

### EXERCISE 7(B)

**Solution:**

Natural or free vibrations are the vibrations of a body in the absence of any external force on it.

For example:

Various strings are set in vibration each at its own natural frequency when we strike the keys of a piano.

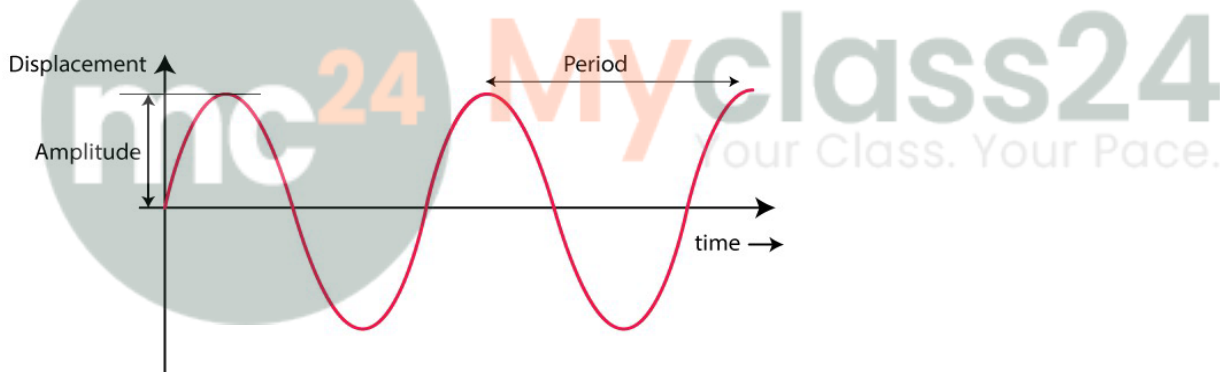
**Solution:**

The natural frequency of vibration of the body occurs when each body capable of vibrating is set to vibrate freely, with a frequency  $f$ .

The natural frequency vibration of a body depends on the shape and size of the body.

**(a) Solution:**

The displacement time graph for the free vibrations is shown below for a body executing free vibrations



The body executes natural vibrations when the oscillations of a body is set into vibrations by any external force and then left to itself.

**Question: 4**

**State one condition for a body to execute the natural vibrations.**

The presence of medium around the body offers some resistance due to which the amplitude of vibration continuously decreases and does not remain constant. Hence for this reason the natural vibrations of a body occur only in vacuum.

**Question: 5**

**(a) Name one factor on which the frequency of sound emitted due to vibration in an air column depends.**

**(b) How does the frequency depend on the factor stated in part (a).**

**Solution:**

(a) When frequency of sound emitted due to vibration in an air column, it affects the length of air column.

(b) The frequency decreases as the length of the air column increases. Hence we can say that they are inversely proportional to each other i.e  $f \propto 1 / l$

**Question: 6**

**State one way of increasing the frequency of a note produced by an air column.**

**Solution:**

By decreasing the length of the air column the frequency of the note produced in the air column can be increased.

**Question: 7**

**State two ways of increasing the frequency of vibrations of a stretched string.**

**Solution:**

The two ways of increasing the frequency of vibrations of a stretched string are

- (i) By increasing the tension in the string
- (ii) By decreasing the length of the string

**Question: 8**

**How does the frequency of sound given by a stretched string depend on its (a) length, (b) tension?**

**Solution:**

(a) Length: The frequency of sound is inversely proportional to the length of the string.

$$f \propto 1 / l$$

(b) Tension: The frequency of sound is directly proportional to the square root of the tension in the string.

$$f \propto \sqrt{T}$$

**Question: 9**

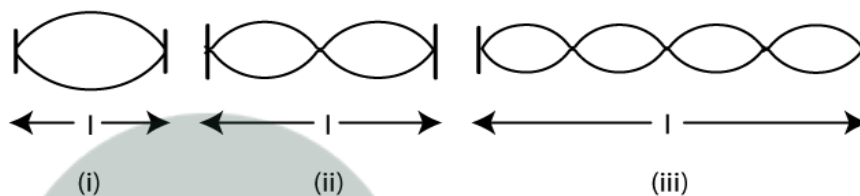
**What adjustments would you make for tuning a stringed instrument for it to emit a note of a desired frequency?**

**Solution:**

By varying the tension, we can get the desired frequency. Thus a stringed instrument is provided with the provision for adjusting the tension of the string.

**Question: 10**

**The diagram below in Fig. shows three ways in which the string of an instrument can vibrate.**



(a) Which of the diagram shows the principal note?

(b) Which vibration has the frequency four times that of the first?

(c) Which vibration is of longest wavelength?

(d) What is the ratio of the frequency of vibrations in diagram (i) and (ii)?

**Solution:**

(a) Diagram showing the principle note is (i)

(b) Diagram which has the frequency four times that of the first is (iii)

(c) Diagram having longest wavelength is (i)

(d) The ratio of the frequency of vibrations in diagram (i) and (ii) is 1 : 2

**Question: 11**

**Explain why strings of different thickness are provided on a stringed instrument.**

**Solution:**

In order to produce different frequency sound waves, strings of different thickness are provided on a stringed instrument. This is because the natural frequency of vibration of a stretched string is inversely proportional to the radius of the string.

**Question: 12**

**A blade, fixed at one end, is made to vibrate by pressing its other end and then releasing it. State one way in which the frequency of vibrations of the blade can be lowered.**

**Solution:**

By increasing the length of the blade or by sticking a small weight on the blade at its free end, the frequency of vibrations of the blade is lowered.

**Question: 13**

**How does the medium affect the amplitude of the natural vibrations of a body?**

**Solution:**

The surrounding medium offers resistance to the motion, so the energy of vibrating body continuously decreases due to which the amplitude of vibration decreases gradually.

**Question: 14**

**What are the damped vibrations? How do they differ from free vibrations? Give one example of each.**

**Solution:**

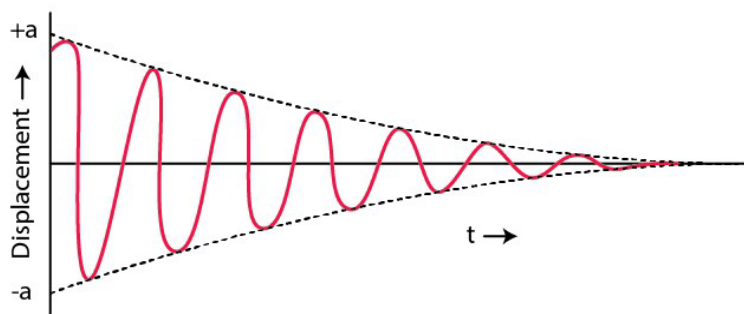
The damped vibrations are the periodic vibrations of a body of decreasing amplitude in presence of a resistive force.

When a body is made to vibrate in a medium, the amplitude of the vibrating body continuously decreases with time and ultimately the body stops vibrating.

For example: Slim branch of a tree makes damped vibrations when it is pulled and then released. The vibrations of a spring having a mass at its end, in air are the damped vibrations.

**Question: 15**

**The diagram in figure shows the displacement-time graph of a vibrating body.**



- (i) Name the kind of vibrations.
- (ii) Give one example of such vibration.
- (iii) Why is the amplitude of vibrations gradually decreasing?
- (iv) What happens to the vibrations of the body after sometime?

**Solution:**

- (i) Damped vibrations

- (ii) Example: A tuning fork when stroked on a rubber pad, executes the damped vibrations in air.
- (iii) The amplitude of vibrations decreases due to the frictional force. The energy of the vibrating body continuously dissipates in doing work against the force of friction. Hence, its amplitude gradually decreases.
- (iv) After some time it stops vibrating when it has lost all its energy.

**Question: 16**

**A tuning fork is set into vibrations in air. Name the kind of vibrations it executes.**

**Solution:**

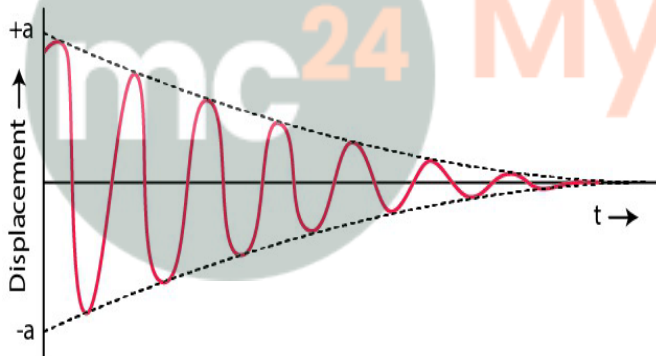
A tuning fork executes damped vibrations in air

**Question: 17**

**Draw a sketch showing the displacement of a body executing damped vibrations, against time.**

**Solution:**

The displacement time graph of damped vibrations shown below



**Question: 18**

**What are the forced vibrations? Give one example to illustrate your answer.**

**Solution:**

Forced vibrations are the vibrations of a body which take place under the influence of an external periodic force acting on it. When an artist plays a guitar he forces the strings of the guitar to execute forced vibrations.

**Question: 19**

**On keeping the stem of a vibrating tuning fork on the surface of a table, a loud sound is heard. Give reason.**

**Solution:**

The tuning fork produces the forced vibrations in the table top when the stem of a vibrating tuning fork is pressed against the top of a table. We hear a loud sound called resonance when the frequency of the periodic force applied on a body is equal to the natural frequency of that body. Hence because of this resonance a loud sound is heard on keeping the stem of a vibrating tuning fork on the surface of a table.

**Question: 20**

**State two differences between the natural and forced vibrations**

**Solution:**

- (i) Free vibrations occur when a body is displaced from its equilibrium position and released while the forced vibration are produced by an external periodic force of any frequency.
- (ii) Amplitude in free vibrations decreases with time and in forced vibration amplitude is small but remain constant as the force is acting.

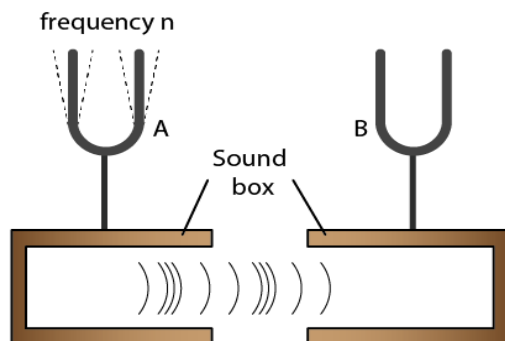
**Question: 21**

**What is meant by resonance? Describe a simple experiment to illustrate the phenomenon of resonance and explain it.**

**Solution:**

When the frequency of the externally applied periodic force on a body is equal to its natural frequency, with an increased amplitude the body readily begins to vibrate. This phenomenon is known as ‘resonance’ and is a special case of forced vibrations.

Mount two identical tuning forks A and B, both having a same frequency on two separate sound boxes such that their open ends face each other as shown in below figure



The prong A of one of the tuning forks starts vibrating when it is struck on a rubber pad. On putting this tuning fork A on its sound box, the tuning fork B also starts vibrating and a loud sound is heard. It is due to the resonance, the vibrations are produced in B.

**Question: 22**

**State the condition for the resonance to occur.**

**Solution:**

Condition for resonance:

When the applied force causes forced vibration in the body and the frequency of the applied force is exactly equal to the natural frequency of the vibrating body, then the phenomenon called resonance occurs.

**Question: 23**

**Complete the following sentence:**

**Resonance is a special case of \_\_\_\_\_ vibrations, when frequency of the driving force is \_\_\_\_\_ natural frequency of the driven body.**

**Solution:**

Resonance is a special case of forced vibrations, when frequency of the driving force is equal to the natural frequency of the driven body.

**Question: 24**

**State two differences between the forced and resonant vibrations**

**Solution:**

Forced vibrations	Resonant vibrations
The amplitude of vibration is small	The amplitude of vibration is very large
The vibrations of the body are not in phase with the external periodic force.	The vibrations of the body are in phase with the external periodic force.

**Question: 25**

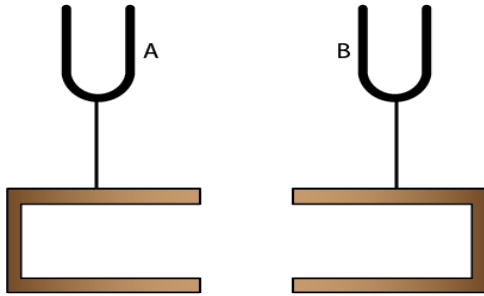
**Why is a loud sound heard at resonance?**

**Solution:**

The body vibrates with a large amplitude at resonance, sends forth a large amount of energy in the medium. Thus conveying more energy to the ear, a loud sound is heard.

**Question: 26**

**Figure shows two tuning forks A and B of the same frequency mounted on two separate sound boxes with their open ends facing each other. The fork A is set into vibration. (a) Describe your observation. (b) State the principle illustrated by this experiment.**



**Solution:**

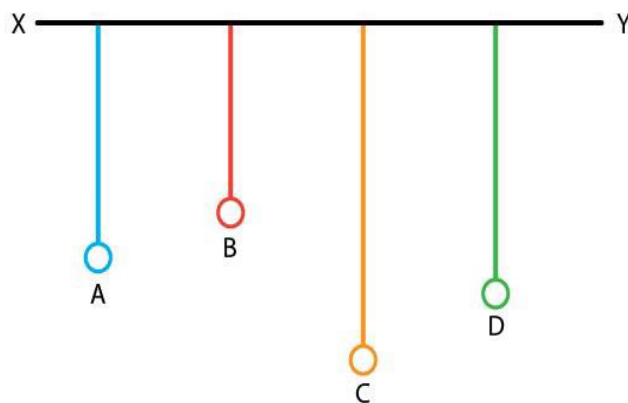
Forced vibrations are produced by the vibrating tuning fork A in the air column of its sound box. Due to the large surface area of air in the sound box, the vibrations are of large amplitude. They are communicated to the sound box of the fork B. The air column of B starts vibrating with the frequency of fork A. Since the frequency of these vibrations is same as the natural frequency of the fork B, the fork B picks up these vibrations and starts vibrating under resonance.

On putting the tuning fork A to vibrate, the other tuning fork B also starts vibrating. Due to the resonance the vibrations are produced in the second tuning fork B.

**Question: 27**

In figure A, B, C and D are the four pendulums suspended from the same elastic string XY. The lengths of pendulum A and D are equal, while the length of pendulum B is shorter and of the pendulum C is longer. The pendulum A is set into vibrations.

- What is your observation about the vibrations of pendulum D?
- Give reason for your observation in part (a).
- What type of vibrations take place in pendulums B and C?
- Give reason for the answer in part (c)



**Solution:**

Set the pendulum A, normal to its length into vibration by displacing it to one side. It is

observed that pendulum D starts vibrating initially with a small amplitude and ultimately it acquires the same amplitude as the pendulum A had initially. Since the total energy is constant, as the amplitude of the pendulum D becomes maximum, the amplitude of the pendulum A becomes minimum. After some time the amplitude of the pendulum D will decrease and the amplitude of A increases. Only between the pendulums A and D, the exchange of energy takes place as their natural frequencies are same. Also, the pendulums B and C vibrate with very small amplitudes.

The vibrations produced in pendulum A are communicated as forced vibrations to the other pendulums B, C and D through XY. The pendulum D comes in the state of resonance while the pendulums B and C remain in the state of forced vibrations.

**Question: 28**

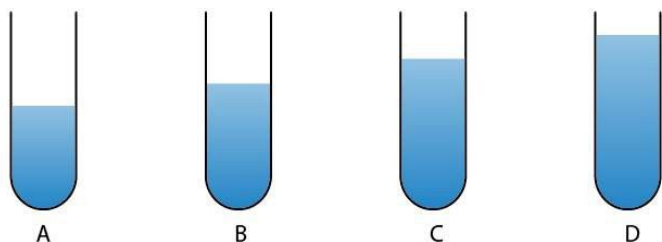
**A vibrating tuning fork, held over an air column of a given length with its one end closed, produces a loud audible sound. Name the phenomenon responsible for it and explain the observation.**

**Solution:**

The phenomenon responsible for producing a loud audible sound when a vibrating tuning fork, held over an air column of a given length with its one end is known as resonance. Forced vibrations in the air column are caused by the vibrating tuning fork. A loud sound is heard for a certain length of air column. This happens when the frequency of the air column becomes equal to the frequency of the tuning fork.

**Question: 29**

**In figure A, B, C and D represent the test tubes each of height 20 cm which are filled with water up to heights of 12 cm, 14 cm, 16 cm and 18 cm respectively. If a vibrating tuning fork is placed over the mouth of test tube D, a loud sound is heard.**



- Describe the observations with the tubes A, B and C when the vibrating tuning fork is placed over the mouth of these tubes.**
- Give the reason for your observation in each tube.**
- State the principle illustrated by the above experiment.**

**Solution:**

(a) No loud sound is heard with the tubes A and C, but a loud sound is heard with the tube B.

(b) Frequency of air column in tube D is equal to the frequency of tuning fork. Resonance occurs with the air column in tube B whereas no resonance occurs with the air column of tubes A and C. The frequency vibrations of air column in tube B is same as the frequency of vibrations of air column in tube D because the length of air column in tube D is  $20 - 18 = 2$  cm and that in tube B is  $20 - 14 = 6$  cm. But the frequency of vibrations of air column in tubes A and C is not equal to the frequency vibrations of air column in tube B

(c) Resonance occurs when the frequency of vibrations of air column is equal to the frequency of the vibrating tuning fork.

**Question: 30**

**When a troop crosses a suspension bridge, the soldiers are asked to break their steps. Why?**

**Solution:**

While the soldiers march in steps, all the separate periodic forces exerted by them are in same phase and hence in the bridge forced vibrations of a particular frequency are produced. If the natural frequency of the bridge happens to be equal to the frequency of the steps, due to resonance the bridge will vibrate with large amplitude and suspension bridge could crumble. Thus when a troop crosses a suspension bridge, the soldiers are asked to break steps.

**Question: 31**

**Why are the stringed instruments like guitar provided with a hollow sound box?**

**Solution:**

The sound box is constructed in such a way that the column of air inside it, has a natural frequency which is same as that of the string stretched on it, so that when the strings vibrate, the air column inside the box is set into forced vibrations. Sound box sets a large volume of air into vibration due to its large area, the frequency of which is same as that of the string. Hence, a loud sound is produced due to resonance.

**Question: 32**

**How do you tune your radio set to a particular station? Name the phenomenon involved in doing so and define it.**

**Solution:**

To tune a radio receiver, we only adjust the values of the electronic components to produce vibrations of frequency equal to that of the radio waves which we want to receive. When both the frequencies match, the energy of the signal of that particular

frequency is received from the incoming waves due to resonance. The signal received is then amplified in the receiver set.

This phenomenon associated resonance and is a special case of forced vibrations. When the frequency of an externally applied periodic force on a body is equal to its natural frequency, the body quickly begins to vibrate with an increased amplitude. This phenomenon is called as resonance.

### **MULTIPLE CHOICE TYPE**

#### **Question: 1**

**A wire stretched between two fixed supports is plucked exactly in the middle and then released. It executes (neglect the resistance of the medium):**

- (a) Resonant vibrations**
- (b) natural vibrations**
- (c) Damped vibrations**
- (d) Forced vibrations**

#### **Solution:**

A wire stretched between the two fixed supports, is plucked exactly in the middle and then released. It executes natural vibrations.

#### **Question: 2**

**When a body vibrates under a periodic force, the vibrations of the body are:**

- (a) natural vibrations**
- (b) Damped vibrations**
- (c) Forced vibration**
- (d) Resonant vibrations**

#### **Solution:**

When a body vibrates under a periodic force, the vibrations of the body are forced vibrations

#### **Question: 3**

**A tuning fork of frequency 256 Hz will resonate with another tuning fork of frequency:**

- a. 128 Hz**
- b. 256 Hz**
- c. 384 Hz**
- d. 512 Hz**

#### **Solution:**

A tuning fork of frequency 256 Hz will resonate with another tuning fork of frequency 256 Hz