Date: 24/9/2021

Q1. Why are the ceilings of concert halls curved?

Q2. The frequency of a source of sound is 100 Hz. How many times does it vibrate in a minute?

Q3. Which characteristic of the sound helps you to identify your friend by his voice while sitting with others in a dark room?

Q4. In which of the three media, air, water or iron, does sound travel the fastest at a particular temperature?

Q5. Guess which sound has a higher pitch: guitar or car horn?

Q6. Suppose you and your friend are on the Moon. Will you be able to hear any sound produced by your friend?

Q7. Why are sound waves called mechanical waves?

Q8. Explain, how sound is produced by your school bell.

Q9. What is sound and how is it produced?

Q10. What is the audible range of the average human ear?

Q11. What is the range of frequencies associated with (a) Infrasound, (b) Ultrasound?

Q12. Which wave property determines (a) loudness, (b) pitch?

Q13. How does the sound produced by a vibrating object in a medium reach your ear?

Q14. What are wavelength, frequency, time period and amplitude of a sound wave?

Q15. How are the wavelength and frequency of a sound wave related to its speed?

Q16. A person has a hearing range from 20 Hz to 20 kHz. What are the typical wavelengths of sound waves in air corresponding to these two frequencies? Take the speed of sound in air as 344 $m\,s^{-1}$.

Q17. Why is sound wave called a longitudinal wave?

Q18. A person is listening to a tone of 500 Hz sitting at a distance of 450 m from the source of sound. What is the time interval between successive comperessions from the source?

Q19. Calculate the wavelength of a sound wave whose frequency is 220 Hz and speed is 440 m/s in a given medium.

Q20. When a sound is reflected from a distant object, an echo is produced. Let the distance between the reflecting surface and the source of sound production remains the same. Do you hear echo sound on a hotter day?

Q21. An echo returned in 3 s. What is the distance of the reflecting surface from the source, given that the speed of sound is 342 $m\,s^{-1}$?

Q22. What is loudness of sound? What factors does it depend on?

Q23. Two children are at opposite ends of an aluminium rod. One strikes the end of the rod with a stone. Find the ratio of times taken by the sound wave in air and in aluminium to reach the second child.

Q24. How is ultrasound used for cleaning?

Q25. Explain, how bats use ultrasound to catch a prey.

Q26. A submarine emits a sonar pulse, which returns from an underwater cliff in 1.02 s. If the speed of sound in salt water is 1531 m/s, how far away is the cliff?

Q27. Flash and thunder are produced simultaneously. But thunder is heard a few seconds after the flash is seen, why?

Q28. What is reverberation? How can it be reduced?

Q29. Give two practical applications of reflection of sound waves.

Q30. A sonar device on a submarine sends out a signal and receives an echo 5 s later. Calculate the speed of sound in water if the distance of the object from the submarine is 3625 m.

Q31. Explain, how defects in a metal block can be detected using ultrasound.

Q32. Cite an experiment to show that sound needs a material medium for its propagation.

Q33. Describe with the help of a diagram, how compressions and rarefactions are produced in air near a source of sound.

Q34. Does sound follow the same laws of reflection as light does? Explain.

Q35. A sound wave travels at a speed of 339 m s^{-1}. If its wavelength is 1.5 cm, what is the frequency of the wave? Will it be audible?

Q36. Distinguish between loudness and intensity of sound.

Q37. Explain how human ear works.

Q38. Explain the working and application of SONAR.

Q39. A stone is dropped from the top of a tower 500 m high into a pond of water at the base of the tower. When is the splash heard at the top? Given, $g = 10$ m s^{-2} and speed of sound = 340 m s^{-1}.

Date: 24/9/2021

S1. The ceilings of concert halls are curved so that sound after reflection from the ceilings reaches all corners of the hall.

S2. Frequency of sound source $\nu = 100$ Hz, time $t = 1$ minute = 60 s

$\therefore$ Total number of vibrations made $n = \nu \times t = 100 \times 60 = 6000$.

S3. The characteristic 'Quality' (also known as Timbre) helps us to identify our friend by his voice, although we are not actually seeing him.

S4. Out of the given media, sound travel fastest through iron and slowest through air at a particular temperature.

S5. Pitch of a modern (electronic type) car horn is much higher than that of a guitar.

S6. No, we shall not be able to hear any sound produced by our friend because there is no atmosphere on the Moon. Without air medium sound wave cannot reach from our friend's mouth to our ear.

S7. Sound waves require a medium, solid or liquid or gas for their propagation and cannot travel without a medium. The velocity of sound in a medium depends on its mechanical properties. Hence, sound waves are called mechanical waves.

S8. The school bell consists of a big size circular metallic disc suspended from a rigid support. When the school peon strikes at the middle of bell of a wooden hammer or a metallic rod, solid particles of school bell start oscillating to and fro and as a result, sound is produced.

S9. Sound is a form of energy which causes sensation of hearing in our ears. Sound is produced due to vibrations (oscillations) of different objects.

S10. For an average human ear the audible range extends from 20 Hz to 20000 Hz (or 20 kHz).

S11. (a) Sounds of frequencies below 20 Hz are called infrasound.

(b) Ultrasounds have a frequency greater than 20 kHz.

S12. (a) Loudness of a sound depends on the amplitude of sound wave oscillations. Greater the amplitude more louder the sound is.

(b) Pitch depends on the frequency of sound waves. As frequency increases, the pitch of sound increases and the sound appears shriller one.

S13. The sound produced by a vibrating object in a medium reaches our ear through setting up of a wave motion in the medium

When an object vibrates, it sets the particles of the medium around it vibrating. A particle of the medium in contact with the vibrating object is first displaced from its equilibrium position. It then exerts a force on the adjacent particles and gets the adjacent particles displaced from its position of rest. After displacing the adjacent particles the first particle comes back to its original position. The process continues in the medium till the sound reaches our ear.

S14. **Wavelength:** The distance between centres of two consecutive compressions or centres of two consecutive rarefactions is called the ***wavelength***. Wavelength is generally denoted by Greek letter λ. Alternately, wavelength is the distance through which a wave is propagated during the time of one complete oscillation. Its SI unit is 1 metre (m).

Frequency: The number of complete oscillations per unit time is called the ***frequency of the wave***. It can be easily shown that

$$\text{Frequency } (\nu) = \frac{1}{\text{Time period}} = \left(\frac{1}{T}\right) \quad \text{or} \quad \nu \cdot T = 1.$$

SI unit of frequency is 1 hertz (1 Hz). Frequency is said to be 1 Hz, if one complete oscillation takes 1 s.

Time period: The time taken by a wave for one complete oscillation of the density (or pressure) of the medium is called the ***time period (T)***.

Amplitude: The magnitude of the maximum disturbance (in density or pressure) in the medium on either side of the mean value is called the ***amplitude of the wave (A)***. The amplitude of sound wave produced by an oscillatiing object depends upon the magnitude of force with which the object is made to oscillate. Its SI unit is "pascal" (Pa).

S15. The wavelength (λ) and frequency (ν) of a sound wave are related to its speed (v) according to the relation:

$$\text{Speed of sound } (v) = \text{Frequency } (\nu) \times \text{Wavelength } (\lambda).$$

S16. $\because$ Speed of sound in air $v = 344 \text{ m s}^{-1}$

Frequency of hearing range is from $\nu_1 = 20$ Hz to $\nu_2 = 20$ kHz.

If frequency is ν_1 then typical wavelength of sound waves in air

$$\lambda_1 = \frac{v}{\nu_1} = \frac{344}{20} = 17.2 \text{ m}$$

and the typical wavelength for frequency ν_2 is

$$\lambda_2 = \frac{v}{\nu_2} = \frac{344}{20 \times 10^3} = 1.72 \times 10^{-2} \text{ m} \quad \text{or} \quad 0.0172 \text{ m}.$$

S17. Sound waves propagate in a medium as a series of compressions and rarefactions and particles of medium move in a direction parallel to the direction of propagation of the wave. Therefore, sound wave is called a longitudinal wave.

S18. Here, frequency of sound $\nu = 500$ Hz.

$\therefore$ Time interval between successive compressions from the source

$\therefore$ $$\text{Time period } (T) = \frac{1}{\nu} = \frac{1}{500} \text{ s} = 0.002 \text{ s}.$$

[***Note:*** Time interval between successive compressions does not depend on the position of a person listening the sound.]

S19. Here, speed of sound $v = 440$ m/s and frequency $\nu = 220$ Hz

$\therefore$ $$\text{Wavelength of sound wave } \lambda = \frac{v}{\nu} = \frac{440}{220} = 2\text{m}.$$

S20. When a sound is reflected from a distant object situated at a distance d, the echo is produced due to reflected sound. The time of echo is given by $t = \frac{2d}{v}$, where v is speed of sound.

On a hotter day, the speed of sound will be comparatively more. As a result, the echo sound will be heard after a lesser time. It means that echo sound is heard sooner on a hotter day than on a colder day for a given distance between the sound source and reflecting surface.

S21. Here, TIme of echo $t = 3$ s, Speed of sound $v = 342$ m s^{-1}

∴ Distance of the reflecting surface from the source

$$d = \frac{vt}{2} = \frac{342 \times 3}{2} = 513 \text{ m.}$$

S22. Loudness of sound is that characteristic of given sound due to which we identify the sound to be loud or soft.

Within audible frequency range the loudness of sound depends on: (a) the amplitude of sound oscillations, and (b) response of the ear of listener to the sound.

S23. We know that at 25°C speed of sound in air $v_{\text{air}} = 346$ m s^{-1} and velocity in aluminium $v_{\text{Al}} = 6420$ m s^{-1}. Let length of rod be l m

∴ Time taken by sound to reach the second child through air

$$t_{\text{air}} = \frac{l}{v_{\text{air}}} = \frac{l}{346} \text{ s}$$

and time taken by sound to reach the second child through aluminium

$$t_{\text{Al}} = \frac{l}{v_{\text{Al}}} = \frac{l}{6420} \text{ s}$$

∴ $$\frac{t_{\text{air}}}{t_{\text{Al}}} = \frac{l/346}{l/6420} = \frac{6420}{346} = 18.55.$$

S24. The object to be cleaned is placed in a cleaning solution and ultrasonic waves are sent into the solution. Due to high frequency, the particles of dust, grease and dirt get detached and drop out in solution. The object thus gets cleaned throughly. The method is specially useful to clean spiral tubes, odd shaped parts, electronic components etc.

S25. Bats search out and catch a prey by emitting and detecting reflections of ultrasonic waves. The high frequency ultrasonic squaks of the bat are reflected from the prey and returned to bat's ear. The nature of reflection tells the bat where the prey is and what it is like. Thus, he can catch the prey.

S26. Here, time between transmission and detection of sonar pulse t = 1.02 s.

Speed of sound in salt water $v = 1531$ m s^{-1}.

∴ Distance of the submarine $d = \frac{vt}{2} = \frac{1531 \times 1.02}{2} = 780.9$ m

S27. In lightning process, flash and thunder are produced simultaneously. Flash is seen almost immediately because speed of light is extraordinarily large ($c = 3 \times 10^8$ m s^{-1}). But thunder is heard a few seconds later because speed of sound is much less (about 346 m s^{-1} at 25°C) and requires time to cover up the distance from the site of thunder in sky to us.

S28. Persistence of sound in an auditorium or big hall due to repeated reflection from the walls and roof is called 'reverberation of sound'. Excessive reverberation is undesirable. To reduce reverberation, the roofs and walls of the auditorium are covered with sound absorbent materials.

S29. Two practical applications of reflection of sound waves are given below:

(a) Megaphones, horns, trumpets etc., are designed to send sound in a particular direction without spreading it in all directions. In these devices, a tube followed by a conical opening reflects sound successively to guide the sound waves from the source in the forward direction towards the audience.

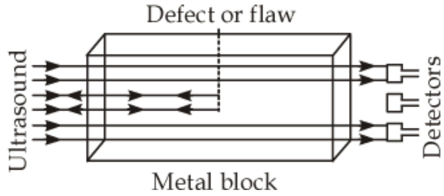
(b) In stethoscopes, the sound of the patient's heartbeat reaches the doctor's ears by multi reflection of sound inside the tube of stethoscope.

S30. Here, $d = 3625$ m and Time of echo $t = 5$ s

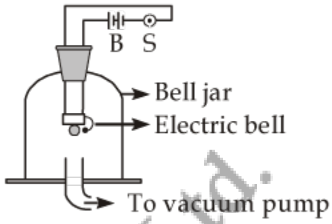
$\therefore$ $$t = \frac{2d}{v}$$

$\therefore$ Speed of sound in water $v = \frac{2d}{t} = \frac{2 \times 3625}{5} = 1450 \text{ m s}^{-1}$.

S31. To detect defects in a metal block, ultrasonic waves are passed through the metal block and detector are used to detect the transmitted waves. If there is even a small defect in the block, the ultrasonic waves are reflected back indicating the presence of defect or flaw in the object as shown in figure.



S32. Take an electric bell and an airtight glass bell jar. The bell is suspended inside the bell jar. The bell jar is connected to a vacuum pump as shown in figure. If your press the switch S of battery circuit, you will be able to listen the sound of bell clearly.

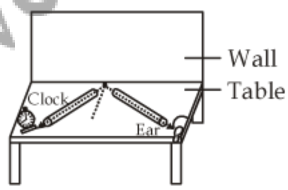


Now start the vacuum pump. As the air in the jar is pumped out gradually, the sound becomes fainter. When the air is completely ejected from the bell jar, no sound is being heard. Although, the bell is working alright and same current is passed through it, but no sound is being heard. It clearly shows that sound cannot travel without a material medium.

S33. Consider a tuning fork as the source to produce sound. When the prong of tuning fork vibrates outward as shown in figure (a), it pushes and compresses the air infront of it creating a region of high pressure, called a compression (*C*). This compression starts to move away from the tuning fork. When the prong of tuning fork moves backward, it creates a region of low pressure called rarefaction (*R*) as shown in figure (b) and consequently, the region of compression is transfrred forward. In this manner, compressions and rarefactions are produced in air near the vibrating tuning fork.

(a) **(b)** **(c)**

S34. Yes, sound follows the same laws of reflection as light does.



To explain it and to demonstrate it experimentally, we take two identical pipes and arrange them on a table near a wall. Keep a clock near the open end of one pipe. Try to hear the sound of clock by putting our ear near the open end of second pipe. Adjust the orientations of the pipes so that sound of clock is clearly heard at the open end of second pipe. Now measure the angle of incidence '*i*' and the angle of reflection '*r*'. We find that angle of incidence is equal to angle of reflection *i.e.*, $\angle i = \angle r$.

If we lift the 2nd pipe to a small height, then we are unable to listen the sound of clock. It shows that incident wave and reflected wave lie in same plane.

S35. Here, speed of sound $v = 339 \text{ m s}^{-1}$ and wavelength $\lambda = 1.5 \text{ cm} = \frac{1.5}{100}$ m .

$\therefore$ Frequency $\nu = \frac{v}{\lambda} = \frac{339}{1.5/100} = \frac{339 \times 100}{1.5} = 22600$ Hz.

S36.

Loudness of sound	Intensity of sound
(a) Loudness of sound is a measure of the response of the ear to the sound, whether it is loud or soft.	(a) Intensity of sound is the amount of sound energy passing per second through unit area.
(b) Loudness depends on the sensitivity of the ear.	(b) Intensity is a physical quantity and its magnitude does not depend on the sensitivity of the ear etc.
(c) Its unit is decibel.	(c) Its unit is W m^{-2}.

S37. The outer ear called 'pinna' collects the sound from the surroundings. The collected sound passes through the auditory canal, at the end of which there is thin membrane called the eardrum. When a compression of the medium reaches eardrum, the pressure on the outer side of membrane of eardrum increases and forces the eardrum inward. Similarly at the time of rarefaction, the eardrum mobes outward. Thus, eardrum begins to vibrate. Three bones of middle ear (the hammer, anvil and stirrup) amplify these vibrations. The middle ear transmits the amplified pressure variations to the inner ear. The inner ear converts the pressure variations into electrical signals. Auditory nerve then sends these electrical signals to the brain. Brain interprets them as sound.

S38. SONAR system consists of a transmitter and a detector and is installed on a ship or motorboat. The transmitter produces and transmits ultrasonic waves. These waves travel through water and strike the object beneath on the sea bed. The object reflects these waves and the reflected waves are sensed by the detector. The detector converts the ultrasonic waves into electrical signals. If d be the depth of the said object and be the velocity of ultrasonic waves in water, then time interval between transmission and reception of ultrasonic waves will be

$$t = \frac{2d}{v}.$$

By knowing the time t we can find the value of d.

SONAR technique is used to determine the depth of the sea and to locate underwater hills, valleys, submarine, iceberg, sunken ship etc.

S39. When stone is dropped from top of the tower, it takes a time t_1, to fall and strike the water surface in pond. As a result, the sound of splash is produced. The sound takes a time t_2 to travel upward up to the top of tower.

As here $h = 500$ m, $h = 10$ m s^{-2} and for stone $u = 0$

As stone is freely falling, its time t_1 is given by

$$h = ut_1 + \frac{1}{2} g t_1^2$$

$$\therefore \quad 500 = 0 \times t_1 + \frac{1}{2} \times (10) \times (t_1)^2 = 5t_1^2$$

$$\Rightarrow \quad t_1^2 = \frac{500}{5} = 100 \quad \text{or} \quad t_1 = \sqrt{100} = 10\,\text{s}$$

Now, the sound of splash travels with a constant speed $v = 340$ m s^{-1}.

$$\therefore \quad \text{Time } t_2 = \frac{h}{v} = \frac{500}{340} = 1.47\,\text{s}$$

$\therefore$ Time of hearing splash at the top of tower $t = t_1 + t_2 = 10 + 1.47 = 11.47$ s.