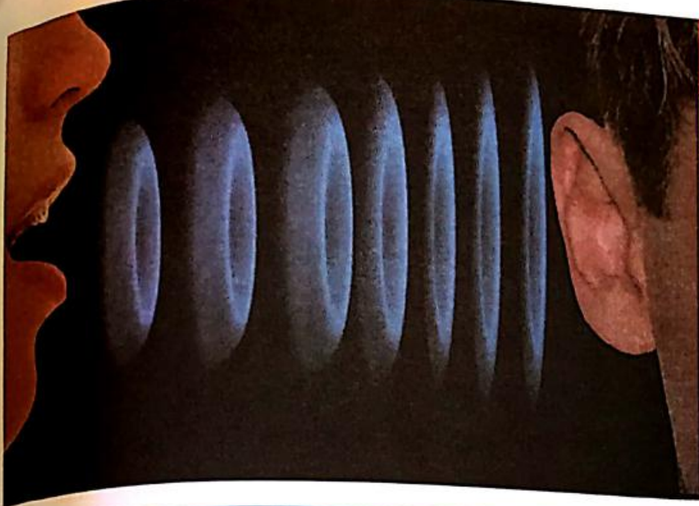


7
Sound

Theme : In the previous classes children were made aware about and enabled to understand that a sound wave is characterised by its frequency and amplitude. Parameters that focus on loudness and pitch; and are commonly used to characterise sound produced by different sources, were also highlighted. The loudness depends on the amplitude, hence when the amplitude of sound is large, sound is loud. Pitch is related to the frequency so when the frequency is high, the pitch is high or the sound is shrill. In this class the theme focuses on showing how sound produced by different musical instruments have different pitch and loudness.

In this chapter you will learn to

- relate pitch and frequency;
- understand pitch and frequency in relation to working of musical instruments (wind, membrane and string);
- explain mono tone;
- relate loudness and amplitude;
- state the unit of loudness in decibels.

LEARNING OBJECTIVES

- Revising previous concepts learnt by children.
- Building on children's previous learning.
- Explaining terms related to pitch and frequency.
- Demonstrating the relation between pitch and frequency.
- Demonstration of pitch and frequency of some common musical instruments.
- Demonstrating monotone sound.
- Demonstrating the relation between loudness and amplitude.
- Explaining units of loudness i.e. decibel.
- Engaging children in tasks/ activities related to pitch, loudness, frequency and amplitude.
- Engaging children in the design of musical toys.

KNOWING CONCEPTS

- Pitch and frequency.
- Pitch and frequency in relation to working of musical instruments (wind, membrane and string).
- Monotone.
- Loudness and amplitude.
- Unit of loudness decibels.

INTRODUCTION

In class VII, we have read that sound is a form of energy which produces a sensation of hearing in our ears. Sound is produced when a body ~~vibrates~~. Thus, each source of sound is a vibrating body.

For example, take a rubber band and cut it to get a string. Now stretch the string, keeping its one end in your mouth under the teeth and other end in your hand as shown in Fig. 7.1. When you pluck the string from the middle, you see that the string starts vibrating and a feeble sound is heard.

Fig. 7.1 A vibrating string produces sound

Sound needs a medium for its propagation. It can not travel in vacuum. This is why two persons can not hear each other on the moon or in space where there is no atmosphere. Sound can travel in solids, in liquids as well as in gases. Its speed is more in solids, less in liquids and still less in gases. The speed of sound in iron is nearly 5000 m s^{-1}, in water it is nearly 1500 m s^{-1} and in air it is nearly 330 m s^{-1}.

When a body vibrates, the particles of the medium also start vibrating. During vibrations, the kinetic energy of particles changes into potential energy and potential energy into kinetic energy. This is why sound is a form of energy.

PROPAGATION OF SOUND IN AIR

When a source of sound vibrates, it creates a periodic disturbance in the medium near it (*i.e.*, the condition of medium changes). The disturbance then travels in the medium in form of waves. This can be understood by the following example.

Example : Take a vertical metal strip with its lower end fixed. Push its upper end to one side and then release it. As it vibrates, *i.e.* moves alternately to the right and left, producing sound. Fig. 7.2(a) shows the steady (or mean position) of the metal strip and normal condition of air layers near the strip.

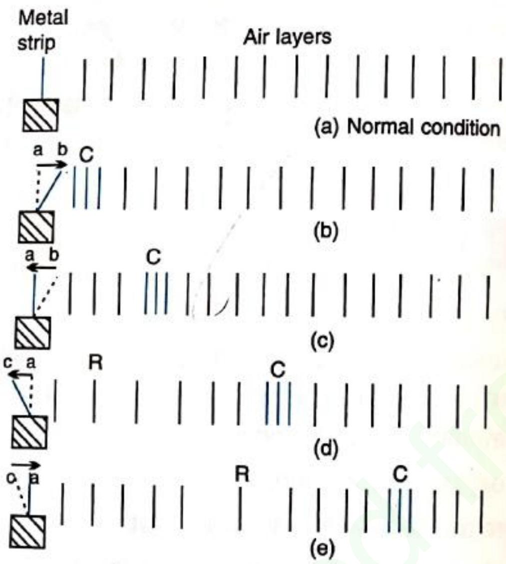


Fig. 7.2 Propagation of sound in air

As the strip moves to the right from a to b in Fig. 7.2(b), it pushes the particles of air layer in front of it. So, the particles of air in this layer come closer to each other *i.e.*, air in that layer gets compressed (or compression is formed at C). The particles of this layer while moving towards right, pushes and compresses the layer next to it, which then compresses the next layer and so on. Thus, the disturbance moves forward in form of compression. The particles of the medium do not move with the compression.

As the metal strip starts returning from b to a in Fig. 7.2(c) after pushing the particles near the strip, the compression C moves forward and the particles of air near the strip return back to their normal positions due to the elasticity of the medium.

When the strip moves to the left from a to c in Fig. 7.2(d), it pulls the layer of air near it towards left and thus produces a space of very low pressure on its right side. The air layers on the right side of the strip expand in this region thus forming the rarefied layers. This region of low pressure is called a rarefaction R.

By the time the strip returns from c to its mean position a in Fig. 7.2(e), the rarefaction R moves forward and air layers near the strip return back to their normal position due to the elasticity of the medium.

In this manner, as the strip moves to the right and left repeatedly, the compression and rarefaction regions are produced one after the other, which carry the disturbance along it with a definite speed depending on the nature of the medium.

One complete to and fro motion of the strip forms one compression and one rarefaction which together constitute one wave. This wave in which the particles of the medium vibrate about their mean positions, in the direction of propagation of sound, is called longitudinal wave. Thus, sound travels in air in form of longitudinal waves. These longitudinal waves can be produced in solids, in liquids as well as in gases.

Thus, due to propagation of wave in a medium, the particles of the medium vibrate about their mean positions (without leaving their positions) and they transfer the energy with a constant speed from one place of medium to other places.

TERMS RELATED TO A WAVE

(1) Amplitude : The maximum displacement of the particle of medium on either side of its mean position, is called the amplitude of wave. It is denoted by the letter *a*. Its S.I. unit is metre (m).

(2) Time period : The time taken by a particle of medium to complete its one vibration is called the time period of the wave. It is denoted by the letter T. Its S.I. unit is second (s).

(3) Frequency : The number of vibrations produced by a particle of the medium in one second is called the frequency of the wave. It is also defined as the number of waves passing through a point in one second. It is denoted by the letter *f*. Its S.I. unit is second^{-1} or hertz (symbol Hz).

The frequency of a wave is equal to the frequency of vibrations of its source. It is the characteristic of its source which produces the sound. It does not depend on the amplitude of vibration or on the nature of medium through which the wave propagates.

Relationship between time period (T) and frequency (*f*) : If T is the time period of a wave, then by definition

In time T, the number of waves = 1

∴ In 1 second, number of waves (or frequency) $f = \dfrac{1}{T}$

Thus, frequency = $\dfrac{1}{\text{Time period}}$

or time period = $\dfrac{1}{\text{frequency}}$

(4) Wavelength : The distance travelled by the wave in one time period of vibration of particle of medium is called its wavelength. It is denoted by the letter λ (lambda). Its S.I. unit is metre (m). It depends on the nature of medium through which the wave travels.

In a longitudinal wave, the distance between two consecutive compressions or between two consecutive rarefactions is equal to one wavelength (λ).

REPRESENTATION OF A WAVE

A wave while propagating in a medium can be represented by the following two graphs :

(1) Displacement-time graph, and

(2) Displacement-distance graph.

(1) Displacement-time graph : Fig.7.3 shows the variation of displacement of a particle of the medium with time at a given position, when a wave propagates through the medium. It is called displacement-time graph. The amplitude is represented by the letter a and time period is represented by the letter T in Fig. 7.3.

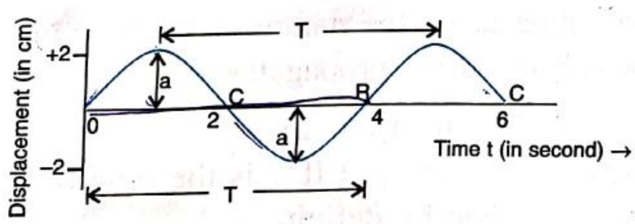


Fig. 7.3 Displacement – time graph of a particle in a wave

In Fig. 7.3, the amplitude of wave is 2 cm and its time period is 4 s (*i.e.* frequency is 0·25 Hz).

(2) Displacement-distance graph : Fig. 7.4 shows the variation of displacement of particles of the medium at different position with distance at the same time. Here amplitude of wave is shown by the letter a and wavelength is shown by the letter λ.

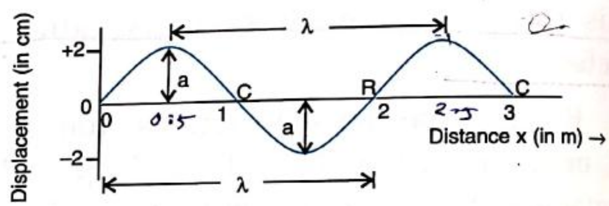


Fig. 7.4 Displacement – distance graph of a wave

For example in Fig. 7.4, amplitude of wave is 2 cm and its wavelength is 2 m.

Do You Know ?

(1) In a longitudinal wave, in Fig.7.3 and 7.4, the displacement on + Y axis shows the motion of medium particles in the direction of propagation of wave while the displacement on – Y axis shows the motion of medium particles in direction opposite to the propagation of sound.

(2) If the particles of medium vibrate normal to the direction of propagation of wave, the wave is called transverse wave.

(3) Sound waves produced in strings are transverse waves.

CHARACTERISTICS OF SOUND

A sound wave is characterized by its amplitude and frequency. Depending upon the amplitude and frequency of the sound wave, two sounds can be distinguished from one another by the following three different characteristics :

(1) Loudness,

(2) Pitch (or shrillness), and

(3) Quality (or timbre or wave form).

The above characteristics of a given sound can be known from the wave pattern of that sound.

(1) Loudness :

Loudness is the characteristic of sound by virture of which a loud sound can be distinguished from a faint sound, both having the same frequency and same wave form.

The loudness of a sound depends on the amplitude of vibration of the vibrating body producing sound. Greater the amplitude of vibrations, louder is the sound produced.

Fig. 7.5 shows two waves A and B of same frequency and same wave form, but the amplitude of wave A is 2 m while that of the wave B is 4 m. Thus, the amplitude of wave B is greater than that of A, hence the sound B is louder than sound A.

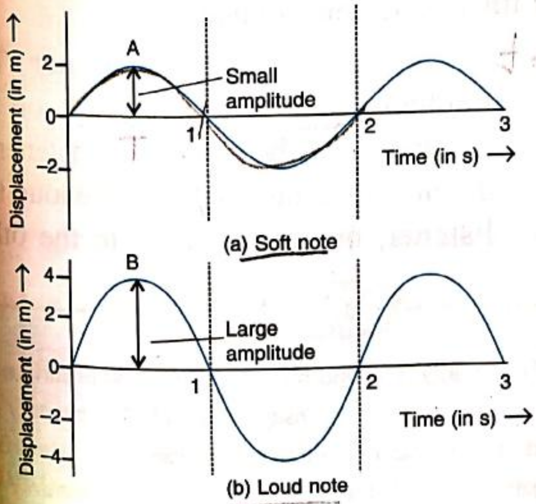


Fig. 7.5 Soft and loud sound

Examples : (i) If you gently pluck the string of a sitar or guitar, a soft (or faint) sound is heard. But if you pluck the string hard, it gets displaced more from its rest position *i.e.*, its amplitude of vibration increases and so a loud sound is heard.

(ii) If you strike the drum gently, a faint sound is heard. But if you strike it hard, you hear a loud sound.

(iii) If you gently strike a tuning fork on a rubber pad, you will hear the feeble (or soft) sound, but if you strike it hard on the rubber pad, a loud sound is heard.

Similarly, if the key of a piano is hit harder or a pipe is blown harder, we put more energy in the vibrating system due to which the amplitude of vibration is increased and a loud sound is produced.

The dependence of loudness on amplitude of vibrations can be demonstrated by the following activity.

ACTIVITY 1

Producing a faint and loud sound by a drum.

Take a drum, a pencil and a stick. First beat the drum gently with the pencil. You will hear a faint sound. The reason is that the membrane of drum vibrates with small amplitude.

Now you beat the drum hard with the stick (Fig. 7.6), so that the membrane of drum vibrates with a large amplitude. You will now hear a loud sound.

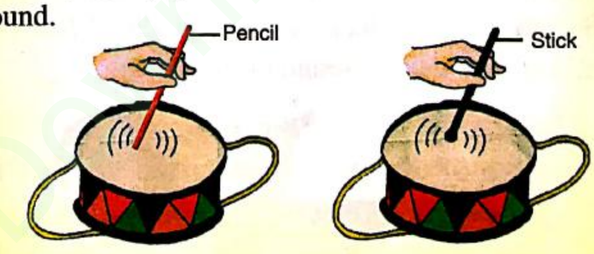


Fig. 7.6 Producing a faint and loud sound by a drum

Factors affecting the loudness of sound : The loudness of sound depends on the following factors :

(i) On the amplitude of wave : When a body vibrates with greater amplitude, it sends forth a greater amount of energy and hence the energy received by the eardrum is large, so the sound heard is louder. This can be understood by the following activity.

ACTIVITY 2

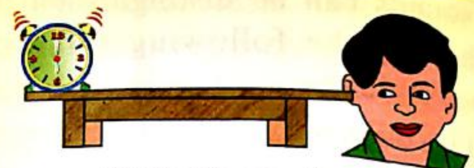
Take a drum. Place a ping-pong ball on the membrane of the drum. Beat the membrane gently with the drum stick. A feeble sound is heard and the ball moves up to a small height and down showing that the amplitude of vibration is small. Now beat the membrane harder with the drum stick. The drum produces louder sound and the ball jumps higher showing that the amplitude has increased.

(ii) On the distance of source of sound : If the listener is close to the source of sound, he hears it quite louder, but if he is far away, the sound becomes feeble. If he moves further away from the source, a stage may reach when the sound becomes inaudible. Thus, closer the source, louder is the sound. This can be demonstrated by the following activity.

ACTIVITY 3

Place a clock on one end of a long table and bring your ear near the clock as shown in Fig. 7.7(a). You will hear the ticking sound of the clock.

(a) Loud sound



(b) Feeble sound

Fig. 7.7 Loudness decreases with increase of distance of source

Now move the clock on the table away from you. You will notice that the ticking sound of clock becomes feeble and a stage comes when you will not be able to hear the sound [Fig. 7.7(b)].

(iii) On the surface area of the vibrating body : A large vibrating area sends forth a greater amount of energy so the amplitude of vibration is large. Hence, larger the surface area of the vibrating body, louder is the sound heard.

If you take two drums, one small and the other big, and beat them one by one to produce vibrations in them, you will notice that the sound produced from the big drum is louder than that produced from the small drum.

In temples, you must have noticed that the bell with a big case produces a louder sound than that with a small case.

(iv) On the sensitivity of the listener : The loudness of a sound depends on the sensitivity of the ears of the listener. A given sound may appear to be loud to a listener, but not so loud to the other

Do You Know ?

The energy of sound reaching a unit area of surface in each second is called intensity of sound. The intensity of sound can be measured, but loudness cannot be measured. Intensity of sound does not depend on the sensitivity of the ears of the listener. However larger the intensity, louder is the sound. Thus, loudness depends on intensity.

listeners. To a partially deaf listener, a louder sound will appear to be feeble.

Relationship between loudness and amplitude of wave : The loudness of sound is directly proportional to the square of amplitude of wave. It implies that on doubling the amplitude of wave, the loudness becomes $(2)^2 = 4$ times. If amplitude of wave is tripled, the loudness become $(3)^2 = 9$ times and so on. Thus

Loudness $\propto$ (amplitude)^2

or $L \propto a^2$

Fig. 7.8 shows two waves A and B The amplitude of wave A is 2 cm and of B is 3 cm, but both waves are of same frequency. The ratio of loudness of B and A is

$$\frac{\text{Loudness of wave B}}{\text{Loudness of wave A}} = \frac{(3\text{ cm})^2}{(2\text{ cm})^2} = \frac{9}{4}$$

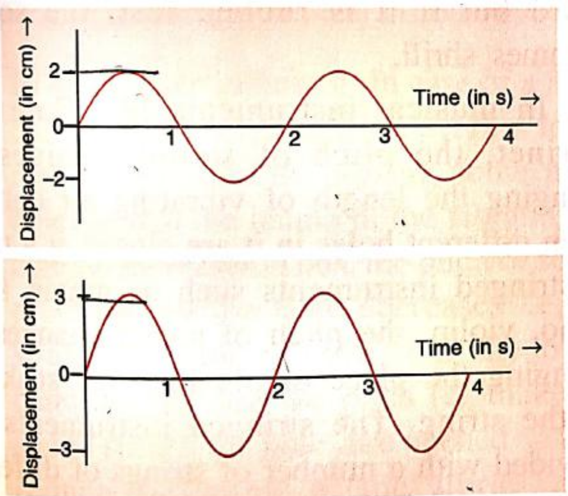


Fig. 7.8 Two waves of different amplitudes

Unit of loudness — decibel (dB)

The loudness of sound is measured on a special scale called the decibel scale. Note that 1 dB = one-tenth of bel where bel is the unit of level of loudness, named after the scientist Alexander Graham Bel, who invented one of the most useful devices, viz, telephone.

The minimum loudness of sound audible at frequency 1 kHz is considered to be the zero level of sound in decibel (*i.e.*, zero dB). It is taken to be the reference level. When the loudness increases 10 times, the level of sound is said to be 10 dB. When the loudness becomes 100 times, its level is 20 dB, when the loudness becomes 1000 times, its level is 30 dB and so on.

The table below gives the level of sound in dB produced by some objects.

Level of sound produced by some objects

Object producing sound	Level (in dB)	Loudness
1. Minimum audible	0	Very much faint
2. Leaves rustling	10	Very faint
3. Recording studio	20	Very faint
4. Whisper	30	Faint
5. Normal conversation	50	Moderate
6. Vacuum cleaner	60	Moderate
7. Vehicle	80	Loud
8. Diesel engine	90	Very loud
9. Heavy hammering machine	110	Painful
10. Police car siren	120	Painful
11. Rocket take off	140	Much painful

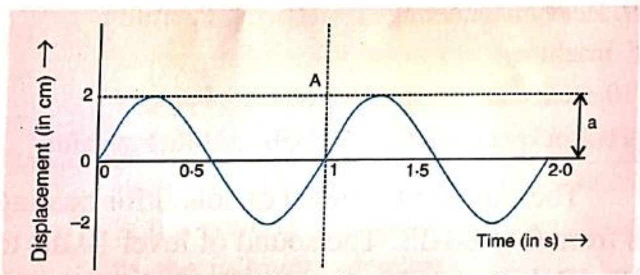
The safe limit of level of sound for hearing is from 0 to 80 dB. The sound of level 10 dB to 30 dB has soothing sensation. A constant hearing of sound of level above 120 dB can cause headache and permanent damage to the ears of the listener. Such sound is called **noise**.

(2) Pitch :

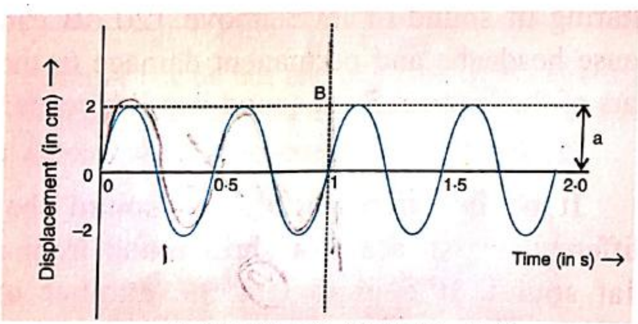
It is the characteristic of sound that differentiates an acute or shrill sound from a flat sound. It depends on the number of vibrations per second. Pitch refers only to the musical sounds and each musical note has a definite pitch. If the pitch is high, the sound is shrill and if the pitch is low, the sound is flat. In a tape recorder (or TV), bass and treble refer to low and high pitch respectively. At a bass (or woofer on), low pitch (*i.e.*, grave) sound produced by tabla or dholak becomes predominant, while at treble, high pitch (*i.e.*, shrill sound produced by flute or ghoonghroo (ankle bells) becomes predominant.

Pitch of a note depends on its frequency. Two notes sounded on the same instrument with same amplitude, will differ in pitch when their vibrations are of different frequencies.

Fig. 7.9 shows two waves A and B each of amplitude 2 cm. The wave A is of time period T = 1 s *i.e.* frequency $f = \frac{1}{1\,s} = 1\ s^{-1}$ while the wave B is of time period T = 0·5 s *i.e.* frequency $f = \frac{1}{0{\cdot}5\,s} = 2\ s^{-1}$. Thus, the wave A is of low pitch while the wave B is of high pitch.



(a) Low pitch note (Frequency = 1 s^{-1})



(b) High pitch note (Frequency = 2 s^{-1})

Fig. 7.9 Two waves of different pitch

Do You Know ?

(i) In the displacement-time graph, if number of waves in same time interval increases, it means that the time period of wave has decreased *i.e.*, its frequency (or pitch) has increased.

(ii) In the displacement-distance graph, if number of waves in the same distance increases, it means that the wavelength of wave has decreased so its frequency (or pitch) has increased.

Examples : (1) The frequency of a sound of a crying baby is more than that of a crying adult, so the sound of a crying baby is shriller than that of a crying adult.

Similarly, the voice of a female is shriller than that of a male.

(2) If a post card is rubbed slowly against the teeth of a comb, a grave sound is heard but if it is rubbed fast, the sound becomes shrill.

In musical instruments like flute and clarinet, the pitch of sound changes by changing the length of vibrating air column when different holes in it are closed at a time. In stringed instruments such as guitar, sitar, piano, violin, the pitch of sound changes by changing the place of plucking (or striking) on the string. The stringed instruments are provided with a number of strings of different thickness and under different tensions so that each string produces sounds of different pitch.

Ways of changing the pitch in different musical instruments

(i) In stringed instruments : Instruments such as piano, violin and guitar have several strings of different thickness under different tensions (Fig. 7.10). The reason is that the frequency of vibration of a string depends on the tension and thickness of the string. A note of higher pitch can be obtained by vibrating the string under high tension or by vibrating a thinner string.

The pitch of sound proudced by a string instrument also depends on the place where it is plucked. If a string stretched between its ends, is plucked more closer to the one fixed end, higher is the pitch of the sound produced.

Fig. 7.10 Stringed musical instruments

(ii) **In wind instruments :** In case of a flute, clarinet, shehnai etc., (Fig. 7.11) a lower note is obtained by closing some more holes so that the length of the vibrating air column increases. Thus, the pitch of sound produced by the flute decreases *i.e.* the sound becomes grave. On the other hand, to increase the pitch (or make the sound shrill), the holes are opened so as to reduce the length of the vibrating air column.

Fig. 7.11 Musical instruments in form of pipe

This can be understood by the following activities.

ACTIVITY 4

Take a pitcher. Keep it below a water tap. You will notice that as the water level in the pitcher rises, the length of air column decreases, so the frequency of sound produced increases *i.e.*, the sound becomes shriller and shriller. Thus, by hearing the sound from a distance, one can get an idea of water level in the pitcher.

ACTIVITY 5

Take a steel wire of length nearly 0·5 m. Stretch the wire between two fixed supports under some tension. Pluck the wire at its middle, it will vibrate in one loop as shown in Fig. 7.12(a).

Now if you pluck the wire at distance $\frac{1}{4}$ of its length from one end, it will vibrate in two loops as shown in Fig.7.12(b). The sound now will be shriller than before.

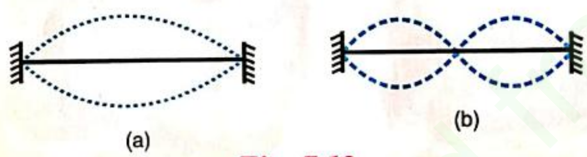


Fig. 7.12

ACTIVITY 6

Take a test tube with a little water in it as shown in Fig. 7.13(a). Blow air in the tube by placing your

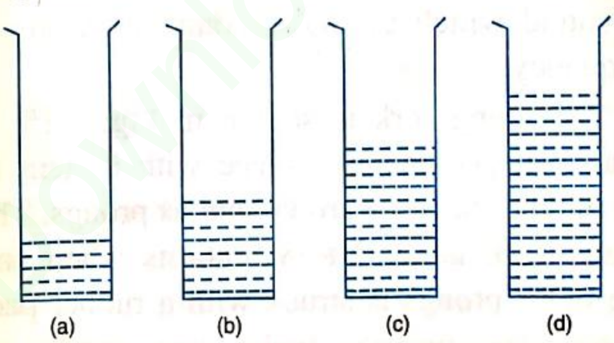


Fig. 7.13 Pitch increases with decreasing length of air column

lip on the mouth of the test tube, You will hear a flat sound (*i.e.*, a sound of low pitch). Now add more and more water in the test tube as shown in Fig. 7.13(b), (c), and (d) so that the length of air column above the water level decreases. Each time, blow air and hear the sound. You will notice that the sound produced becomes more and more shrill.

(iii) In membrane Instruments : In instruments such as dholak, tabla, drum etc. shown in Fig. 7.14, there is a membrane which is stretched by means of strings. To produce sound, the membrane is made to vibrate by striking or tapping it. The pitch of sound depends on the size and tension of the membrane. More tight and small is the membrane, higher is the pitch of sound produced. Thus, to increase shrillness of sound, the instrument of small membrane is taken and its strings are stretched and tightened.

Fig. 7.14 Membrane instruments

MONOTONE

A sound of single frequency is called a monotone. A tuning fork is the only source of sound which produces sound of a single frequency.

A tuning fork is shown in Fig. 7.15. It is a U-shaped metallic piece with a stem in the middle. Its arms are known as prongs. The tuning fork is set into vibrations when any one of its prongs is struck with a rubber pad. Generally, tuning forks are made of frequencies which correspond to musical notes. Different tuning forks may have

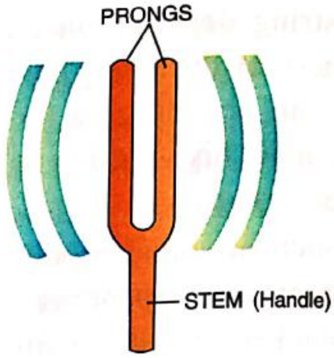


Fig. 7.15 Tuning fork

different frequencies. When struck with a rubber pad, a tuning fork vibrates with its own frequency. The frequency produced by the tuning fork is marked on it. Generally the tuning forks are available of frequencies 256 s^{-1}, 288 s^{-1}, 320 s^{-1}, 384 s^{-1}, 480 s^{-1} and 512 s^{-1}.

The wave form of sound of a tuning fork is shown in Fig. 7.16.

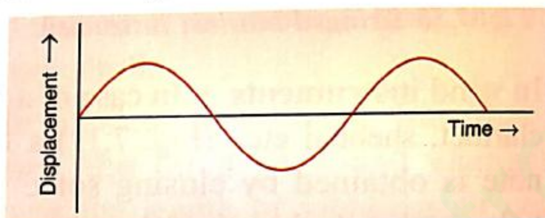


Fig. 7.16 Wave form of a monotone

(3) Quality (or timbre or wave form)

Quality is the characteristic which distinguishes two sounds of the same pitch and same loudness.

The sound produced by any musical instrument or human being contains in small amplitudes two or more waves of different frequencies which are integer multiples of the frequency of source. These waves are different in different sources. Due to the presence of such vibrations, the wave form (or quality) of sound changes. The wave form is different for different sources of sound even if their loudness and pitch are same.

Each vibrating body has its characteristic wave form. This makes it possible for one to recognize the vibrating body even without seeing it. You generally recognize a person by hearing his voice on telephone, without seeing him. It is because the vibrations produced by the vocal chord of each person have a characteristic wave form which is different for different persons. Similarly, one can distinguish and recognize the sounds of two different musical instruments even if they are of same pitch and same loudness.

Fig. 7.17 shows the wave form of sound produced by a tuning fork and a piano, both of same pitch (*i.e.* same frequency) and same amplitude, but they have the different wave forms, by which they are distinguished from each other.

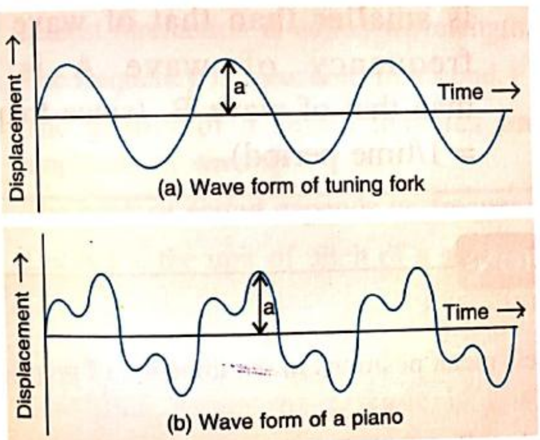


Fig. 7.17

A note played on a piano has a large number of notes, while the same note when played on a flute contains only a few notes. Thus, we can easily distinguish between the sounds of a piano and a flute by their different wave forms, though they may have exactly the same loudness and same pitch.

To summarize, the table below gives the factors affecting the different characteristics of sound.

Characteristics ⟶	Loudness	Pitch	Timbre or quality
Factor ⟶	Amplitude	Frequency	Wave form

MAKING A MUSICAL TOY

To make a guitar, take a shoe box (without lid), a card board cylinder of diameter nearly 6 to 7 cm, five-six rubber bands, cellotape, a pair of scissors and pencil.

1. Place one end of the card board tube on one side of the shoe box. Trace its outline. Cut this part of the box using scissors to make a hole in the box (Fig. 7.18).

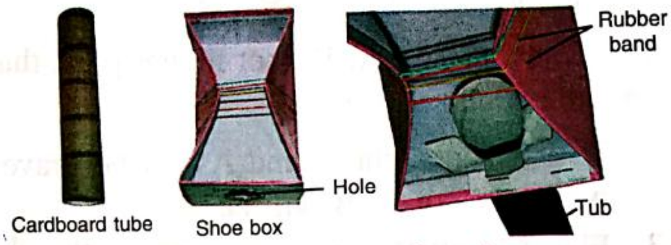


Fig. 7.18 Home made guitar

2. Insert the end of card board tube into the box. Fold the edges of tube inside the box so as to fix it in the box with a cellotape.
3. Stretch the rubber band across the shoe box. This will compress the central part of the box as shown in Fig. 7.18.
4. Play on rubber strings by your fingers. You will hear a twanging sound like guitar. Use the guitar for the following activity.

ACTIVITY 7

Use your internet to obtain a programme on tuning a guitar. Try to practice it yourself.

SOLVED EXAMPLES

1. Two waves A and B are of amplitudes 3 cm and 4 cm respectively. Compare their loudness. Which sound is louder ?

Solution : *Given*, amplitude of A = 3 cm, amplitude of B = 4 cm

$$\frac{\text{Loudness of A}}{\text{Loudness of B}} = \frac{(\text{amplitude of A})^2}{(\text{amplitude of B})^2}$$

$$= \frac{(3\,\text{cm})^2}{(4\,\text{cm})^2} = \frac{9}{16}$$

∴ Sound B is louder than sound A.

2. Two sources of sound A and B are of frequencies respectively 120 Hz and 256 Hz. Which sound is of higher pitch ? To a listener, how do the two sounds differ ?

Solution : *Given*, frequency of A = 128 Hz

Frequency of B = 256 Hz

Thus, the sound B is of higher pitch than the sound A.

To a listener, the sound A will be grave while the sound B will be shrill.

3. Fig. 7.19 shows two waves A and B.
   (i) Which sound is louder ? Give reason.
   (ii) Which sound is shriller ? Give reason.

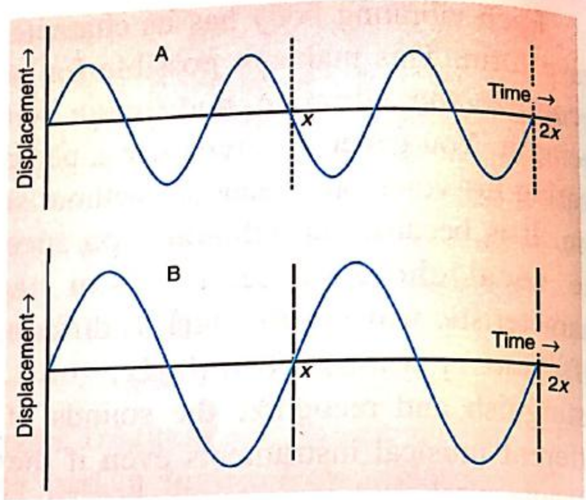


Fig. 7.19

(i) Sound B is louder than sound A. The reason is that the amplitude of sound B is more than that of sound A.

(ii) Sound A is shriller than sound B. The reason is that time period of wave A is smaller than that of wave B *i.e.* frequency of wave A is more than that of wave B. (since frequency = 1/time period).

RECAPITULATION

- Sound travels in air in form of longitudinal waves.
- In a longitudinal wave, the particles of air vibrate about their mean positions in the direction of propagation of sound.
- One complete to and fro motion of the particle of medium is called one vibration.
- The maximum displacement of a vibrating particle from its rest (or mean) position is called its amplitude. It is expressed in metre.
- The time taken by a vibrating particle to complete one vibration is called its time period. It is expressed in second.
- The number of complete vibrations that a vibrating particle makes in one second is called its frequency. It is expressed in hertz (symbol Hz).
- The frequency and time period are related as frequency = 1/time period.
- We distinguish different sounds by their loudness, pitch and quality.
- The loudness of sound depends on the amplitude of vibration of the vibrating body producing sound. Greater the amplitude, louder is the sound produced.

- Loudness is the characteristic of sound that distinguishes a loud sound from a feeble or soft sound.
- The loudness of sound increases if the vibrating area of the body is increased.
- The pitch of a sound depends on the frequency of the vibrating body. A sound of high frequency is said to have a high pitch, while a sound of low frequency is said to have a low pitch.
- Higher the pitch, the shriller is the sound. Lower the pitch, the flat (or grave) is the sound.
- Pitch is the characteristic of sound which distinguishes a shrill sound from a flat (or grave) sound.
- Quality is the characteristic of sound which distinguishes two sounds of the same pitch and same loudness since they differ in wave form due to the presence of sounds of other frequencies in small amplitudes.
- The sound of single frequency is called monotone. Only a tuning fork produces a monotone.

TEST YOURSELF

A. Objective Questions :

1. Write **true** or **false** for each statement :
   (a) When sound propagates in air, it does not carry energy with it. F
   (b) In a longitudinal wave, compression and rarefaction are formed. T
   (c) The distance from one compression to nearest rarefaction is called wavelength. F
   (d) The frequency is measured in second. F
   (e) The quality of a sound depends on the amplitude of wave. F
   (f) The pitch of sound depends on frequency.
   (g) Decibel is the unit of pitch of a sound.

   Ans. True—(b), (f) **False**—(a), (c), (d), (e), (g)

2. Fill in the blanks :
   (a) The time period of a wave is 2 s. Its frequency is $\frac{1}{2}$..........
   (b) The pitch of a stringed instrument is increased by increasing tension in string.
   (c) The pitch of a flute is decreased by increasing length of air column.
   (d) Smaller the membrane, ..higher.... is the pitch.
   (e) If a drum is beaten hard, its loudness increases
   (f) A tuning fork produces sound of single... frequency.

   Ans. (a) 0·5 s^{-1} (b) increasing (c) increasing (d) higher (f) increases (f) single

3. Match the following :

Column A	Column B
(a) Amplitude	(i) frequency
(b) Frequency	(ii) amplitude
(c) Loudness	(iii) maximum displacement on either side
(d) Pitch	(iv) presence of other frequencies
(e) Wave form	(v) 1/Time period

   Ans. (a)–(iii), (b)–(v), (c)–(ii), (d)–(i), (e)–(iv)

4. Select the correct alternative :
   (a) Sound can not travel in :
   (i) solid (ii) liquid
   (iii) gas ✓(iv) vacuum
   (b) When sound travels in form of a wave
   (i) the particles of medium move from the source to the listener
   (ii) the particles of medium remain stationary
   (iii) the particles of medium start vibrating up and down
   ✓(iv) the particles of medium transfer energy without leaving their mean positions.
   (c) The safe limit of loudness of audible sound is :
   ✓(i) 0 to 80 dB (ii) above 80 dB
   (iii) 120 dB (iv) above 120 dB.

(d) The unit of loudness is :

(i) cm (ii) second

(iii) hertz (iv) decibel.

(e) In a piano, pitch is decreased by :

(i) using thicker string

(ii) increasing tension

(iii) reducing length of string

(iv) striking it hard.

Ans. (a)–(iv), (b)–(iv), (c)–(i), (d)–(iv), (e)–(i)

B. Short/Long Answer Questions :

1. How does sound travel in air ?
2. What is a longitudinal wave ?
3. Explain the mechanism of formation of a longitudinal wave when source vibrates in air.
4. Define the following terms :
   (a) Amplitude
   (b) Frequency
   (c) Time period.
5. Obtain relationship between the time period and frequency.
6. Name three characteristics of a musical sound.
7. Name the quantity from below which determines the loudness of a sound wave :
   (a) Wavelength (b) Frequency, and (c) Amplitude.
8. How is loudness related to the amplitude of wave ?
9. If the amplitude of a wave is doubled, what will be the effect on its loudness ?
10. How does the wave pattern of a loud note differ from a soft note ? Draw a diagram.
11. Name the unit in which the loudness of sound is expressed.
12. Why is the loudness of sound heard by a plucked wire increased when mounted on a sound board ?
    [**Hint :** The surface area of vibrating air increases]
13. State three factors on which loudness of sound heard by a listener depends.
14. What determines the pitch of a sound ?
15. Name the characteristic of sound related to its frequency. **Ans.** pitch
16. Name and define the characteristic which enables one to distinguish two sounds of same loudness, but of different frequencies, given by the same instrument.
17. Draw a diagram to show the wave pattern of high pitch note and a low pitch note, but of the same loudness.
18. How is it possible to detect the filling of a bucket under a water tap by hearing the sound standing at a distance ?
19. The frequencies of notes given by flute, guitar and trumpet are respectively 400 Hz, 200 Hz and 500 Hz. Which one of these has the highest pitch ? **Ans.** Trumpet
20. Fig. 7.20 shows two jars A and B containing water up to different heights. Which will produce sound of higher pitch when air is blown on them?

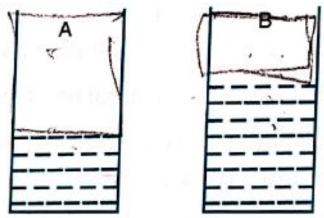


Fig. 7.21 **Ans.** B

21. Two identical guitars are played by two persons to give notes of the same pitch. Will they differ in quality ? Give reason for your answer.
22. Two musical notes of the same pitch and same loudness are played on two different instruments. Their wave patterns are as shown in Fig. 7.21.

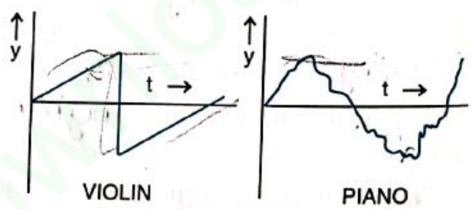


Fig. 7.21

How do they differ in

(a) loudness, (b) pitch and

(c) quality ?

Ans. (a) Same (b) Same (c) Different

23. Which characteristic of sound makes it possible to recognize a person by his voice without seeing him ?

24. State the factors that determine
(a) the pitch of a note.
(b) the loudness of the sound heard.
(c) the quality of the note.

Ans. (a) frequency (b) amplitude (c) wave form.

25. Name the characteristic of the sound affected due to a change in its (a) amplitude (b) wave form (c) frequency.

Ans. (a) loudness (b) quality (c) pitch.

26. Fig. 7.22 shows four waves A, B, C, and D.

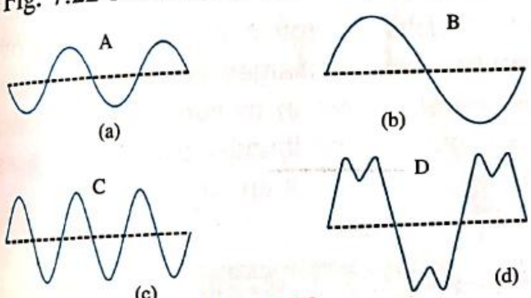


Fig. 7.22

Name the wave which shows
(a) a note from a musical instrument,
(b) a soft note, (a)
(c) a shrill note. (c)

Ans. (a)–(D) (b)–(A) (c)–(C)

27. How is the pitch of sound in a guitar changed if (a) thin wire is used, (b) wire under less tension is used ?

C. Numericals

1. Two waves of the same pitch have amplitudes in the ratio 1 : 3. What will be the ratio of their (i) loudness, (ii) pitch ?

Ans. (i) 1 : 9 (ii) 1 : 1

2. Two waves have frequencies 256 Hz and 512 Hz, but same amplitude. Compare their (i) loudness, and (ii) pitch.

Ans. (i) 1 : 1 (ii) 1 : 2