes of the same pitch (i.e. two notes having the same dominant frequency) is the range and amplitude of other frequencies accompanying the main frequency. That is why the same note from a sitar and a tanpura sound somewhat similar, but they can still be distinguished from each other.

The figure below shows the pressure variation observed at the listening point for three notes: a pure note as created by a tuning fork, and two others of the same dominant frequency (i.e. the same pitch) but of different timbre. Understand and analyse the similarity and differences in the three.

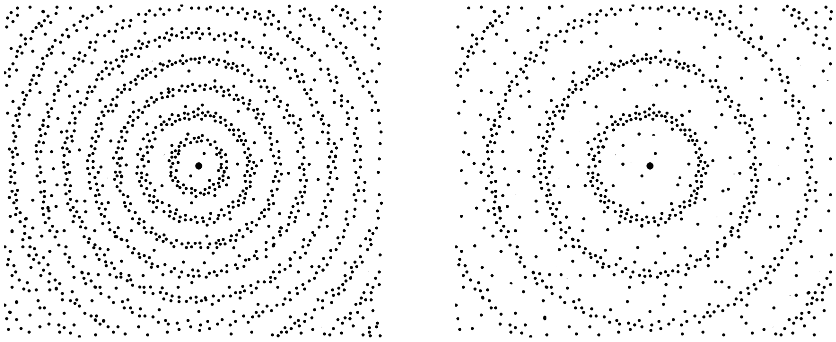



## Comparing different sounds

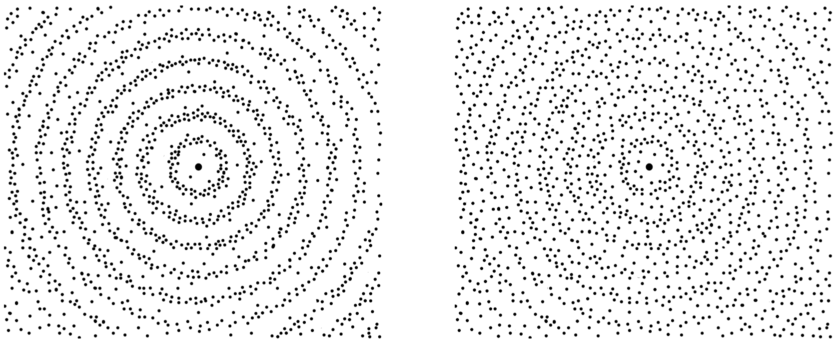
When we compare different sounds, we use many words to describe the nature of the sound. Try to recall the words and discuss or write down what each of them convey. Group together words that convey the same aspect of sound: loud, soft, shrill, dull, flat, deep, sharp, pitch, note, timbre etc.

Operate the sonometer under different conditions and describe the sound in each case using the terms listed previously and make correspondences between the type of sound and sonometer conditions. Tuning forks can be used for reference/aid.

Inspect the nature of the sound in the context of the terms *frequency* and *amplitude* that we used to describe the basic mechanisms of sound. The commonly used term *pitch* is related to frequency, the higher the pitch, the higher is the dominant frequency of the sound, and the lower the pitch, the lower are the dominant frequencies. *Loudness* of a note is related to the amplitude of the oscillation, louder note means larger oscillation.
*Density or pressure variation in a medium (e.g. air) in case of sounds of high frequency and low frequency of the same loudness.*



*Density or pressure variation in a medium (e.g. air) in case of sounds of loud and soft sound of the same frequency.*



In most cases a certain pitch implies the presence of a one frequency of large amplitude and it multiples of the base frequency with smaller amplitudes.