Module - 01

01 SOUND

02 WAVE MOTION

03 TYPES OF WAVES – ELECTROMAGNETIC WAVES AND MECHANICAL WAVES

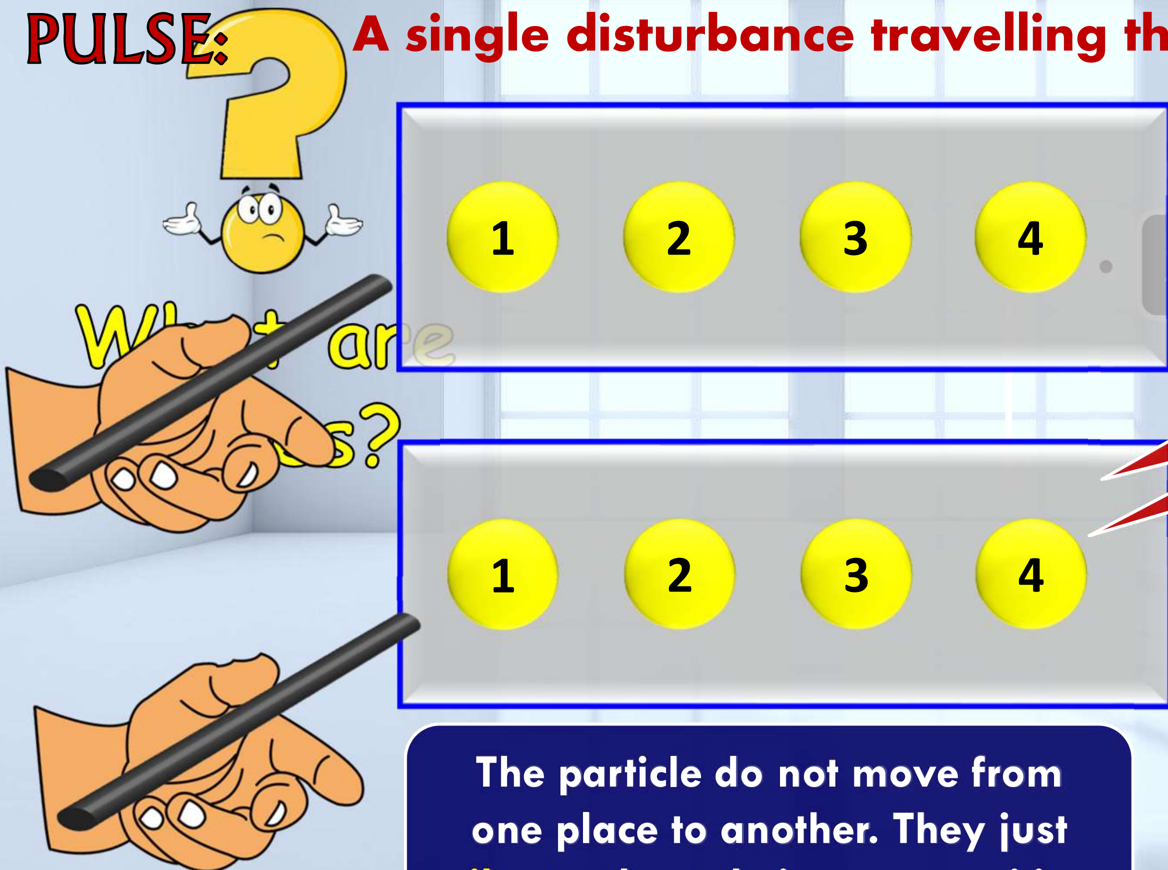
SOUND

Sound is a form of energy which produces sensation of hearing in our ears.

SOUND is produced by a vibrating source.

Sound travels in the form of wave

PULSE: A single disturbance travelling through a medium is a PULSE



If continuous disturbance is produced, the particles vibrate

This continuous motion forms a WAVE.

WAVE

A wave motion is a mode of transmission of energy through a medium.

The particle do not move from one place to another. They just vibrate about their mean position

Module - 02

Types of Waves

- Electromagnetic Wave
- Mechanical Or Elastic Waves

Mechanical waves

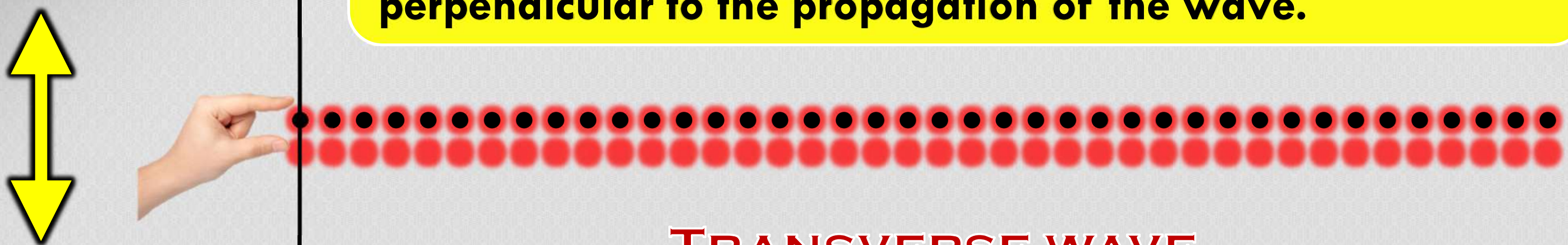
Waves which require a material medium like solid, liquid or gas

Transverse wave

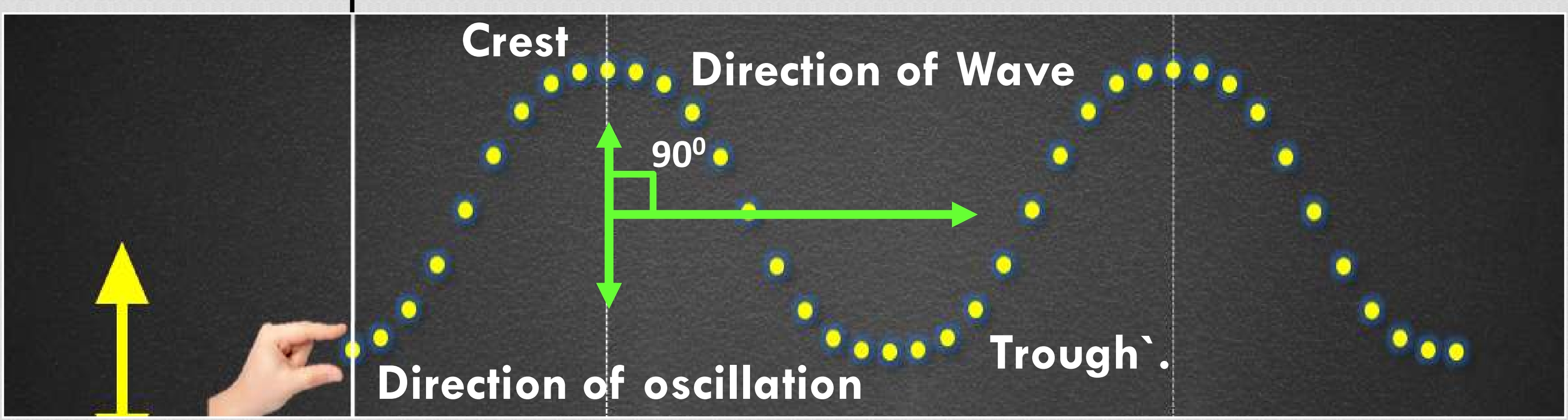
Longitudinal wave

Transverse wave

In **transverse waves**, the particles of the medium oscillate about their central or mean positions, in a direction perpendicular to the propagation of the wave.



TRANSVERSE WAVE

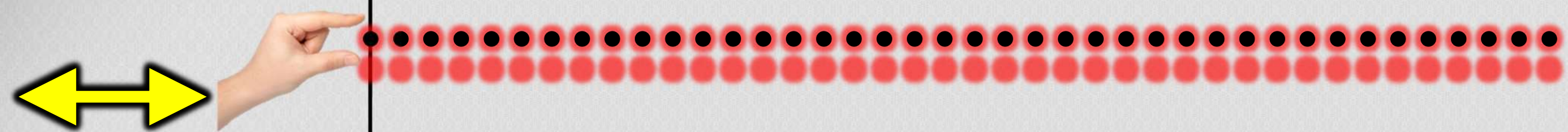


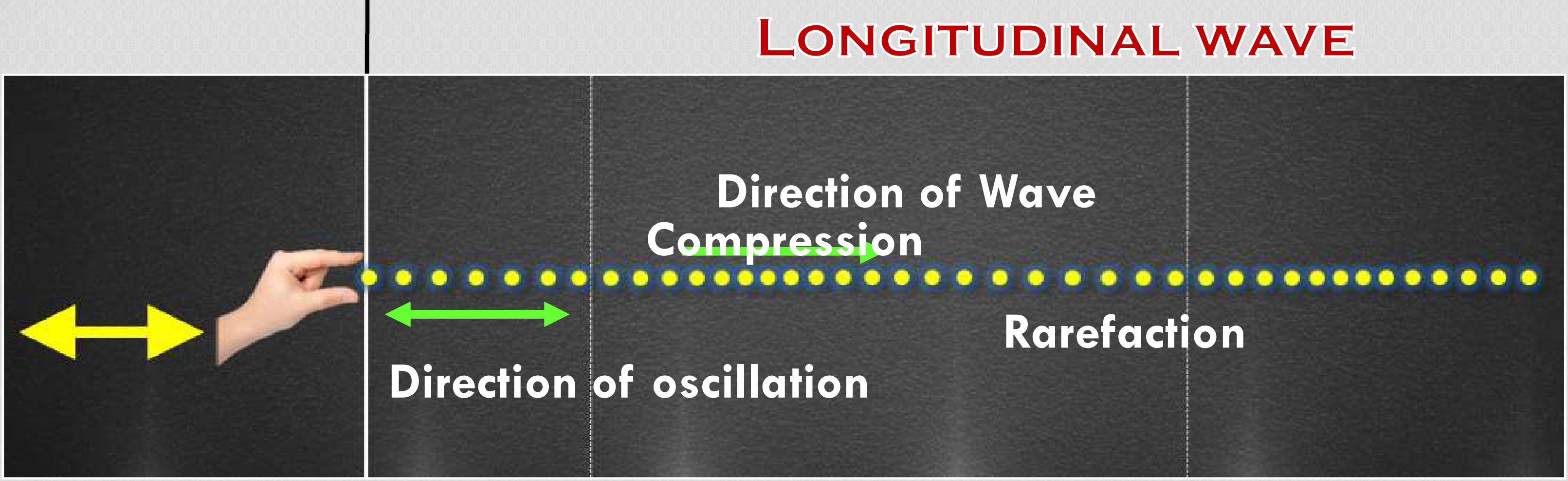
Mechanical waves

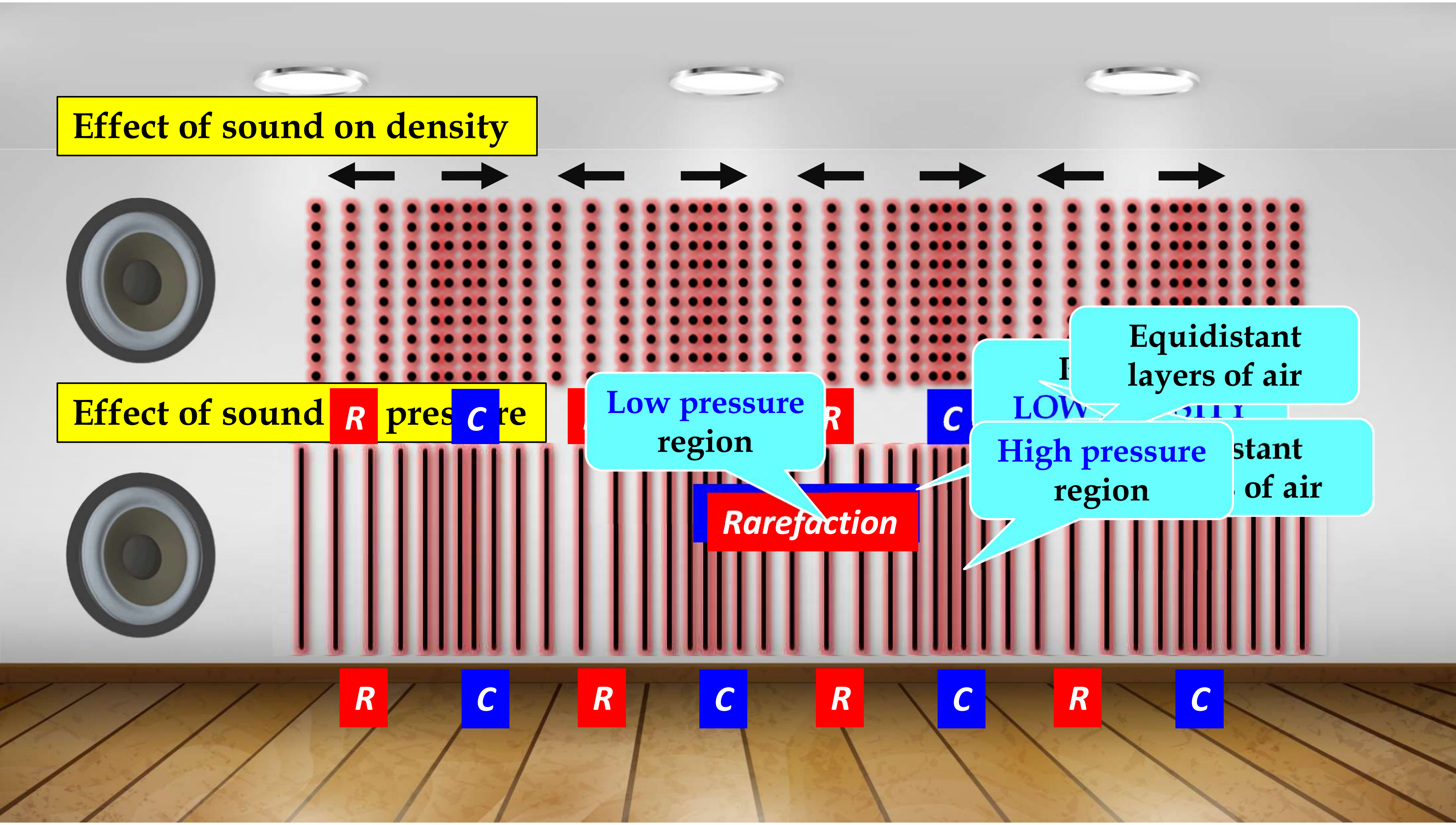
- Transverse wave
- Longitudinal wave

Longitudinal wave

In **longitudinal waves**, the particles of the medium oscillate about their central or mean positions, in a direction parallel to the propagation of the wave.

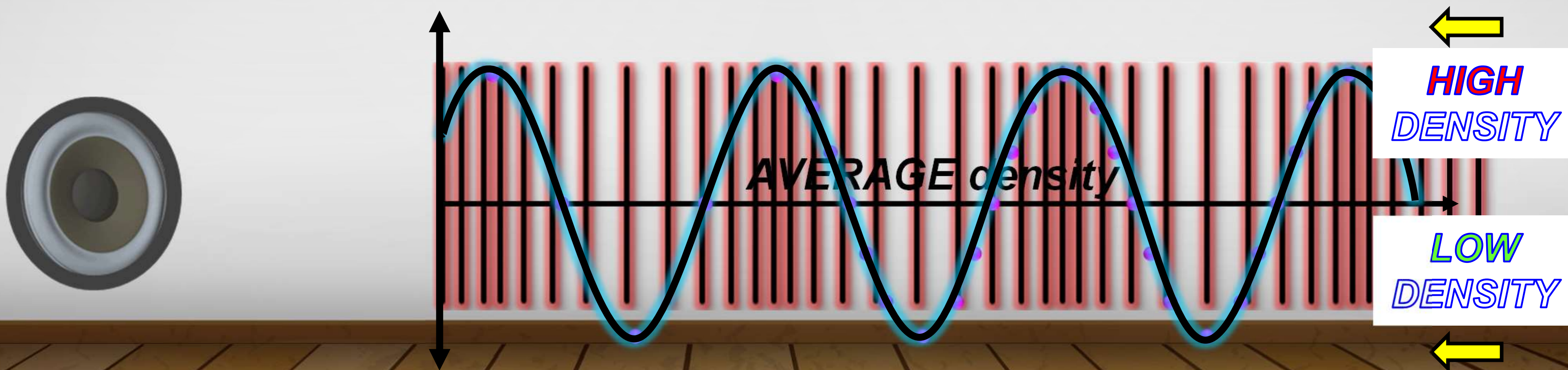






Effect of sound on density
Effect of sound
Low pressure region
Rarefaction
High pressure region
Equidistant layers of air
R
C
R
C
R
C
R
C

GRAPH FOR CHANGES IN DENSITY



Difference between Transverse wave & Longitudinal wave

TRANSVERSE WAVE

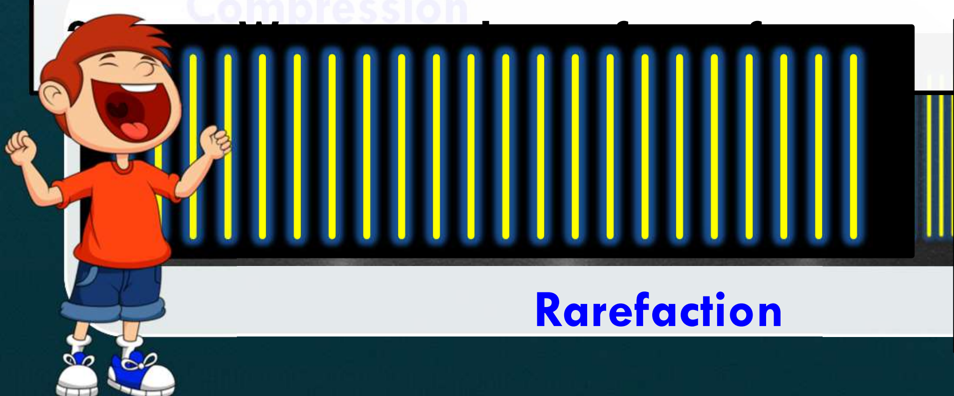
1. In **transverse waves**, the particles of the medium oscillate about their central or mean positions, in a direction perpendicular to the propagation of the wave.

2. It consist of **crest** and **trough**

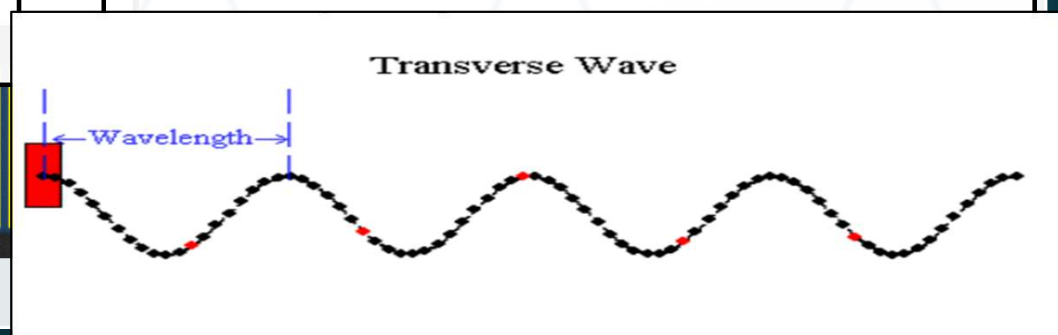
LONGITUDINAL WAVE

1. In **longitudinal waves**, the particles of the medium oscillate about their central or mean positions, in a direction parallel to the propagation of the wave.

2. It consist of **compressions** and rarefactions



Crest

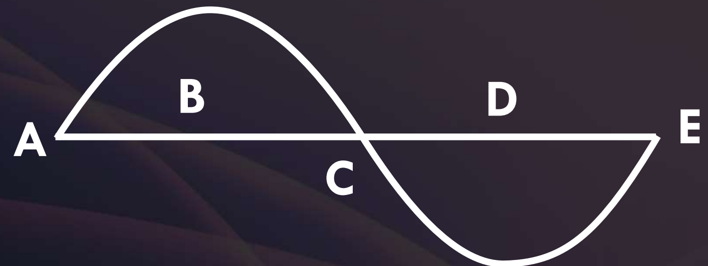


Q. Why are sound waves called mechanical waves?

Ans :

- Sound waves are called mechanical waves because they need a material medium, solid, liquid or gas, for their propagation.
- The sound waves involve vibration of particles of the medium through which they travel.

Q. In the given curve, half the wavelength is



(a) AB (b) BD (c) DE (d) AE

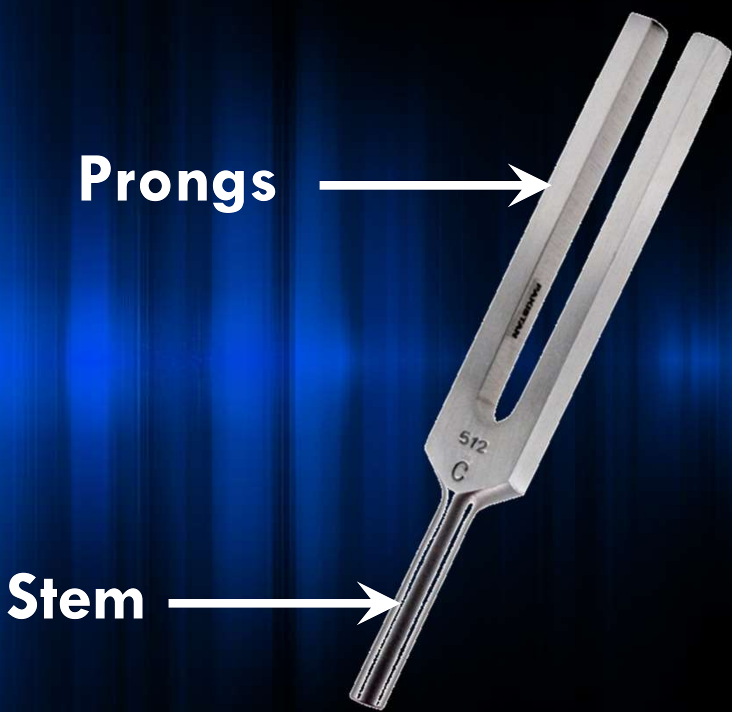
Module - 03

01 PROPAGATION OF SOUND THROUGH AIR

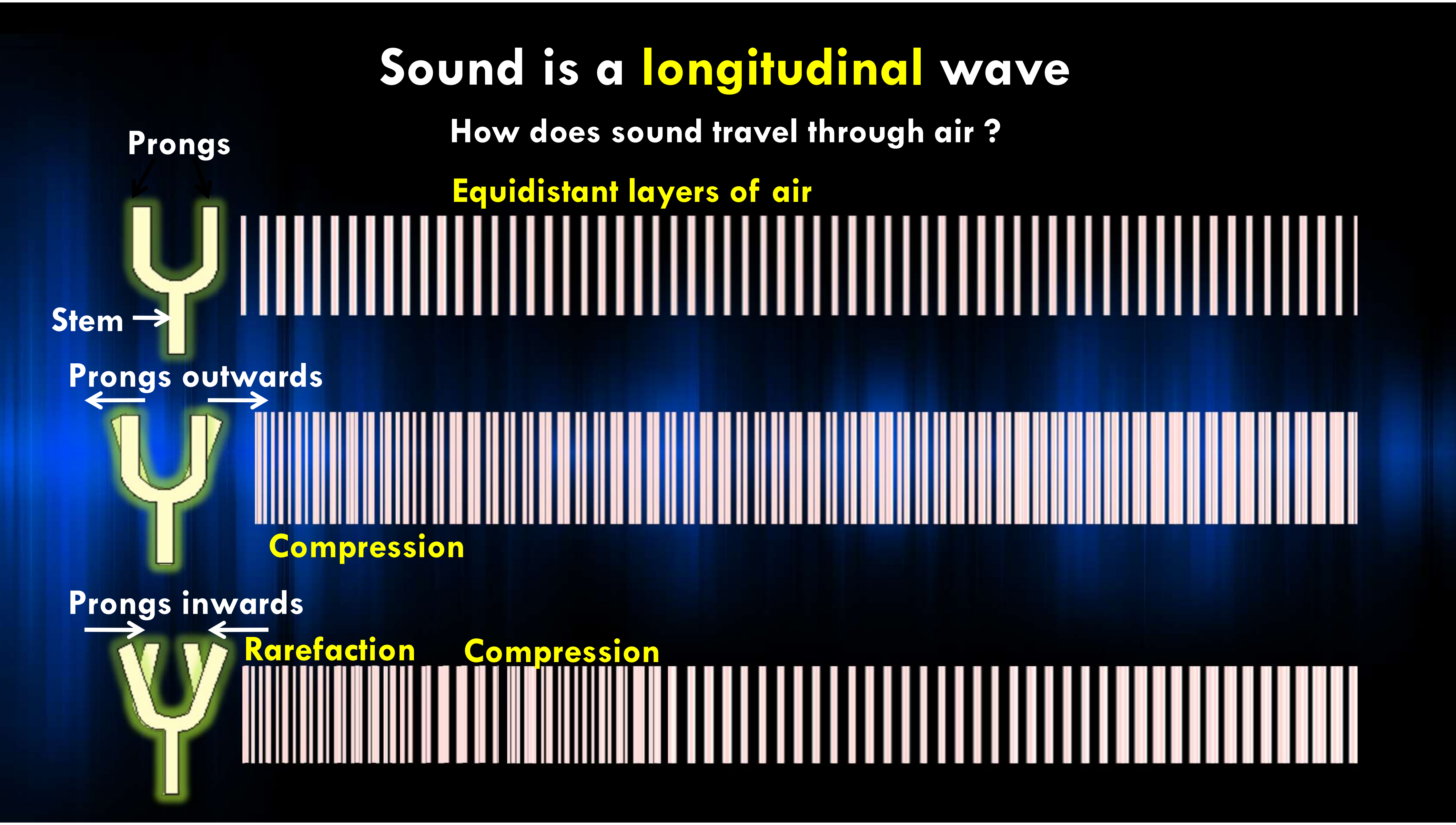
02 SOUND CANNOT TRAVEL THROUGH VACUUM

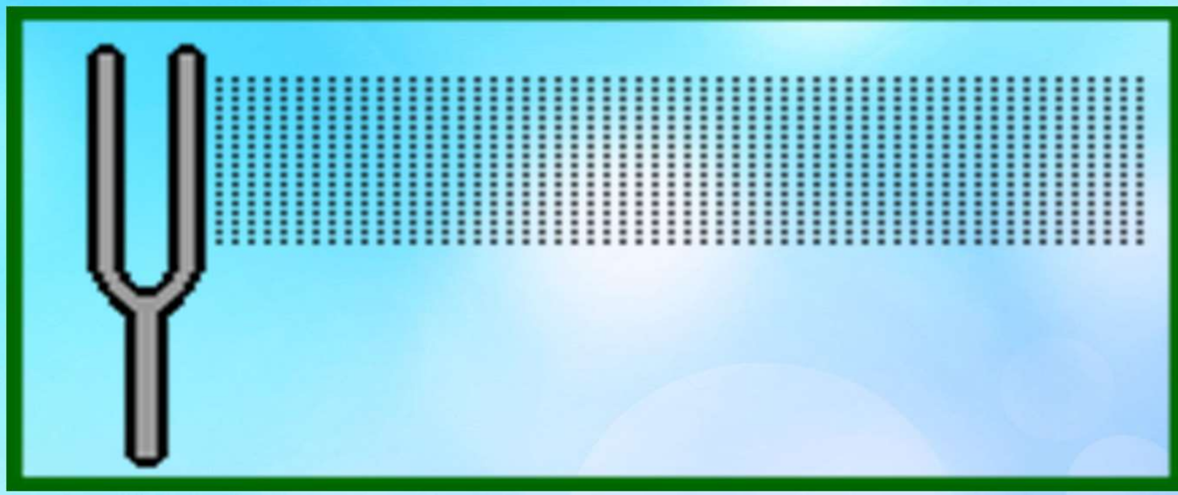
Sound is a longitudinal wave

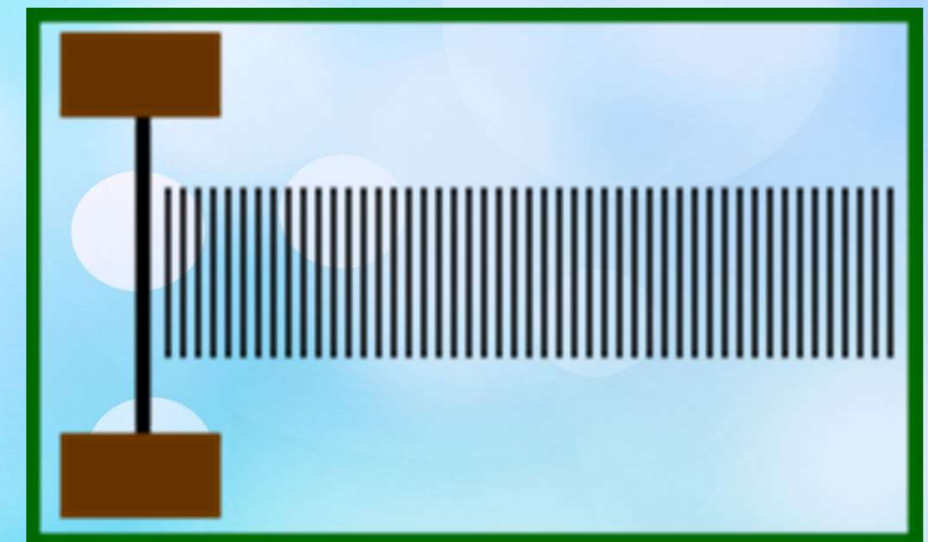
How does sound travel through air ?



TUNING FORK

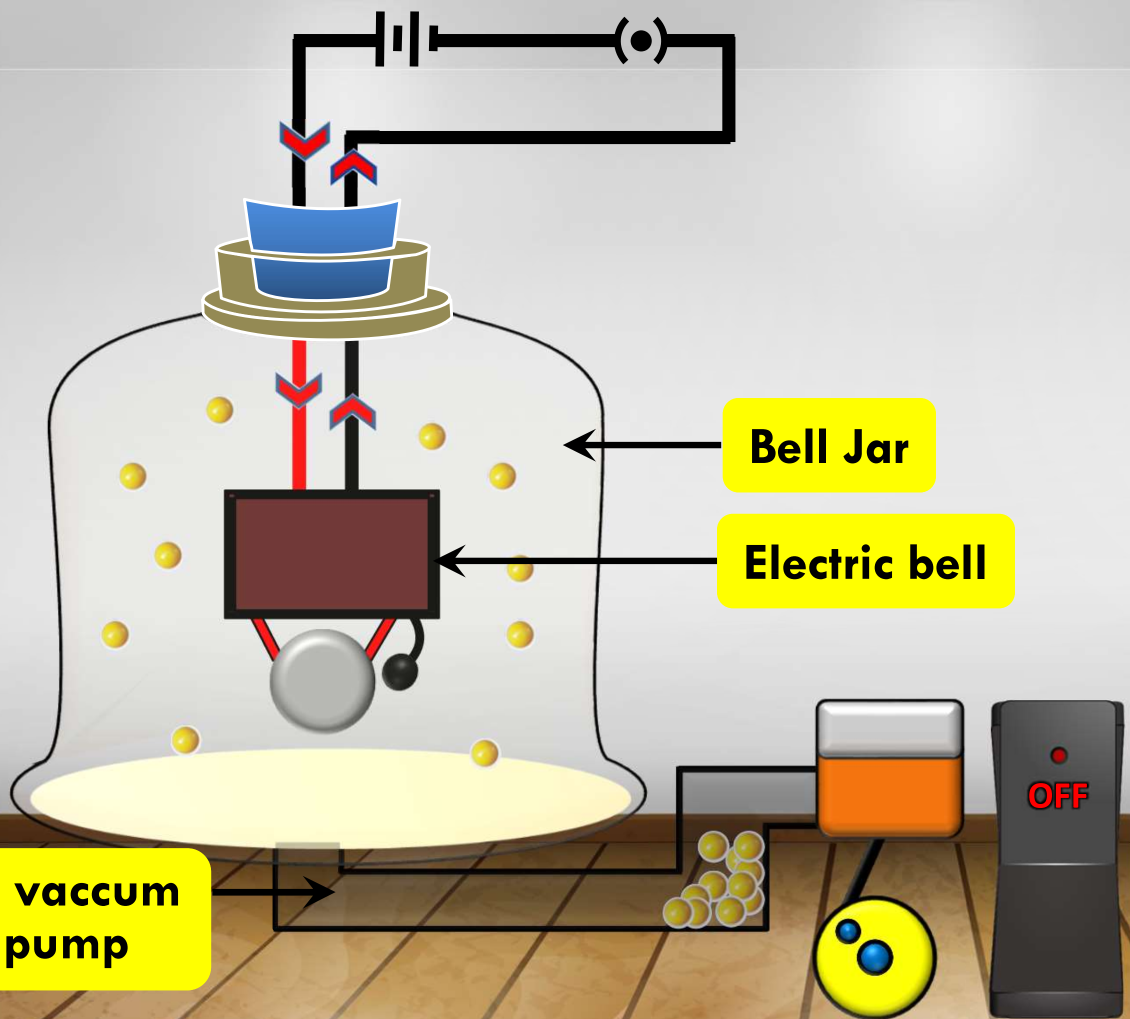

Sound is a longitudinal wave
How does sound travel through air ?
Prongs
Equidistant layers of air
Stem
Prongs outwards
Compression
Prongs inwards
Rarefaction
Compression





How does sound travel through air when we talk ?

To show that sound cannot travel through vacuum



Conclusion

Thus we can conclude that for the sound to be produced we require a material medium like air, water etc.

Q. A sound producing body is at a considerable distance from a man. There can be four different media W, X, Y, Z between the sound producing body and the man. The medium X brings the sound to a man most quickly whereas medium Z takes the maximum time. The time taken by medium W in bringing the sound to the man is less than that of X but more than that of Z. The medium Y, however, fails to bring the sound from the sound producing body to the man.

Which of the medium could be the one :

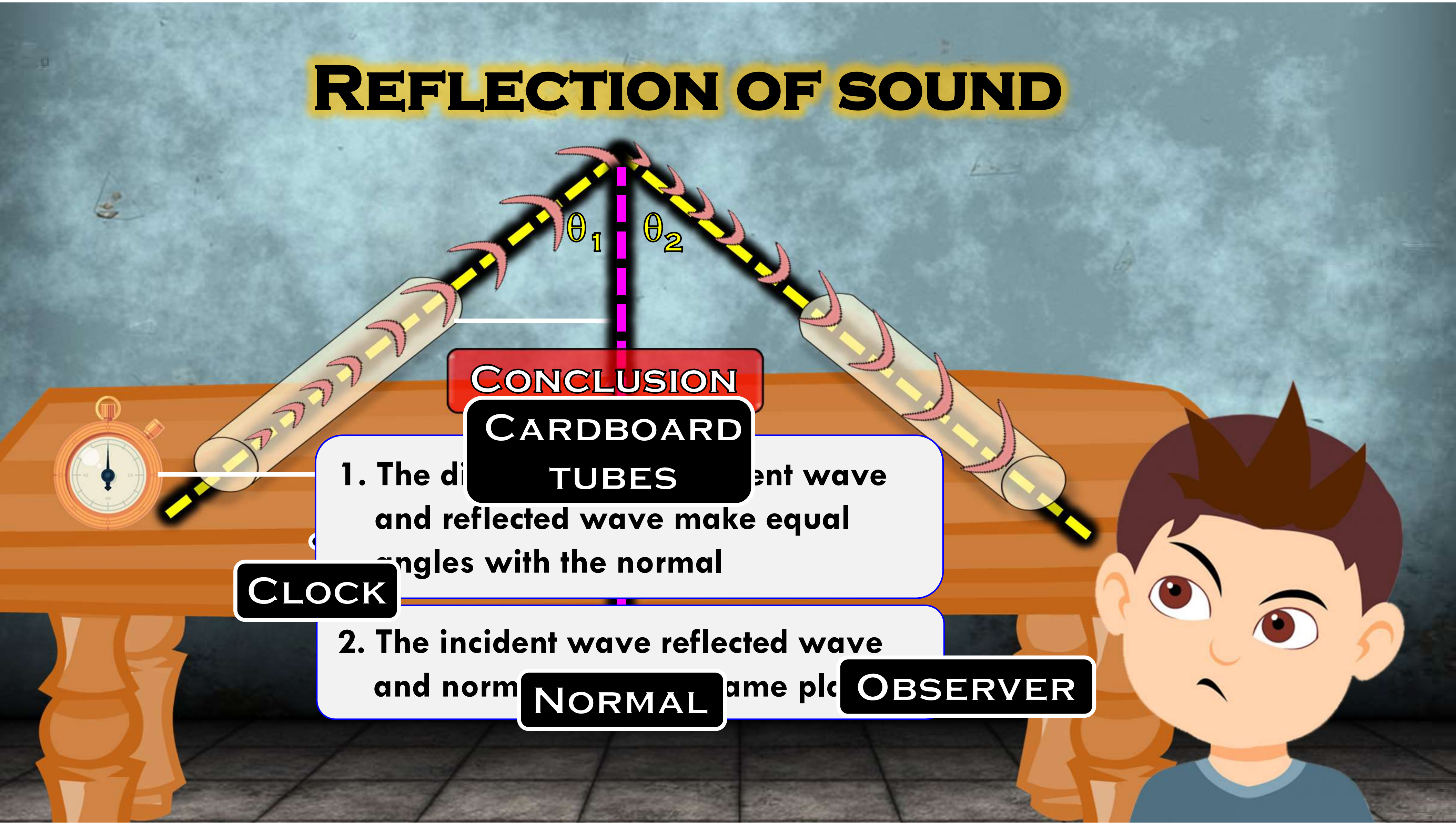
(a) Having no fixed shape and no fixed volume? — Medium Z (gas)

(b) Having a fixed volume but no fixed shape? — Medium W (liquid)

(c) Having same composition as that on moon? — Medium Y (vacuum)

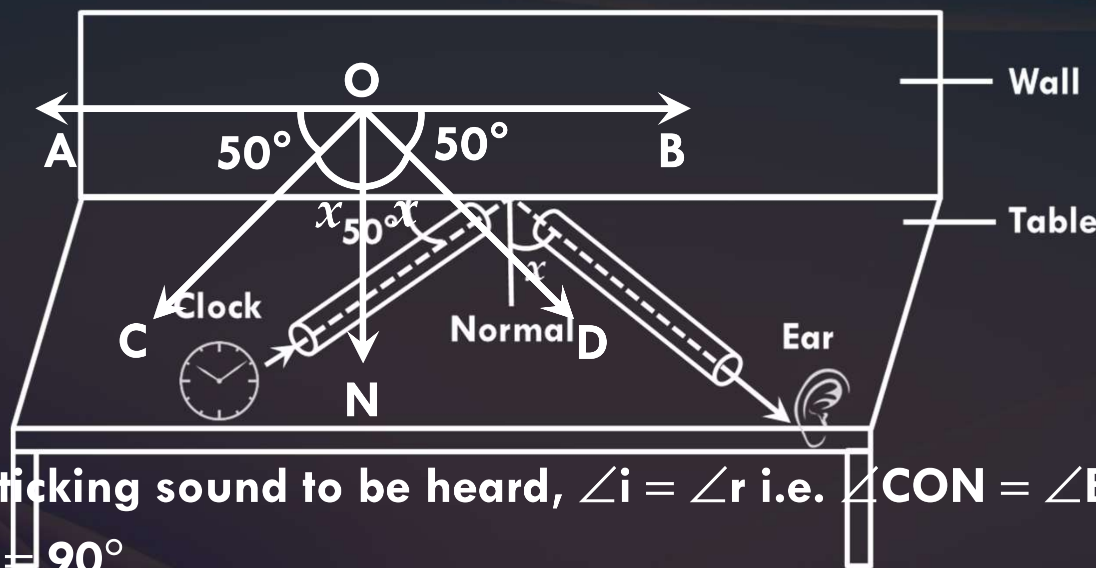
(d) Having fixed shape and a fixed volume? — Medium X (solid)

Module - 04



REFLECTION OF SOUND
θ1
θ2
CONCLUSION
CARDBOARD TUBES
1. The di
ent wave
and reflected wave make equal
ngles with the normal
CLOCK
2. The incident wave reflected wave
and norm
ame pl
NORMAL
OBSERVER

Q. For the loudest ticking sound to be heard by the ear, find the value of x in the figure.



For loudest ticking sound to be heard, $\angle i = \angle r$ i.e. $\angle CON = \angle BON = x$

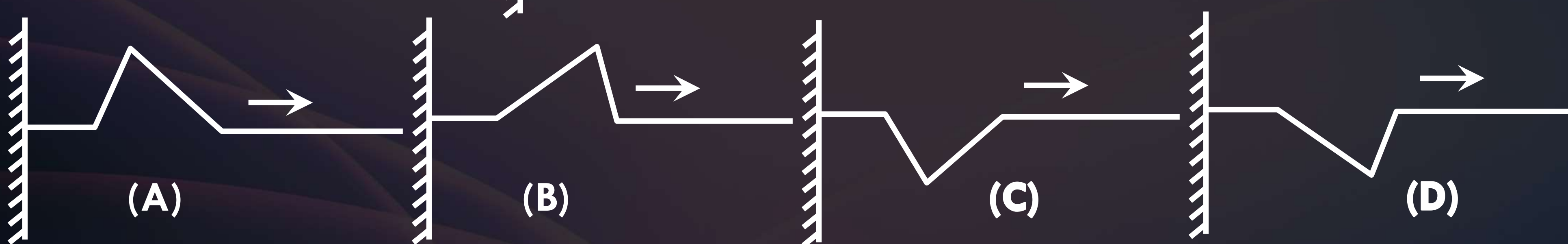
But, $\angle AON = 90°$

$\therefore \quad \angle AOC + \angle CON = 90°$

$50° + x = 90°$

$x = 90° - 50° = 40°$

Q. The figure given below shows an incident pulse P reflected from a rigid support. which out of the four represents the reflected pulse correctly.



(a) A (b) B (c) C (d) D

STUDY OF SOUND

- **Echo**
- **Conditions for echo**


ECHO
The repetition of sound due to reflection from a distant surface is called ECHO.

Conditions required to hear reflected sound clearly

- Echo can be heard only if the distance between the observer and the reflecting surface is at least **17.2 meters**.

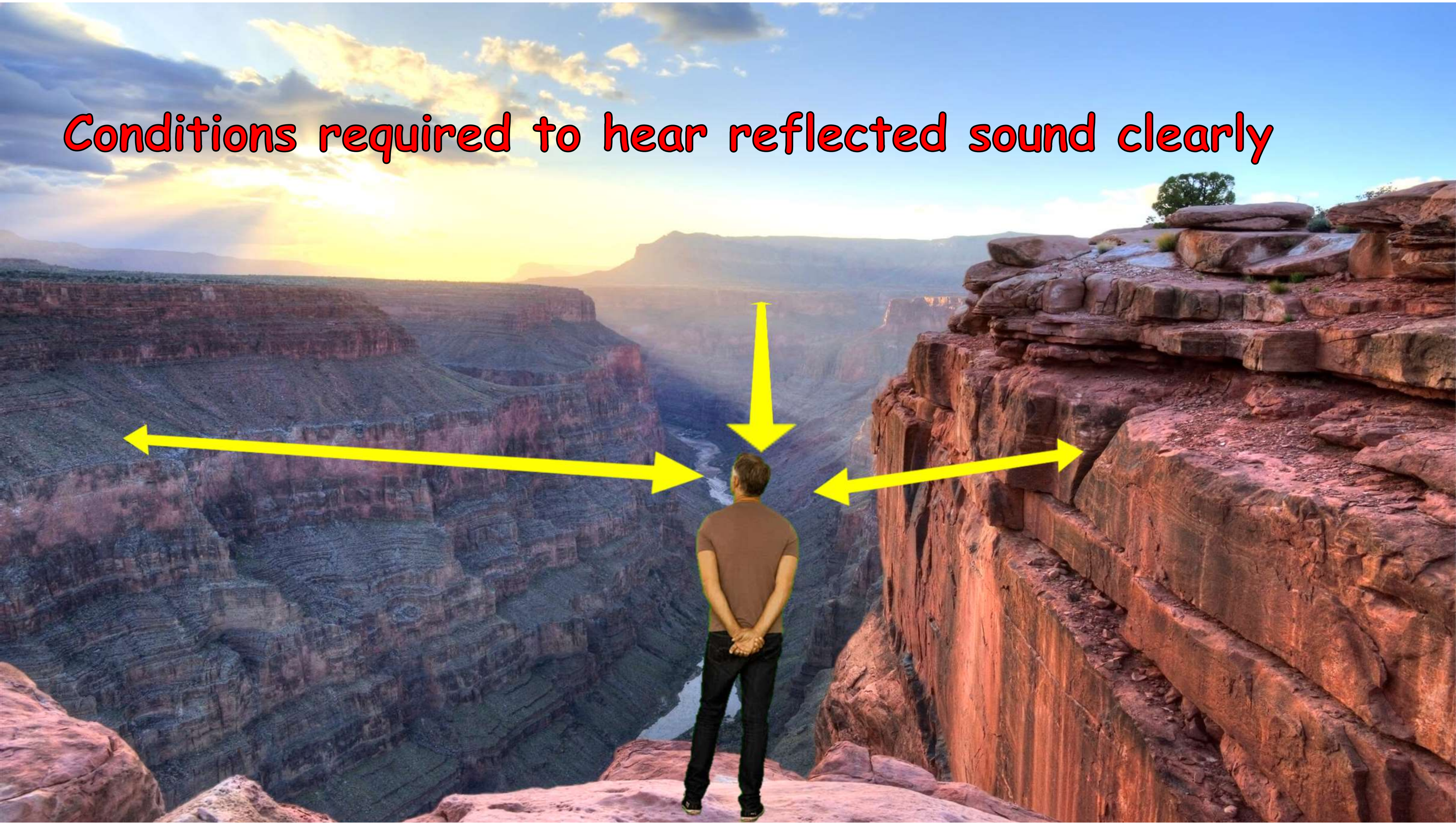
$$\text{velocity} = \frac{\text{distance}}{\text{time}}$$

$$\therefore \text{distance} = \text{velocity} \times \text{time}$$

$$\therefore \text{distance} = 344 \times 0.1$$

$$\therefore \text{distance} = 34.4 \text{ m}$$

velocity of sound in air = 344 m/s


Conditions required to hear reflected sound clearly

Conditions required to hear reflected sound clearly

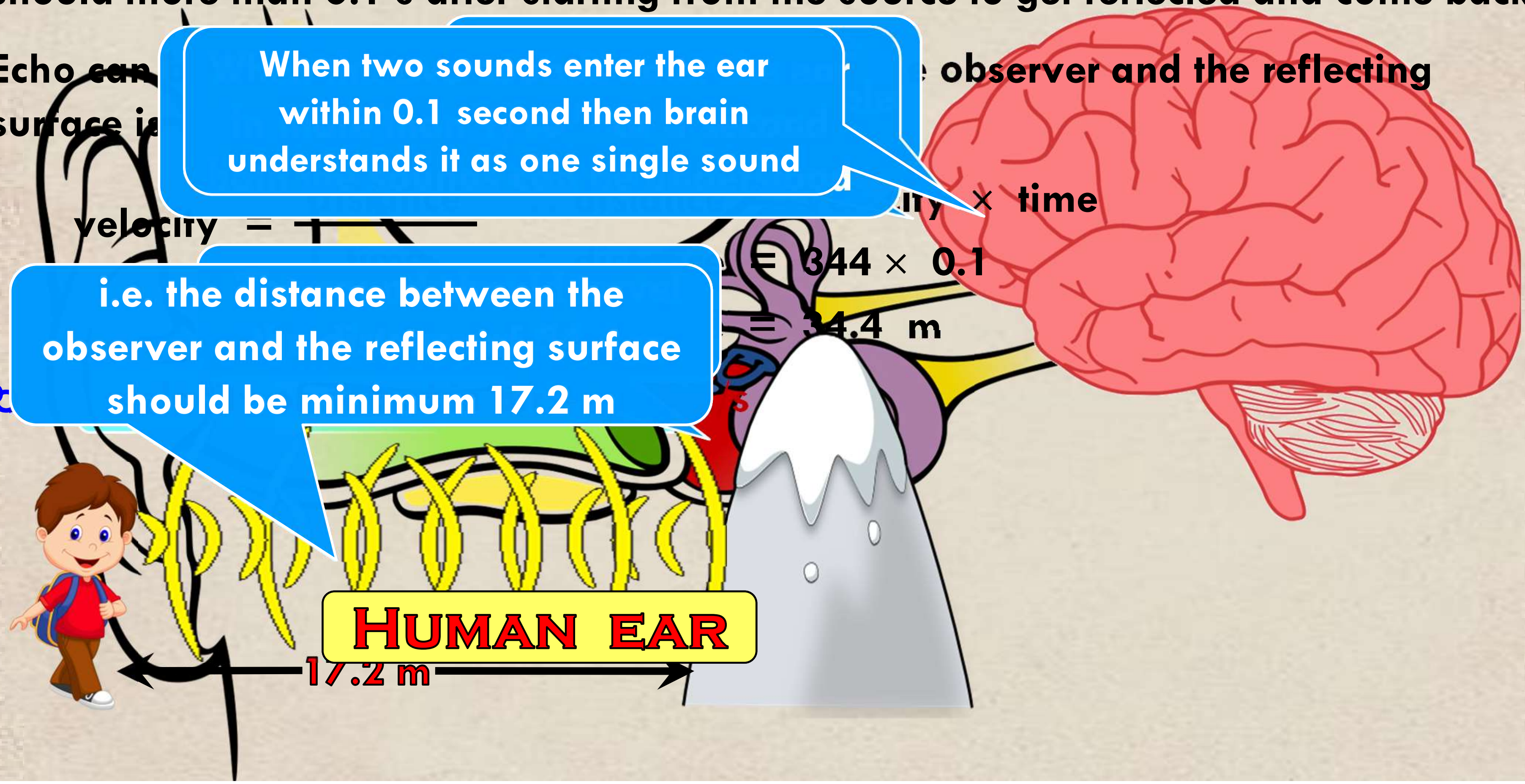
- At 22° C, the speed of sound in air is 344 m/s. To hear a distinct echo, the sound wave should more than 0.1 s after starting from the source to get reflected and come back to us.
- Echo can ... observer and the reflecting surface is ...

velocity =

× time

= 344 × 0.1

= 34.4 m




Echo can only be heard if the surface is rigid.
Why echo is not heard everywhere?


Echo cannot be heard if the mountains are covered with trees, because trees absorb sound.
Can echo be heard at this place?

Echo cannot be heard because there is too much disturbance.

Can echo be heard at this place???


Furniture in the house absorbs the sound hence, echo is not heard.
Can echo be heard in a furnished house?

Q. If the distance d between the source and the sound is increased to 4d and the velocity v of the sound is doubled, then what will be the time t, after which the echo could be heard?

For echo to be heard : $v = \frac{2d}{t}$

i.e. $\boxed{t = \frac{2d}{v}}$ ....(1)

$\boxed{d_1 = 4d,}$ $\boxed{v_1 = 2v}$

$$t_1 = \frac{2d_1}{v_1} = \frac{2 \times 4d}{2v} = \frac{4}{\cancel{2}\,2} \times \frac{2d}{v} = 2\,t \qquad \text{........ [From (1)]}$$

Q. If the speed of sound is reduced by 1/3 and time for the echo to be heard is doubled, will the echo be heard?

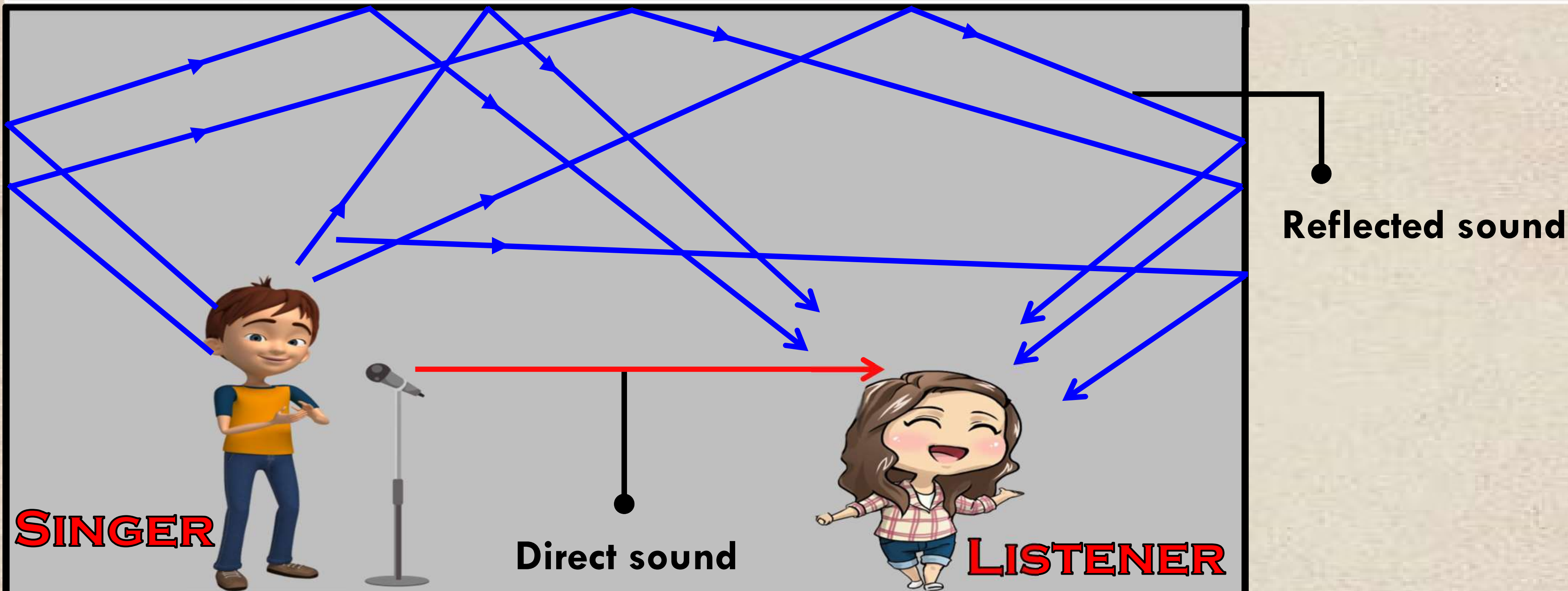
(a) Yes

(b) No

Module - 05

Reverberation

Sound waves get reflected from the walls and roof of a room multiple time. This causes a single sound to be heard not once but continuously. This is called **reverberation.**



Reverberation

Sound waves get reflected from the walls and roof of a room multiple time. This causes a single sound to be heard not once but continuously. This is called **reverberation.**

Reflected sound

Actual sound

It produces bad quality of sound

2 MARKS

The roof of a movie theatre and a conference hall is curved.

(i) Sound waves get reflected from the walls and roof of a room multiple times. This causes a single sound to be heard not once but continuously. This is called reverberation.

(ii) Due to reverberation some auditoriums or some particular seats in an auditorium have inferior sound reception which can be compensated with curtains.

(iii) Ceilings of these halls are made curved so that sound after reflecting from the ceiling, reaches all parts of the hall and the quality of sound improves.

2 MARKS

How will you reduce reverberation in public halls or buildings?

By using sound absorbing materials like curtains on wall, carpets on the floor.

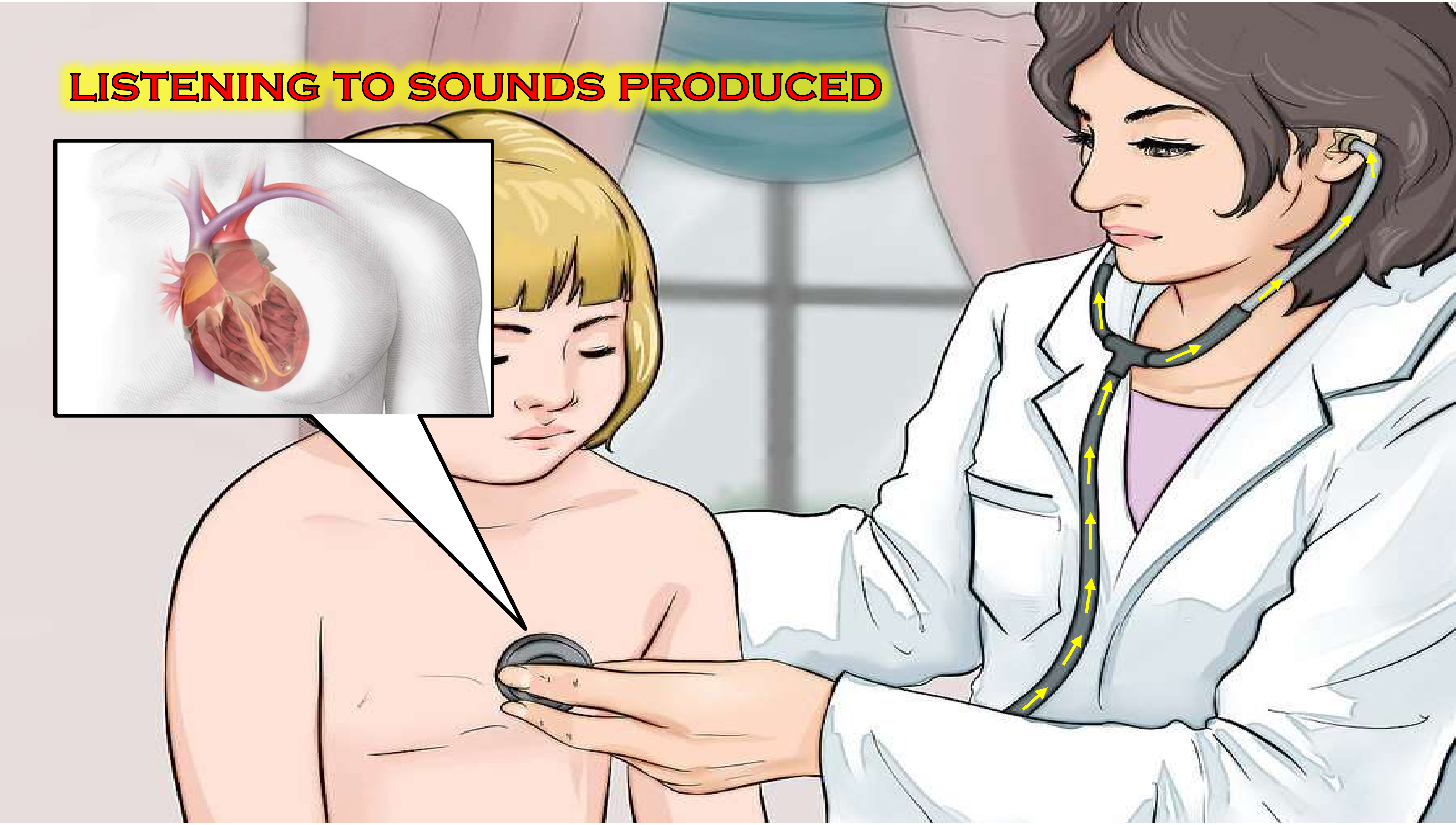
By keeping the windows open, as sound will not get reflected.

2 MARKS

When is the reflection of sound harmful?

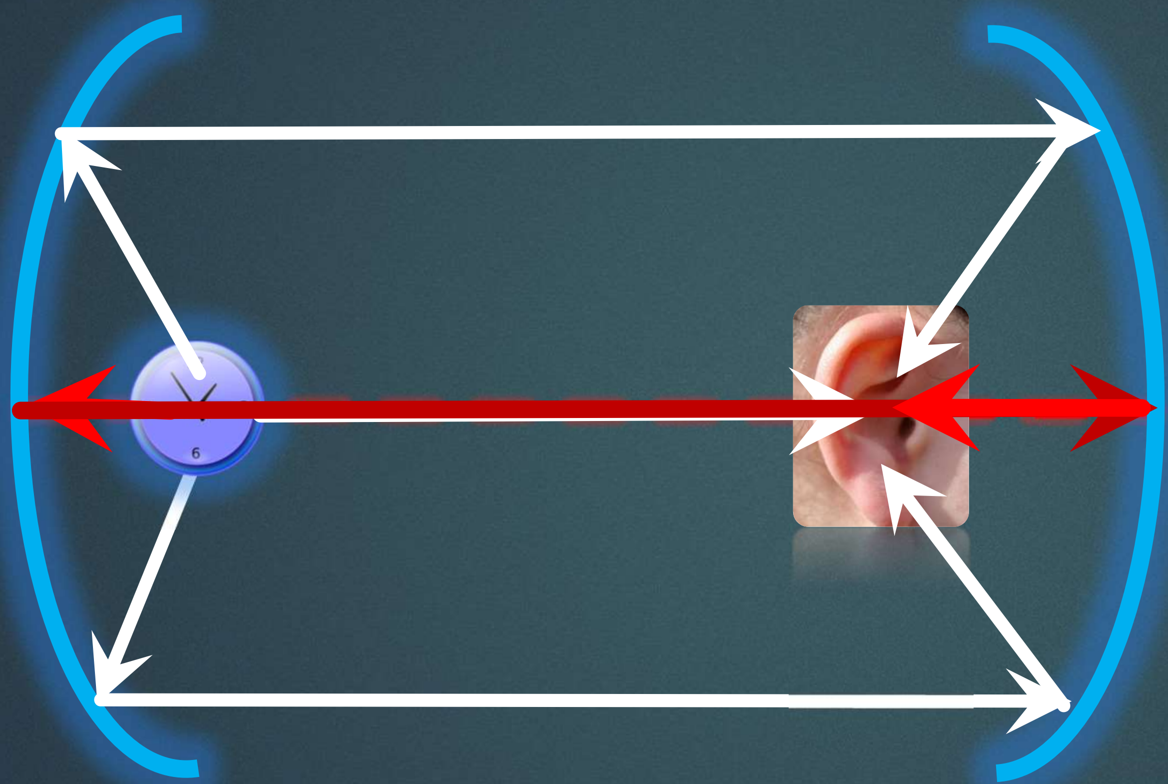
(i) Reflected sound of high intensity called as noise is disturbing and harmful to the ears.

(ii) When sound reverberates i.e it undergoes multiple reflection, poor quality of sound is produced.

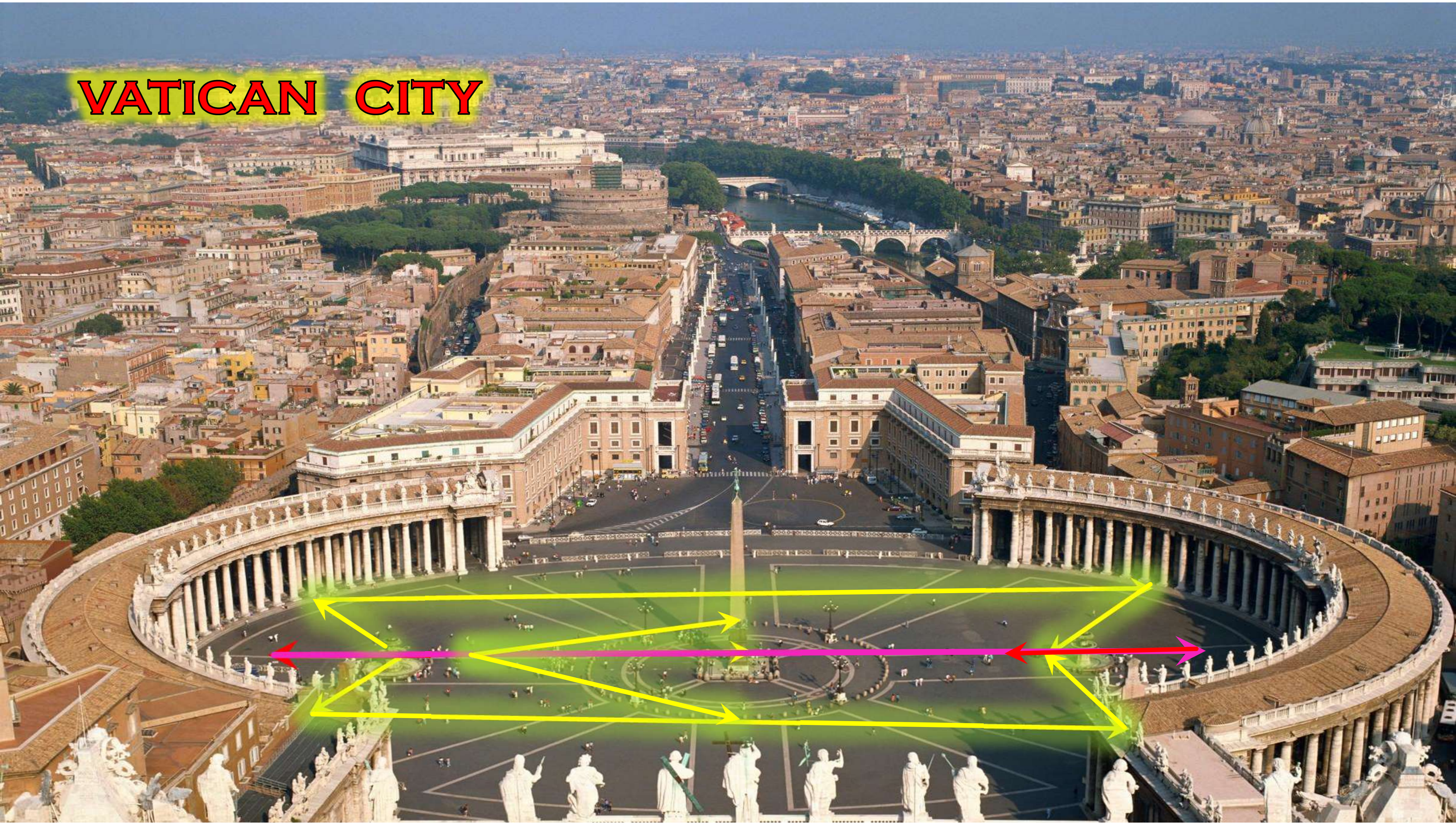

LISTENING TO SOUNDS PRODUCED

Module - 06

REFLECTION OF SOUND FROM CURVED SURFACES



The sound is heard clearly when the listener and the source both are at focus.


VATICAN CITY

Module - 07

STUDY OF SOUND

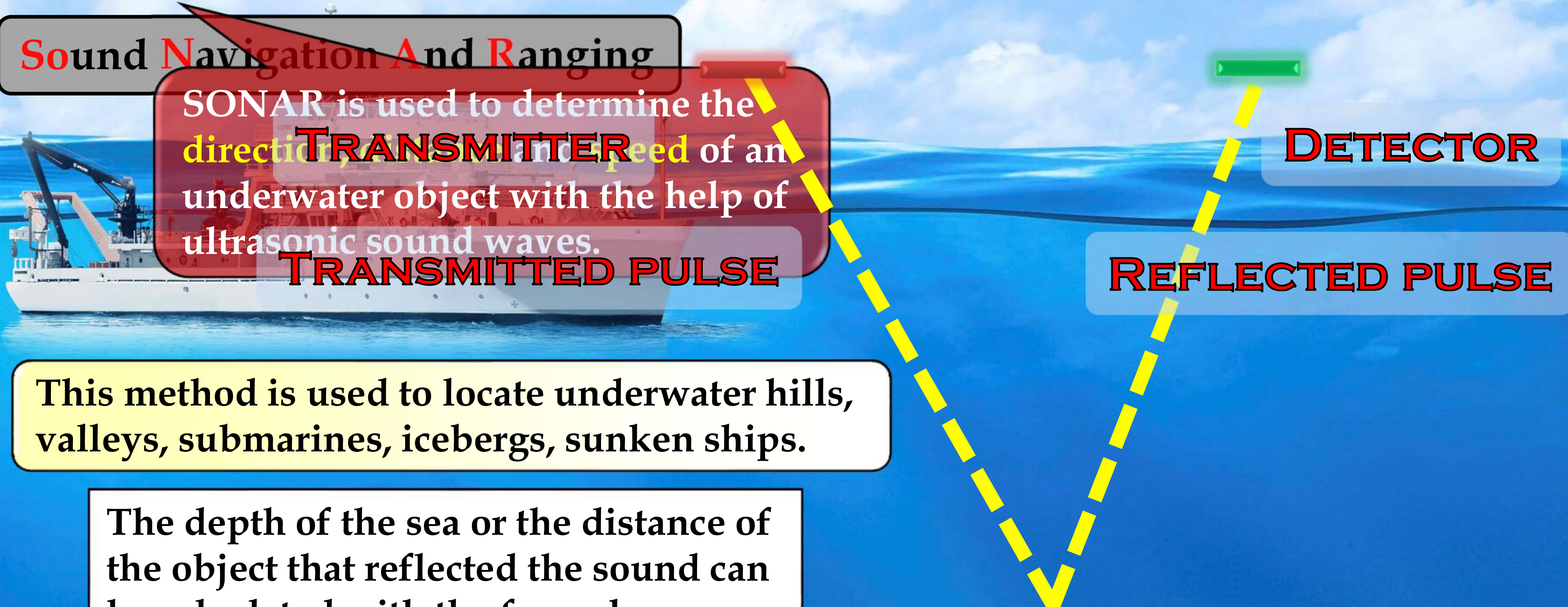
- **SONAR system**


Why did the TITANIC sink?
Titanic did not have a SONAR system

SONAR SYSTEM

Sound Navigation And Ranging

SONAR is used to determine the **direction, distance and speed** of an underwater object with the help of ultrasonic sound waves.



This method is used to locate underwater hills, valleys, submarines, icebergs, sunken ships.

The depth of the sea or the distance of the object that reflected the sound can be calculated with the formula

$$\text{Velocity } (v) = \frac{2d}{t}$$

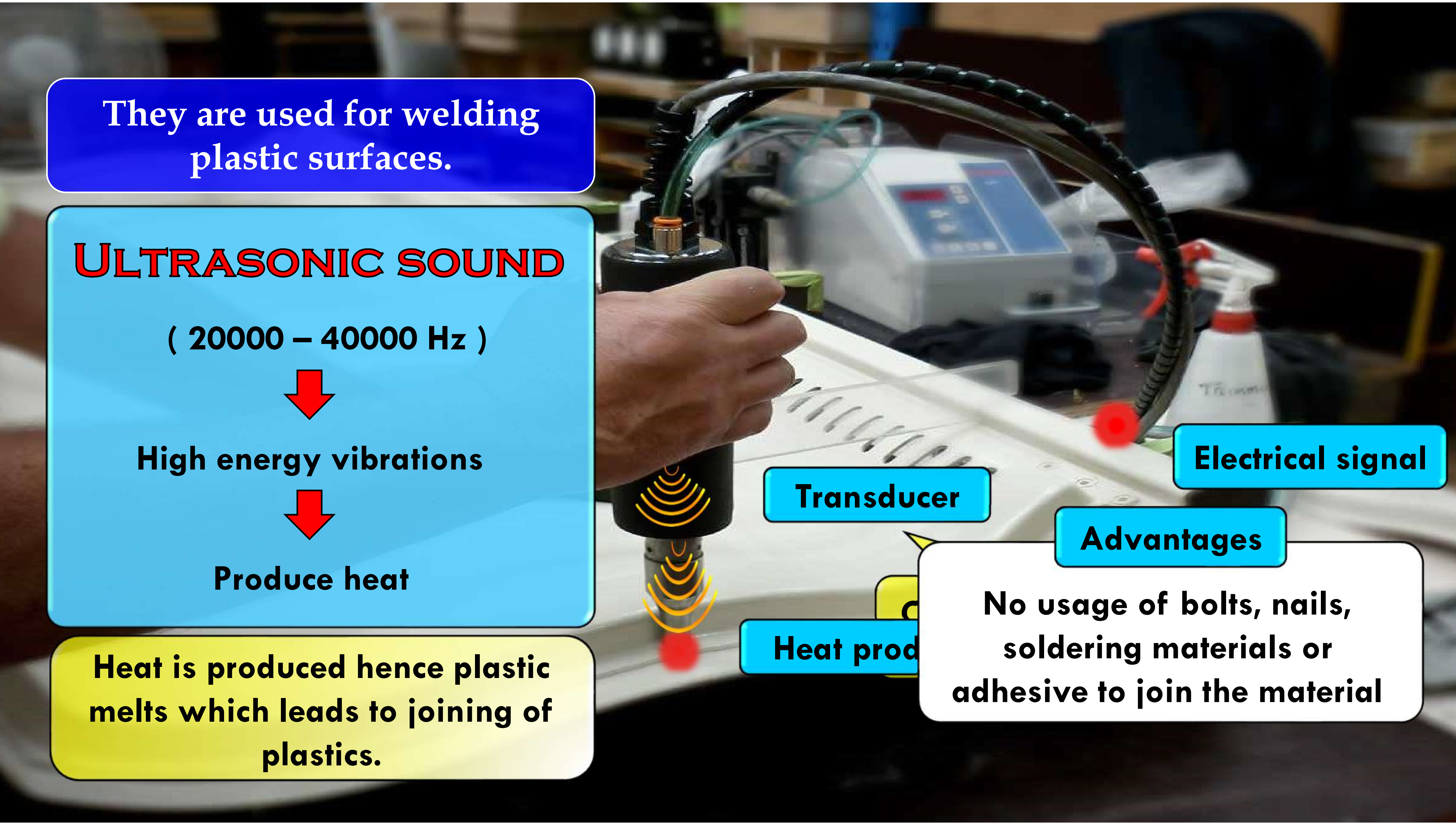
STUDY OF SOUND

- **Uses of Ultrasound**

USES OF ULTRA SOUND

The special property of ultrasound is that they are able to travel along well defined path even in presence of obstacles.

Ultrasound are used to establish Ship to ship communication.


They are used for welding plastic surfaces.
ULTRASONIC SOUND
(20000 – 40000 Hz)
High energy vibrations
Produce heat
Heat is produced hence plastic melts which leads to joining of plastics.
Transducer
Electrical signal
Advantages
No usage of bolts, nails, soldering materials or adhesive to join the material

Ultrasonic waves are used to kill bacteria in liquids like milk to preserve them for a longer period of time.

Ultrasonic waves are used to kill bacteria to zero level which spoil the milk.

Advantages

There is no decr
level of protein or
content of m

Advantages

er hand
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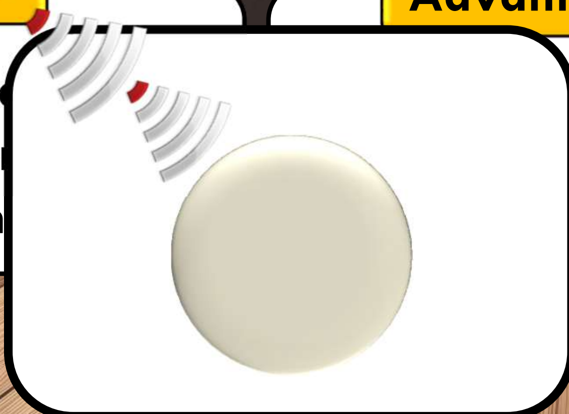
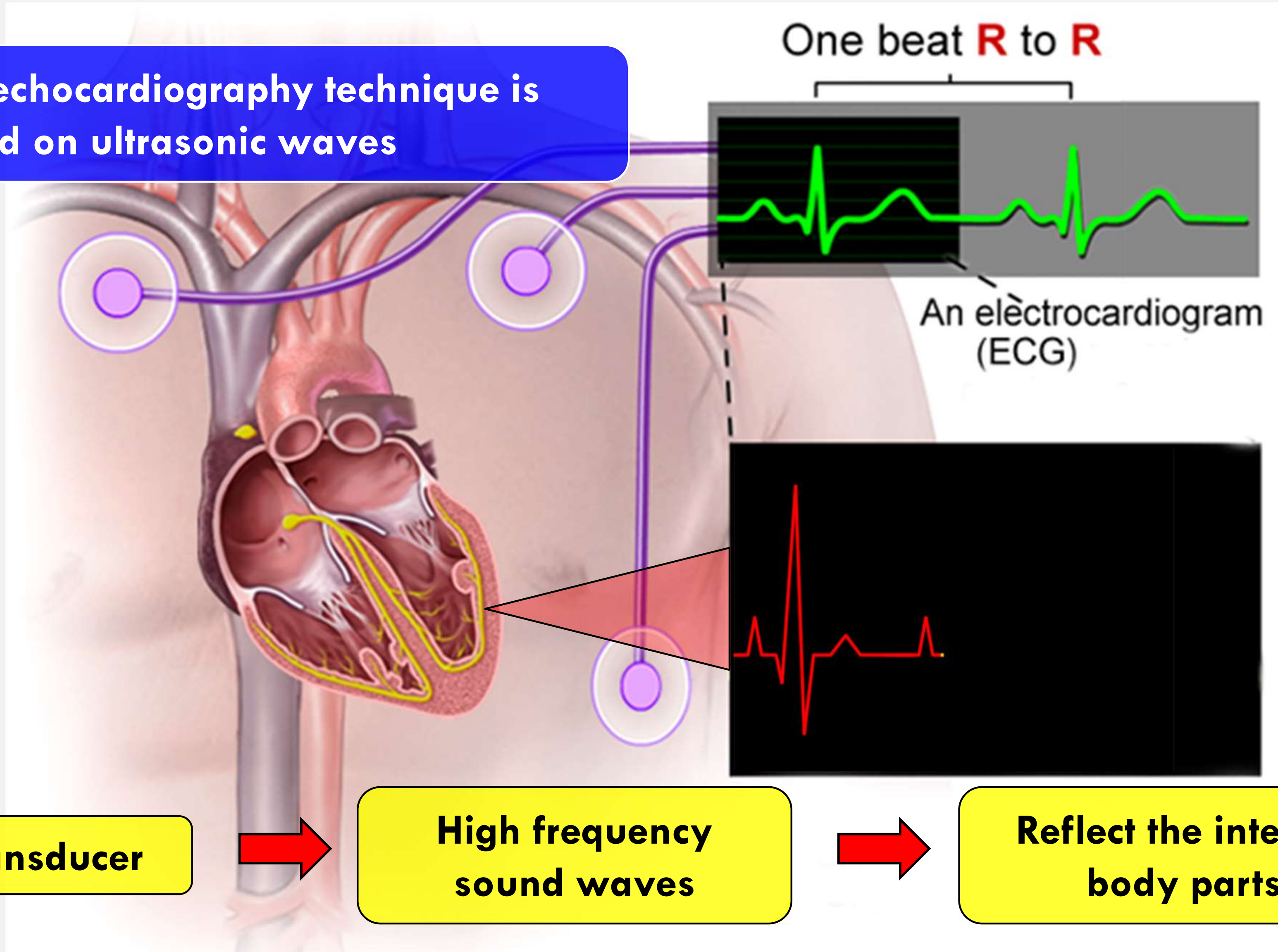
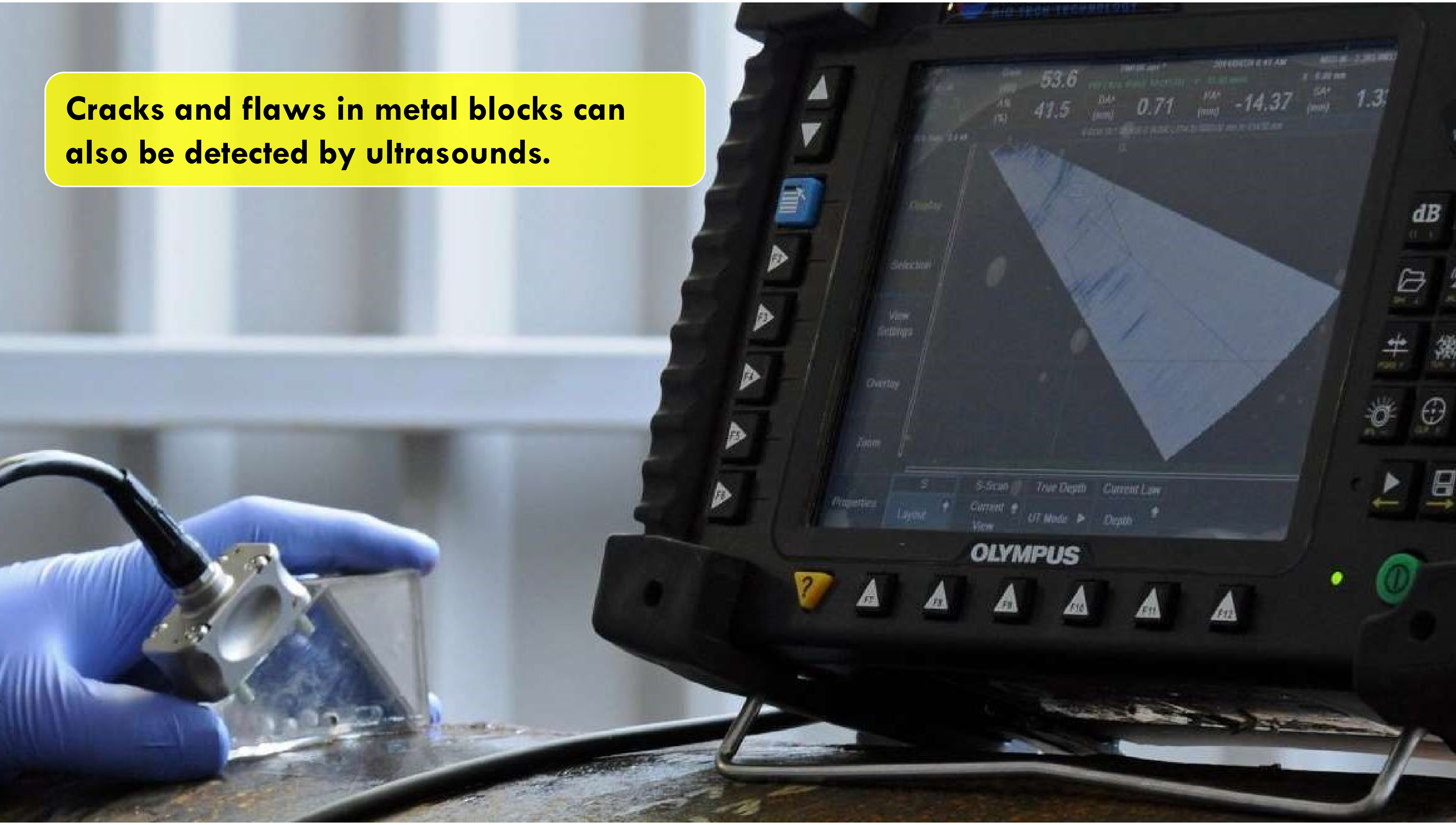


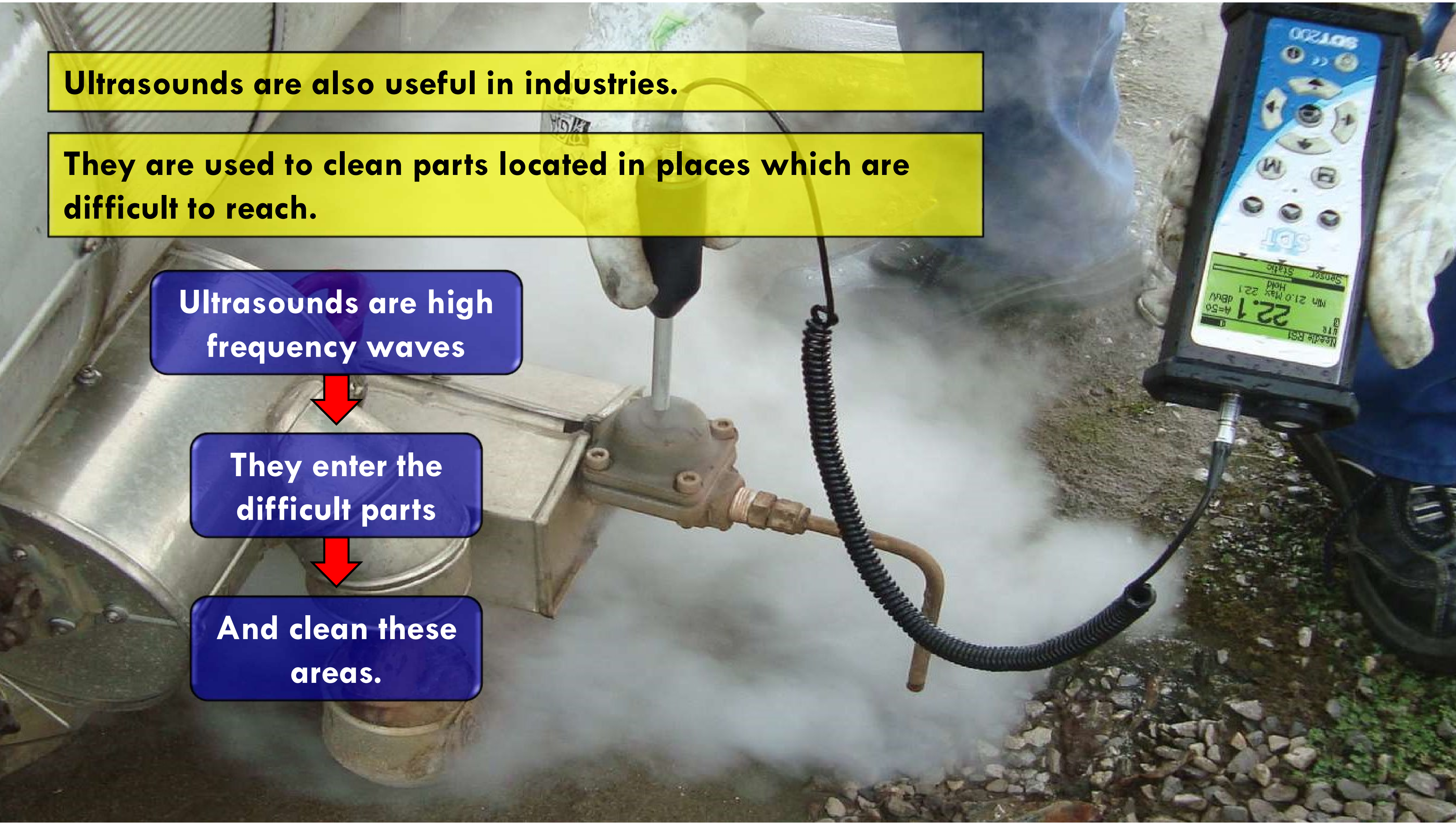
The echocardiography technique is based on ultrasonic waves



Transducer → **High frequency sound waves** → **Reflect the internal body parts**

Cracks and flaws in metal blocks can also be detected by ultrasounds.





Ultrasounds are also useful in industries.

They are used to clean parts located in places which are difficult to reach.

Ultrasounds are high frequency waves

They enter the difficult parts

And clean these areas.

Q. Three different vibrating objects produce three different sounds X, Y and Z. Sounds X and Y cannot be heard by a man having normal range of hearing but sound Z can be heard easily. Sound X can be used in hospitals to break kidney stones of a patient into fine grains which then gets flushed out with urine. The sound Y is produced during an earthquake before the main shock waves is generated.

(a) What type of sound is (i) X - ultrasonic sound
(ii) Y - infrasonic sound
(iii) Z - Audible sound

(b) State the frequency range of sound X. More than 20 kHz

(c) Name one device used in science laboratory that can produce sound like Y.
Simple pendulum

(d) Name one device in our home that can produce sound like Z.
Television

(e) What is the frequency range of sound like Z ?
20 Hz to 20 kHz

Q. If an explosion occurs at the bottom of the lake, what type of shock waves will be produced in water?

Ans : If an explosion occurs at the bottom of the lake, infrasonic type of shock waves will be produced in water?

Q. Which among the following is an infrasonic wave?

(a) Waves generated through quartz crystals.

(b) Waves emitted by pest controllers.

(c) Waves generated during earthquake

(d) Waves emitted by a dog's whistle.

Module - 08

STUDY OF SOUND

- **Characteristics of a wave**

CHARACTERISTICS OF A WAVE

1) Wavelength (λ)

The distance between two consecutive compressions or two consecutive rarefactions is called wavelength. It is measured in meters (m).

2) Amplitude (A)

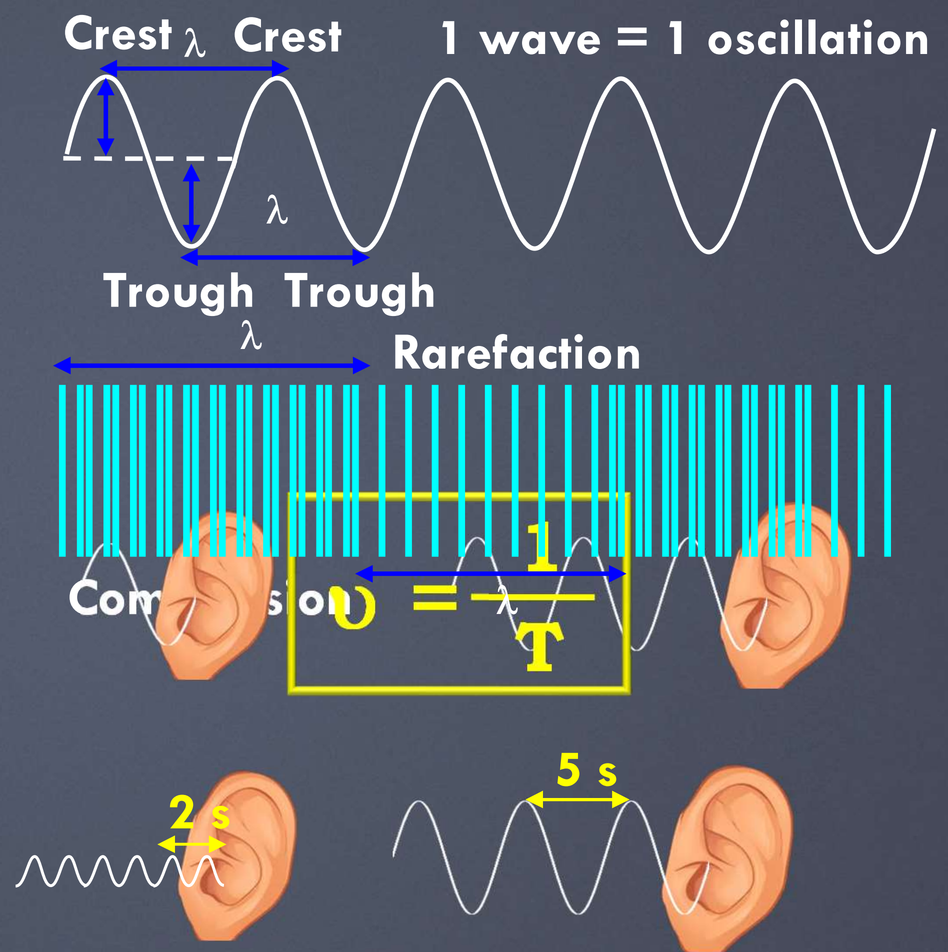
The maximum value of pressure or density is called amplitude.

3) Frequency (υ)

The frequency of a sound wave is defined as the number of complete oscillations of density (or pressure of the medium) per second. It is measured in hertz (Hz).

4) Time Period (T)

The time taken for one complete oscillation of pressure or density at a point in the medium is called the time period.



STUDY OF SOUND

- **Relation between speed, frequency and wavelength**

Relation between speed (v), frequency (υ), and wave length (λ)

$$\text{Speed} = \frac{\text{distance}}{\text{time}}$$

If we consider the distance travelled by the sound wave in one time period, then we get.

$$\text{Speed} = \frac{\text{Wave length}}{\text{Time period}}$$

$$v = \frac{\lambda}{T}$$

$$\text{But, frequency } (\upsilon) = \frac{1}{T}$$

$$v = \upsilon\lambda$$

i.e. speed = Frequency × Wavelength

Will
incr

As frequ
increases

As frequency
increas s…

In any medium, at **fixed physical conditions**, the velocity of sound of different frequencies is very nearly the **SAME**

Q. A sound wave of wavelength of λ and frequency f propagates through a gold rod and then exits into air. If λ' and f' are the new wavelength and frequency of the sound wave, then which of the following is true?

a. $\lambda > \lambda'$ and $f = f'$

b. $\lambda = \lambda'$ and $f < f'$

c. $\lambda < \lambda'$ and $f = f'$

d. $\lambda = \lambda'$ and $f > f'$

Q. If in a medium, a wave travels with velocity V and wavelength λ. When this same wave enters another medium, its velocity become 2V. What will be its wavelength in second medium?

a. λ

b. 2λ

c. $\lambda/2$

d. 4λ

Module - 09

STUDY OF SOUND

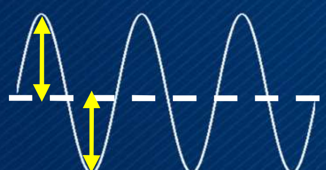
- **Characteristics of sound**

CHARACTERISTICS OF SOUND

Amplitude

Amplitude explains loudness of sound

Amplitude is less, sound is soft.

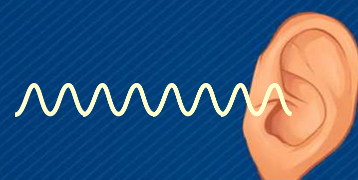


Amplitude is more, sound is loud.

Intensity α (Amplitude)^2

Pitch

Pitch explains shrillness in sound



Shorter wavelength, higher frequency, pitch is high

Larger wavelength, lower frequency, pitch is low

Timbre

Timbre explains quality of sound.

Generally girls sound is high pitch

Every person has different timbre.

Generally boys sound is low pitch

Tone

A sound of single frequency is called **tone**.

Minor Ditonic

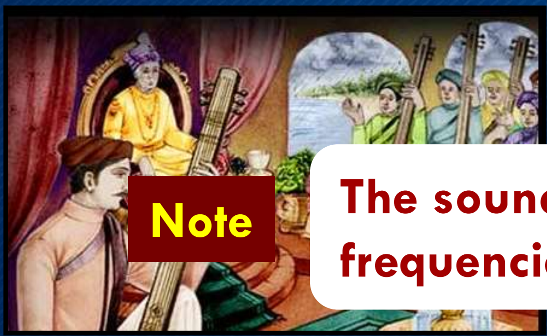
Played in olden days.

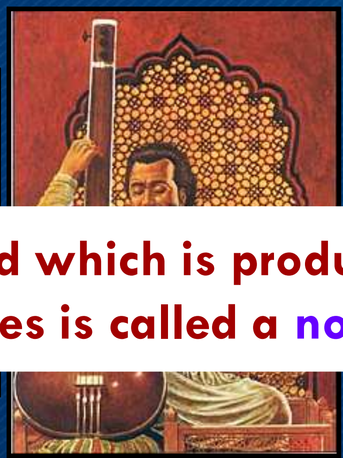
Express **sadness**

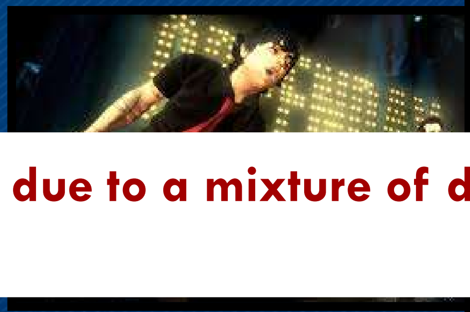
Major Ditonic

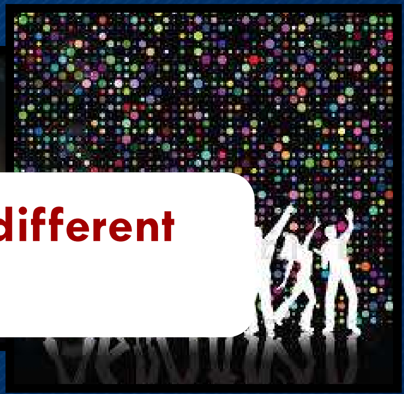
Played now a days.

Express **happiness**.









Note

The sound which is produced due to a mixture of different frequencies is called a **note**.

Q. Which wave property determines (a) loudness and (b) pitch

Ans : (a) Loudness is determined by amplitude of sound waves

(b) Pitch is determined by the frequency of vibrations of the sound producing source.

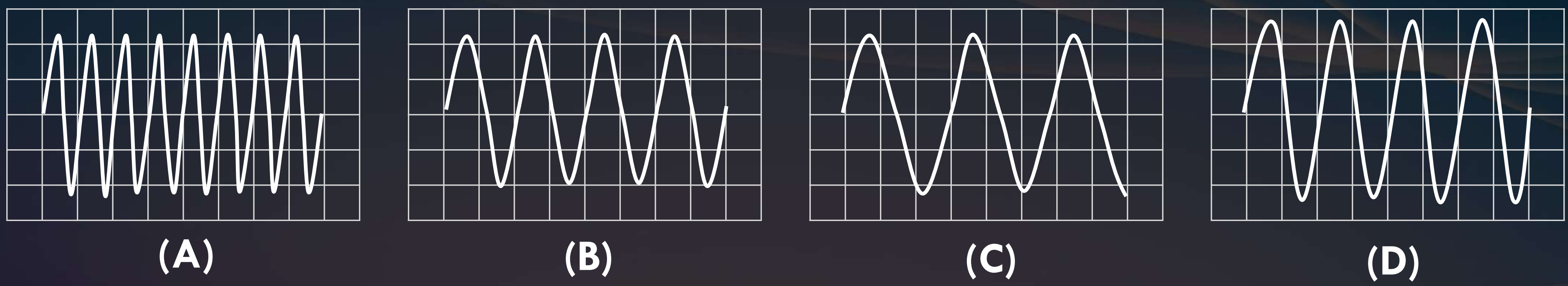
Q. Guess which sound has a higher pitch: guitar or car horn?

Ans : The sound from a guitar has a higher pitch than that from a car horn due to its higher frequency.

Difference between loudness and intensity

Loudness	Intensity
1. The sensation produced in the ears that enables us to distinguish between a feeble sound and a loud sound is called loudness of sound	1. The average energy transported by a sound wave per unit area, perpendicular to the direction of propagation, is called intensity of sound.
2. Loudness is measured in decibel (dB)	2. Intensity is measured in watts per square metre (W/m^2)
3. S.I. unit of work is joule (J).	3. S.I. unit of power is watt (W).

Q. Consider the following sound waves marked A, B, C and D :



(a) Which two waves represents sound of same loudness but different pitch ?

Ans : Waves A and C

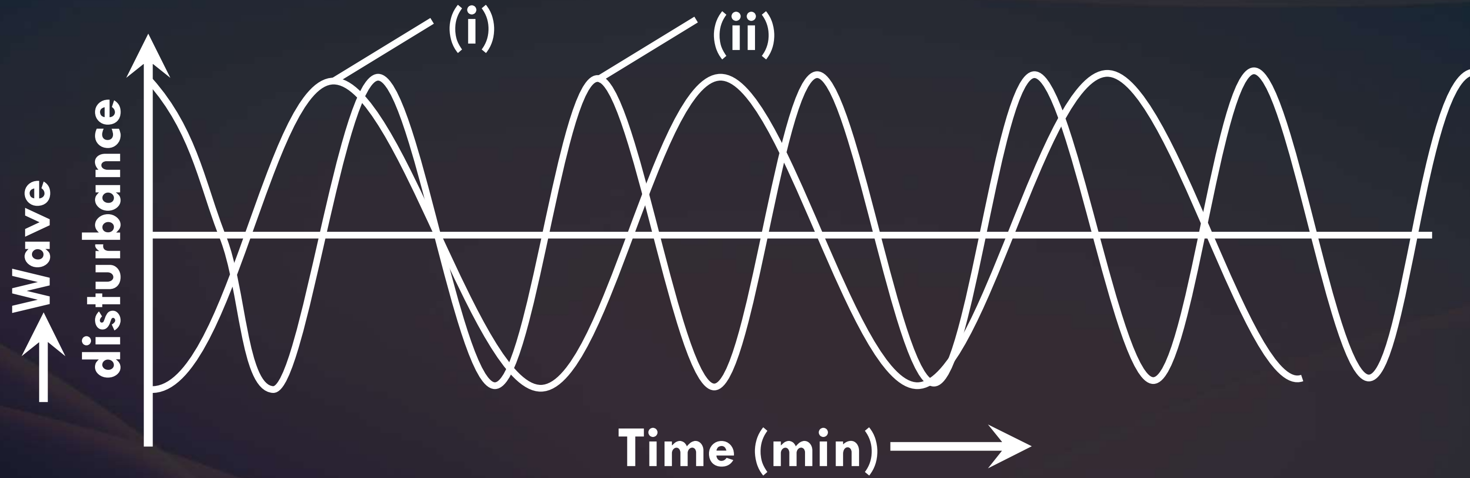
(b) State whether all these sound waves are produced by same vibrating body or different bodies.

Ans : Same vibrating body

(c) Which vibrating body/bodies could have generated the sound waves shown here

Ans : Tuning fork

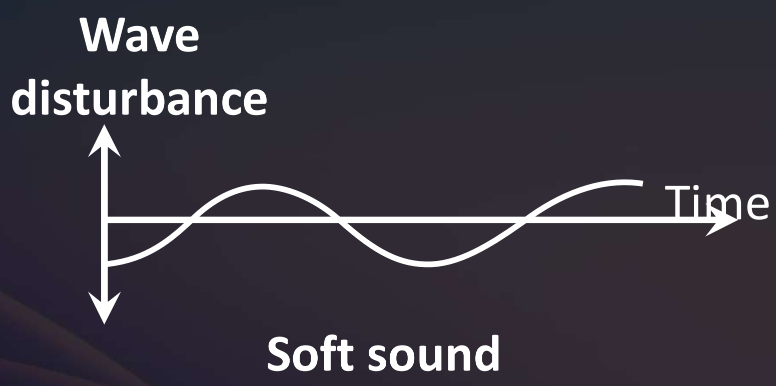
Q. Which of the two graphs (i) or (ii) representing human voice is likely to be a male voice ? Give reason for your answer.



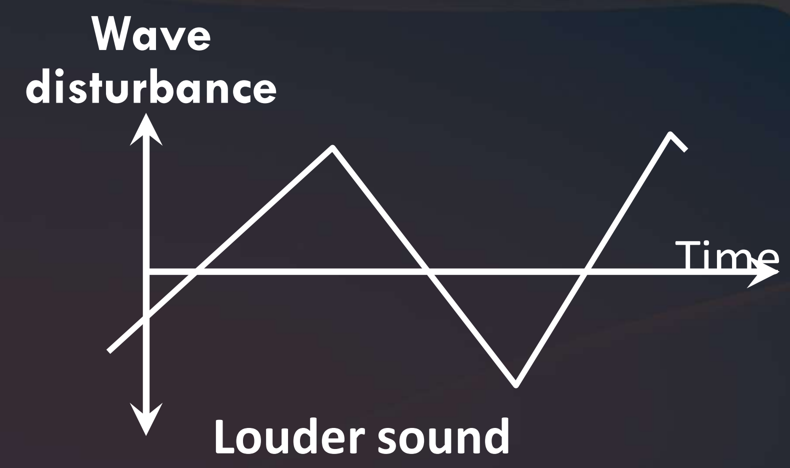
Ans : Graph (i) represent male voice.

Since the pitch and the frequency of a male voice is lower than the pitch of a female voice and vibration of graph (ii) represents a higher frequency and higher pitch.

Q. The following figures show the wave shapes of two sounds of same frequency. Which of these is likely to represent the sound produced by a car-horn ?



(A)



(B)

Ans : **Sound (B) because amplitude is large**

Module - 10

SOUND

- **Numerical based on echo and kinematical equations**

Type - A

$$v = \lambda \times \upsilon$$

Wave

Frequency

Speed = $\frac{\text{distance}}{\text{time}}$

NUMERICAL

Note : When sound travels from one medium to another its frequency remains the same.

1. The drawing shows a ship 800 m from a cliff. A gun is fired on the ship. After 5 seconds the people at the front of the ship hear the sound of the gun again.

(a) Name of the effect.

(b) What happens to the sound at the cliff.

(c) Distance travelled by the sound in 5 sec.

(d) Speed of sound.

1. The drawing shows a ship 800 m from a cliff.
A gun is fired on the ship. After 5 seconds the people at the front of the ship hear the sound of the gun again.

Given : Distance from the cliff = 800 m

Time taken to hear the echo = 5 sec

To find:

(a) Name of the effect.

(b) What happens to the sound at the cliff.

(c) Distance travelled by the sound in 5 secs.

(d) Speed of sound.

Formula : Distance = Speed × time

Solution : (a) Name of the effect is "ECHO".

(b) At the cliff, the sound gets reflected.

(c) Since, people on the ship heard the echo after 5 seconds,

Distance travelled by sound

$= 800 + 800$

$= 1600$ m

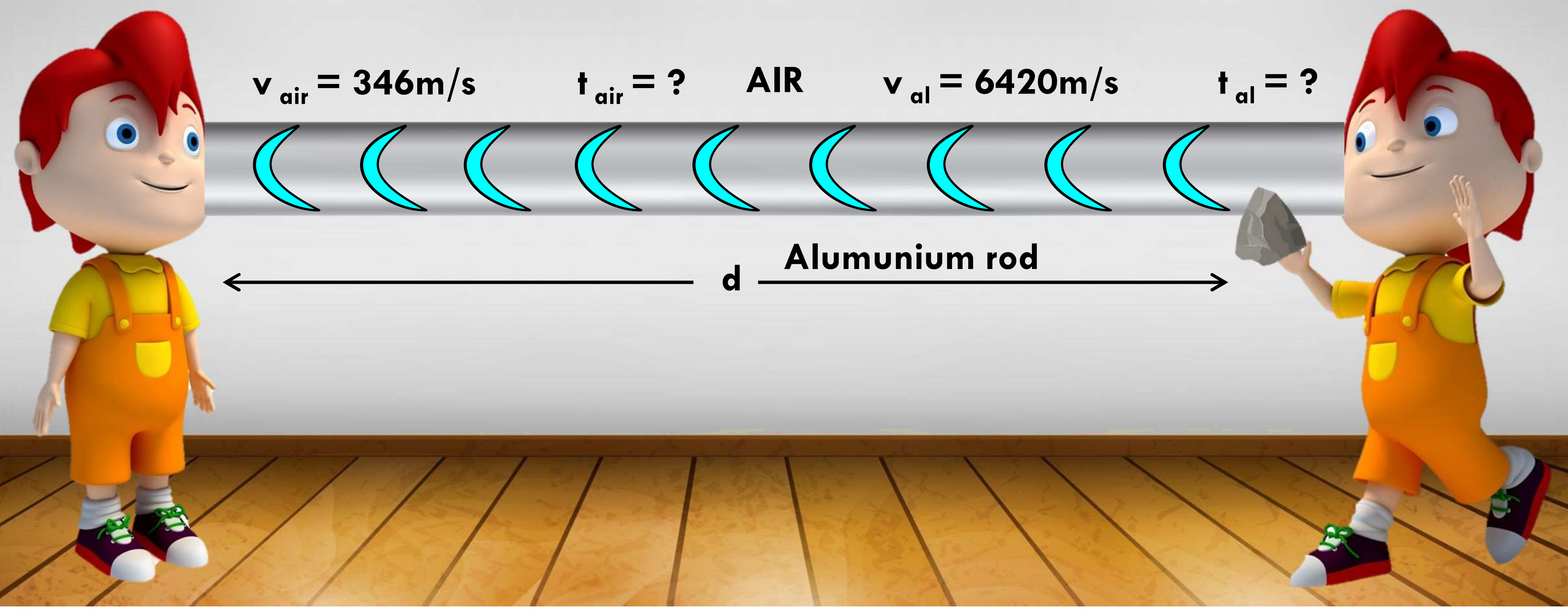
∴ Sound travels a distance of 1600 m in 5 s.

(d) $\text{Speed} = \dfrac{\text{distance}}{\text{time}} = \dfrac{1600}{5}$

$= 320$ m/s

∴ Speed of Sound is 320 m/s.

2. 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. (velocity of sound in air = 346 m/s , velocity of sound in aluminum = 6420 m/s)



2. 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. (velocity of sound in air = 346 m/s , velocity of sound in aluminum = 6420 m/s)

Given : Velocity of sound in air (v_{air}) = 346 m/s

velocity of sound in aluminium (v_{al}) = 6420 m/s

To find: Ratio of times taken by sound wave in air and in aluminium (v_{air} / v_{al}) = ?

Formula : $v = \frac{d}{t}$

Solution : Since the distance travelled by both the sound waves (d) is same, we get

$$\frac{t_{air}}{t_{al}} = \frac{v_{al}}{v_{air}}$$

$$\frac{t_{air}}{t_{al}} = \frac{6420}{346}$$

$$\frac{t_{air}}{t_{al}} = \frac{18.55}{1}$$

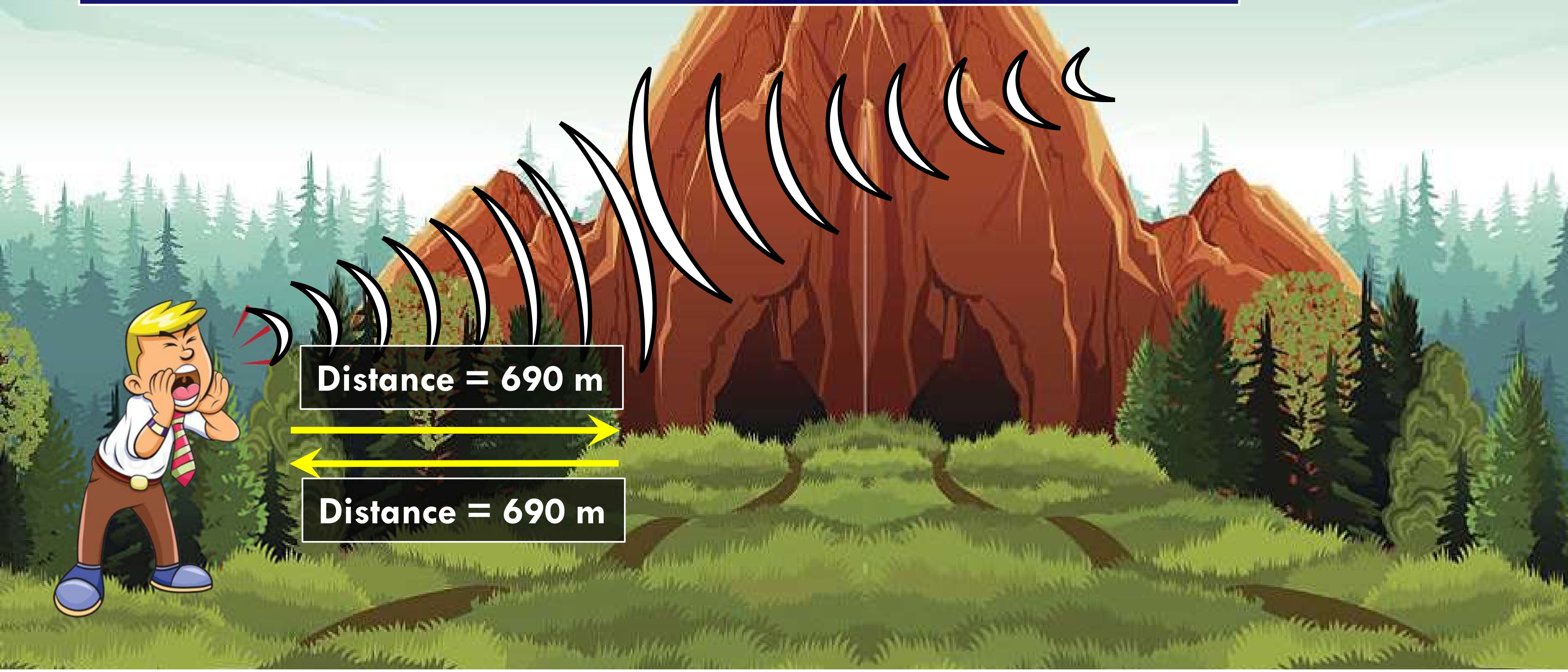
Ans : The ratio of the time taken by sound wave in air and aluminium is 18.55 : 1

Module - 11

SOUND

- **Numerical based on speed, frequency and wavelength.**

3. A child shouted 'Hello' near a cliff and heard the echo after some time. If the speed of sound is taken as 345 m/s at respective temperature and the distance of cliff from the child is 690 m. Calculate the time after which echo is heard by the child.



3. A child shouted 'Hello' near a cliff and heard the echo after some time. If the speed of sound is taken as 345 m/s at respective temperature and the distance of cliff from the child is 690 m. Calculate the time after which echo is heard by the child.

Given : Total distance travelled by sound (d) = distance from child to cliff + distance from cliff to child

= 690 + 690

= 1380 m

Velocity of sound = 345 m/s

To find: Time (t) = ?

Formula : $\text{velocity} = \dfrac{\text{distance}}{\text{time}}$

Solution : $\text{velocity} = \dfrac{\text{distance}}{\text{time}}$

$\text{time} = \dfrac{1380}{345}$

Time (t) = 4 sec

Ans : The echo is heard by the child 4 second after shouting.

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

Given : frequency (υ) = 100 Hz

time (t) = 60 sec

To find : No. of vibrations in 60 sec = ?

Formula : $\text{frequency} = \dfrac{\text{No. of vibrations}}{\text{time}}$

Solution : $\text{frequency} = \dfrac{\text{No. of vibrations}}{\text{time}}$

$\therefore$ frequency $\times$ time = No. of vibrations

$\therefore$ 100×60 = No. of vibrations

$\therefore$ No. of vibrations = 6000

Ans : The source vibrates 6000 times in a minute

Module - 12

SOUND

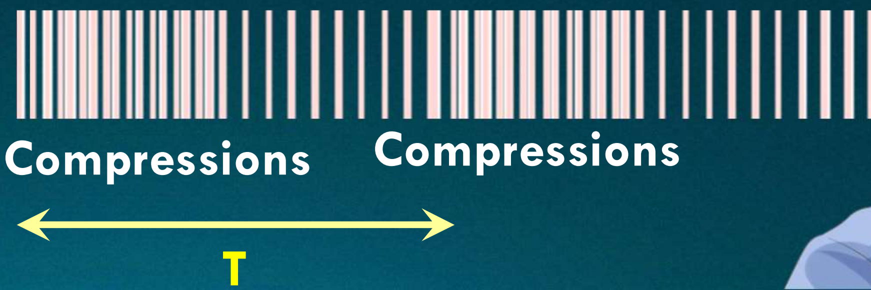
- **Numerical based on speed, frequency and wavelength.**

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

Given : frequency (ν) = 500 Hz

distance (d) = 450 m

To find : Time period (T) = ?



Formula : $\nu = \dfrac{1}{T}$

Solution : $\nu = \dfrac{1}{T}$

$\therefore \quad T = \dfrac{1}{\nu}$

$\therefore \quad T = \dfrac{1}{500}$

$\therefore \quad T = 0.002$ sec

Ans : The time interval between successive compressions i.e time period is 0.002 sec.

6. A sound wave has a frequency of 2 kHz and wavelength 35 cm. how long will it take to travel 1.5 km ?

Given : frequency (ν) = 2 kHz = 2000 Hz

Wavelength (λ) = 35 cm = 0.35 m

Distance (d) = 1.5 km = 1500 m

To find : Time (t) = ?

Formula : $\text{velocity} = \dfrac{\text{distance}}{\text{time}}$

$v = \nu \lambda$

Solution : $v = \nu \lambda$

$\therefore v = 2000 \times 0.35$

$\therefore v = 700 \text{ m/s}$

$\text{velocity} = \dfrac{\text{distance}}{\text{time}}$

$\therefore \text{time} = \dfrac{\text{distance}}{\text{velocity}}$

$\therefore t = \dfrac{1500}{700}$

$\therefore$ Time (t) = 2.1 s

Ans : Thus, sound will take 2.1 s to travel a distance of 1.5 km.

Module - 13

SOUND

- **Numerical based on speed, frequency and wavelength.**

7. The human ear can detect continuous sounds in the frequency range from 20 Hz to 20000 Hz. Assuming that the speed of sound in air is 330 ms^{-1} for all frequencies, Calculate the wavelengths corresponding to the given extreme frequencies of the audible range.

Given : Frequency (ν_1) = 20 Hz

Frequency (ν_2) = 20000 Hz

Speed (v) = 330 ms^{-1}

To find : Wavelengths (λ_1) and (λ_2) = ?

Formula : $v = \nu \lambda$

Solution : $\lambda_1 = \frac{v}{\upsilon_1} = \frac{330}{20} = \boxed{16.5 \text{ m}}$

$\lambda_2 = \frac{v}{\upsilon_2} = \frac{330}{20000} = \frac{165}{10000} = \boxed{0.0165 \text{ m}}$

Ans : The range of wavelength is 16.5 m to 0.0165 m.

8. A sound wave travels at a speed of 339 m/s. If its wavelength is 1.5 cm, what is frequency of the wave? Will it be audible to humans ?

Given : Speed of sound (v) = 339 m/s

Wavelength (λ) = 1.5 cm

= 330 ms^{-1}

To find : Frequency (ν) = ?

Formula : $v = \nu \lambda$

Solution : $v = \nu \lambda$

$\therefore \quad \nu = \frac{v}{\lambda}$

$\therefore \quad \nu = \frac{339}{0.015} = \frac{\cancel{339}^{113} \times \cancel{1000}^{200}}{\cancel{15}\ \cancel{3}_{1}}$

$\therefore \quad \nu = 22,600 \text{ Hz}$

Ans : Frequency of the wave is 22,600 Hz and it is not audible to human.

Module - 14

SOUND

- **Numerical based on speed, frequency and wavelength.**

9. A sound wave has wave length 1.5 m in a gas and 0.8 m in air. Calculate: (a) Frequency of sound and (b) Velocity of sound in gas if velocity of sound in air is 340m/s

Given : wavelength in gas (λ_g) = 22,600 Hz

wavelength in air (λ_a) = 0.8 m

velocity of sound in air (v_a) = 340 m/s

To find : Frequency (ν) = ?

Velocity of sound in gas (v_g) = ?

Formula : $v = \nu \lambda$

Solution : $v_a = \nu_a \lambda_a$

$\therefore \quad \nu_a = \dfrac{v_a}{\lambda_a}$

$\therefore \quad \nu_a = \dfrac{340}{0.8}$

$\therefore \quad \nu_a = 425 \text{ Hz}$

But frequency does not change with change in medium.

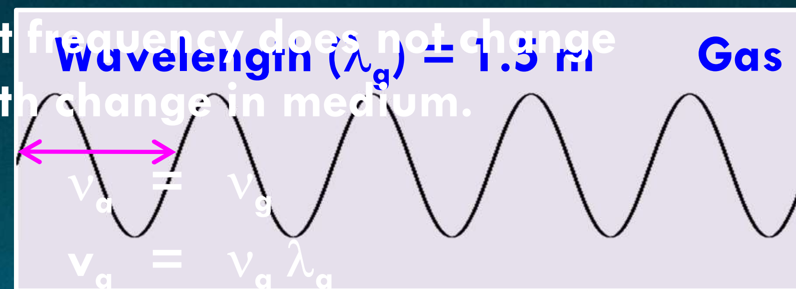
$\therefore \quad \nu_a = \nu_g$

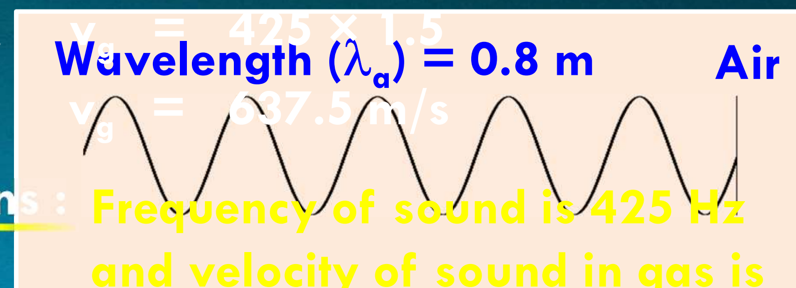
$\therefore \quad v_g = \nu_g \lambda_g$

$\therefore \quad v_g = 425 \times 1.5$

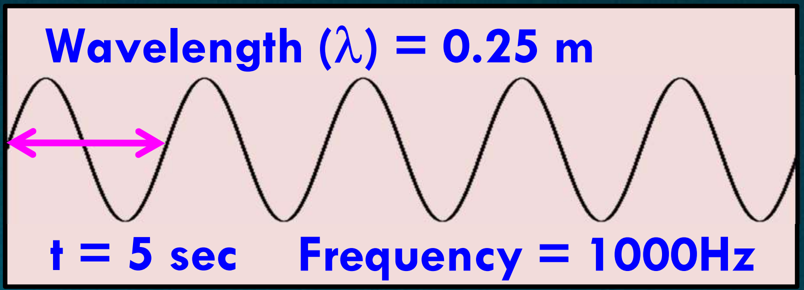
$\therefore \quad v_g = 637.5 \text{ m/s}$

Ans : Frequency of sound is 425 Hz and velocity of sound in gas is 637.5 m/s





10. Calculate distance travelled by a sound wave having frequency 1000 Hz and wavelength 0.25 m, if it travels for 5 second in a certain medium.



Given : frequency (ν) = 1000 Hz

wavelength (λ) = 0.25 m

time (t) = 5 sec

To find : distance (d) = ?

Formulae : velocity = $\dfrac{\text{distance}}{\text{time}}$

$v = \nu \lambda$

Solution : $v = \nu \lambda$

$\therefore \quad v = 1000 \times 0.25$

$\therefore \quad v = 250$ m/s

velocity = $\dfrac{\text{distance}}{\text{time}}$

$\therefore$ distance = velocity × time

$\therefore$ distance = 250×5

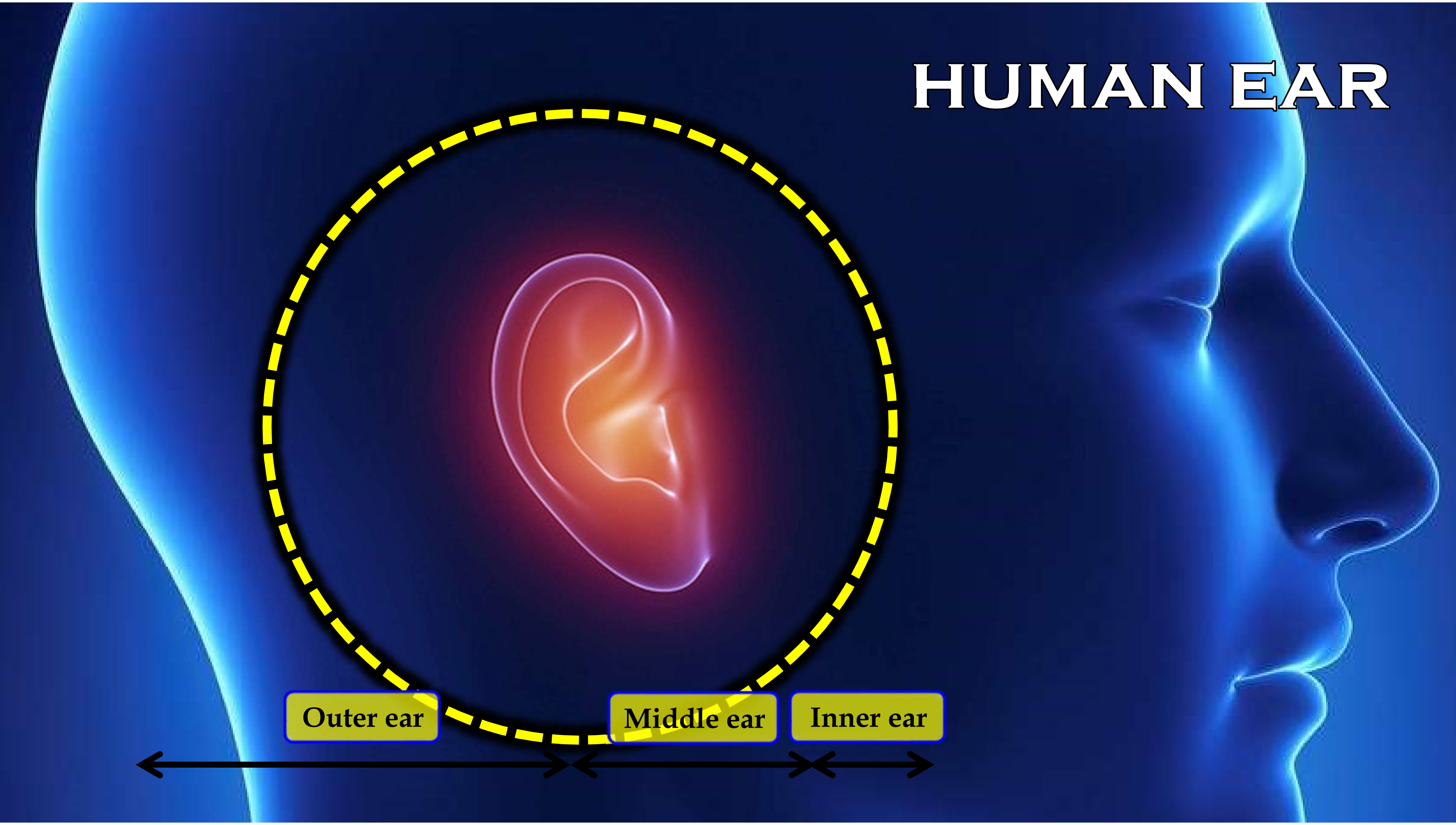
$\therefore$ distance = 1250 m.

Ans : The distance travelled by a sound wave is 1250 m.

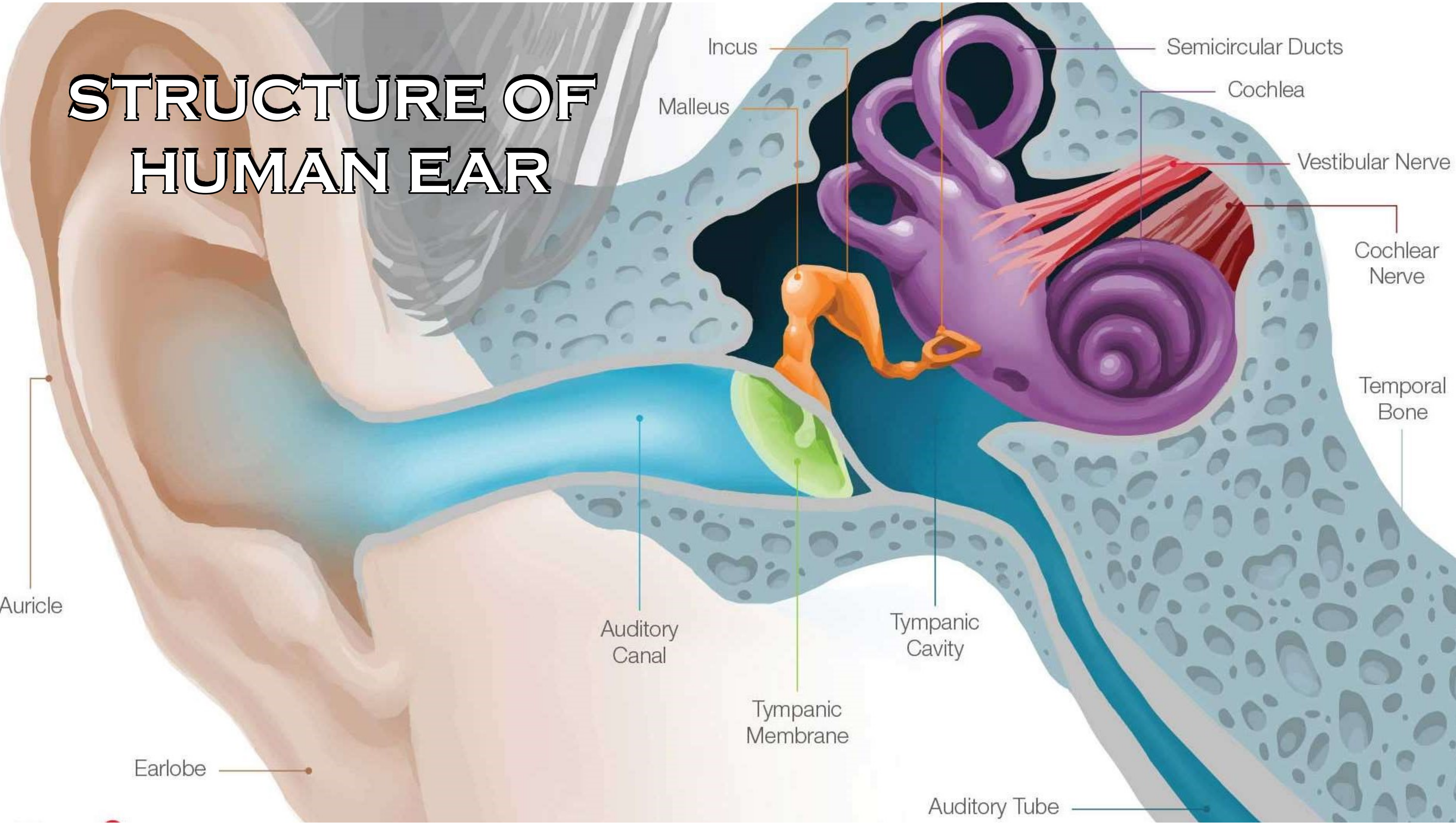
Module - 15

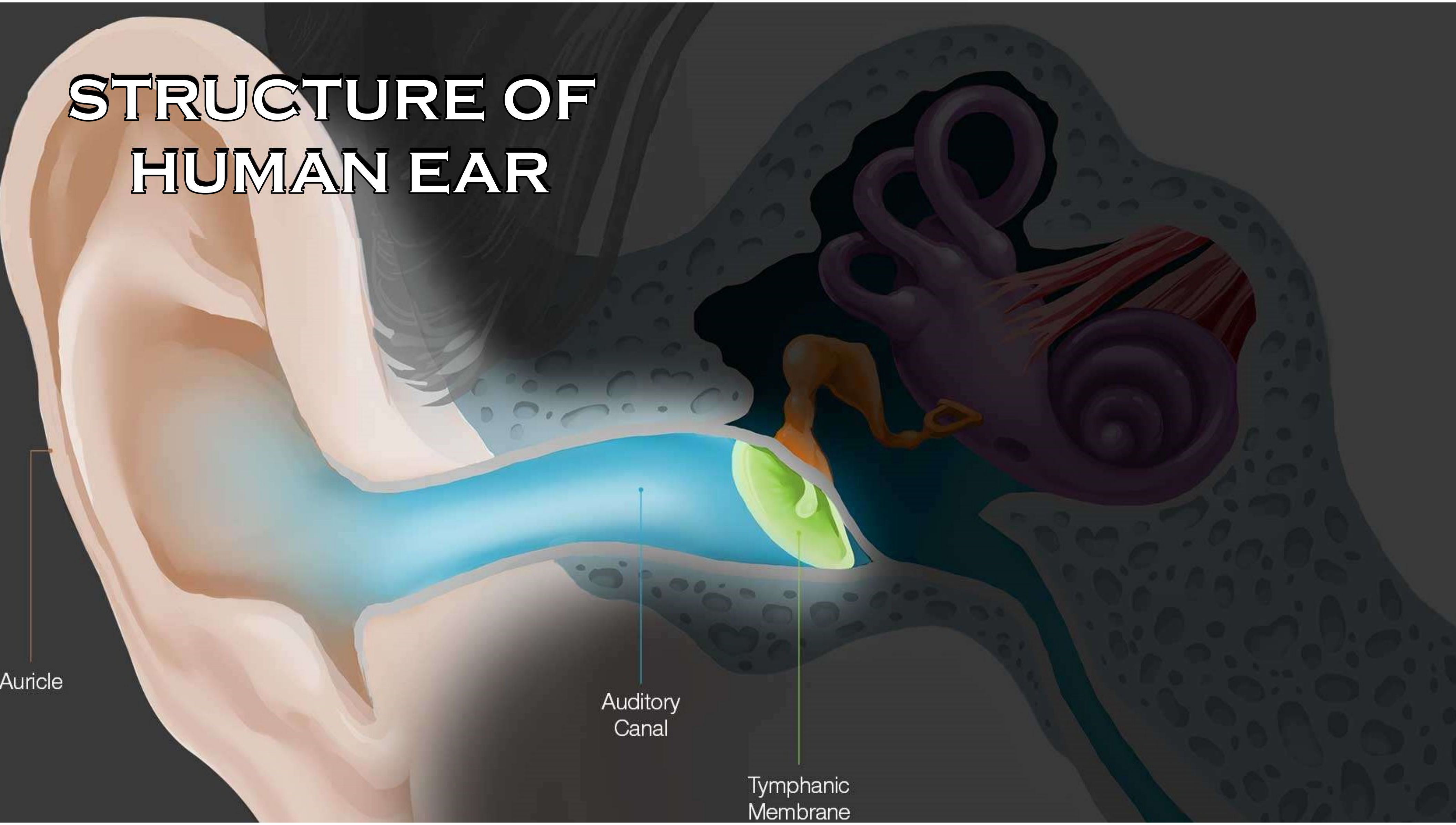
STUDY OF SOUND

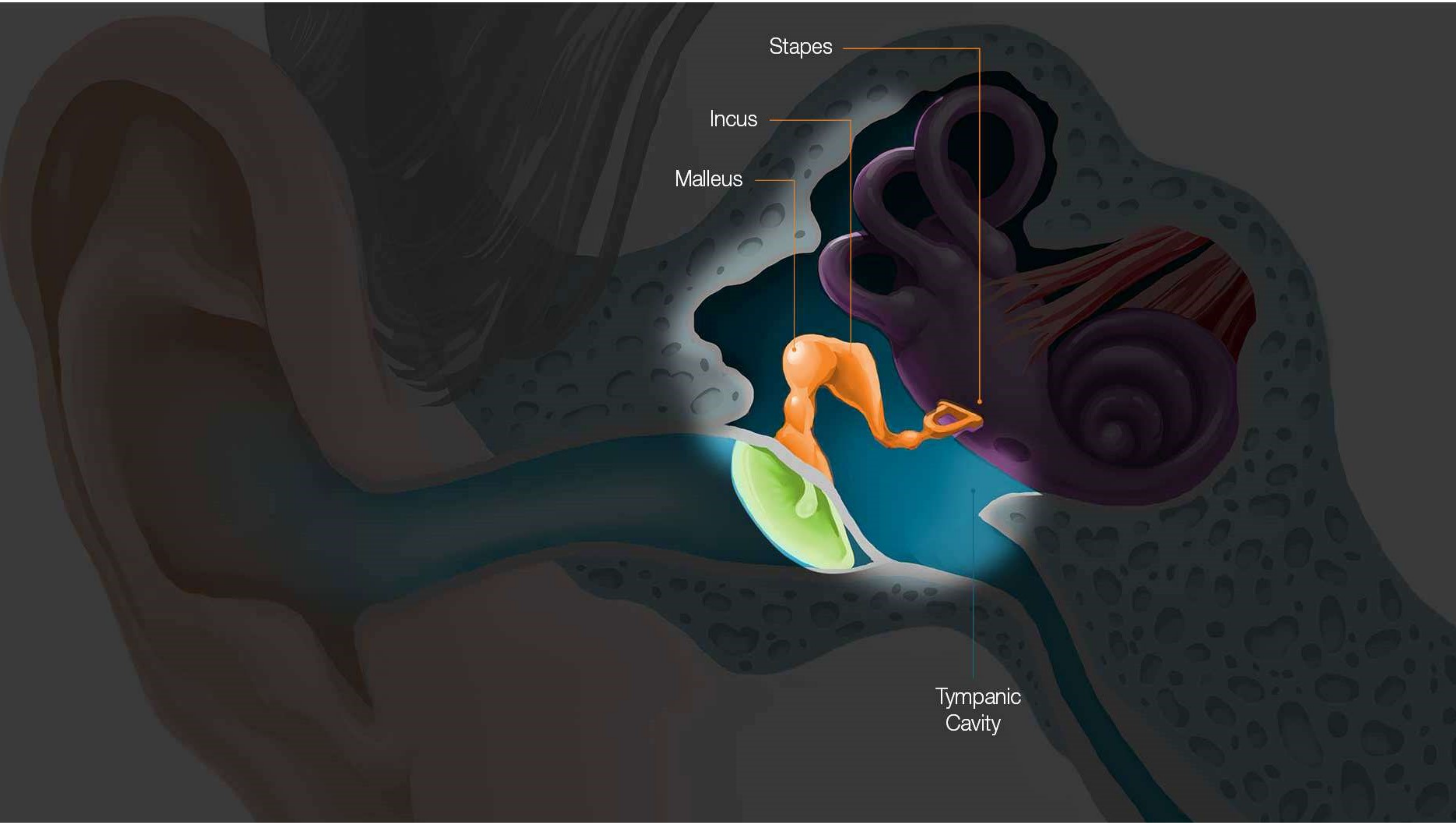
- **Human ear**

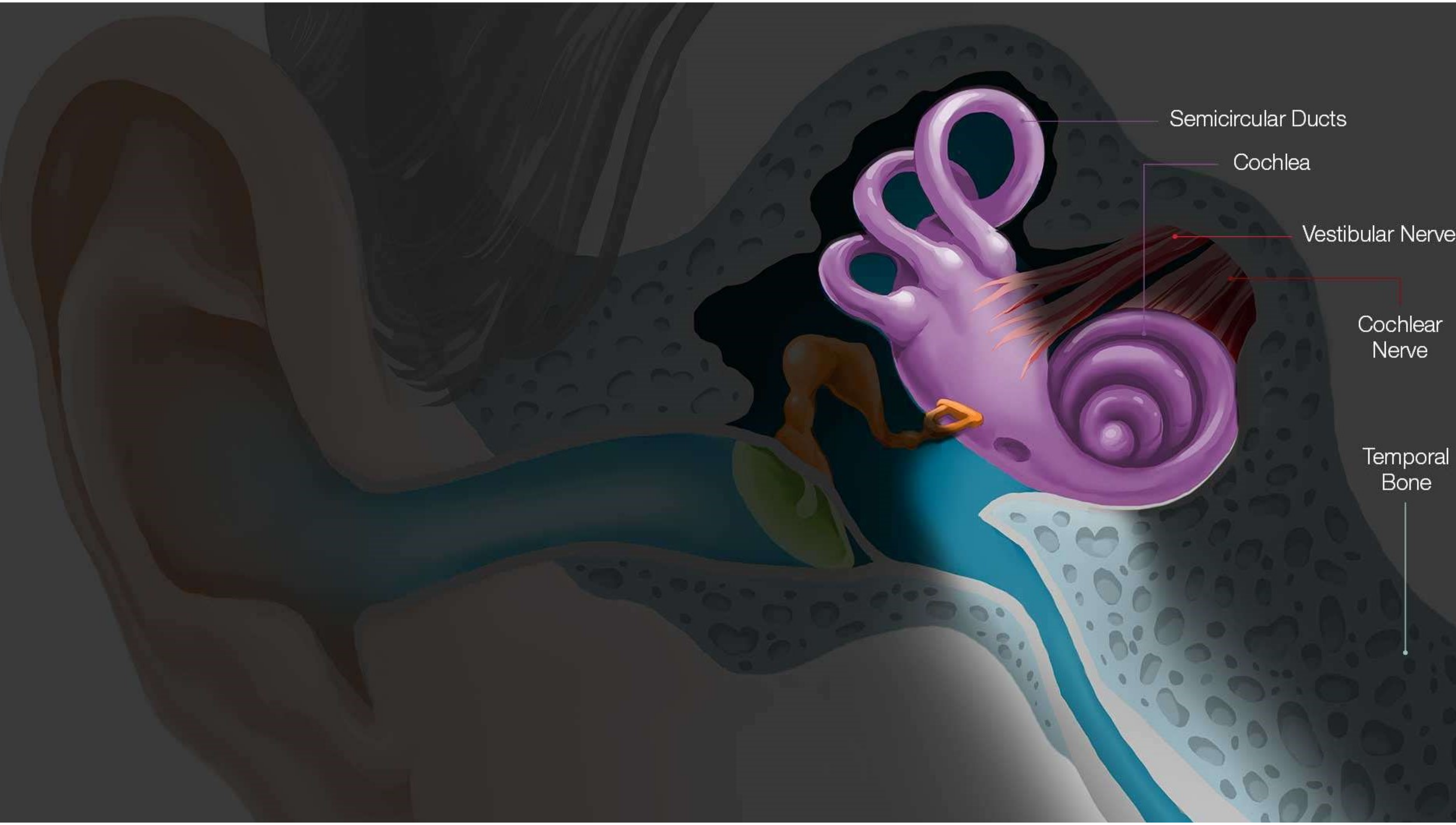

HUMAN EAR
Outer ear
Middle ear
Inner ear

STRUCTURE OF HUMAN EAR

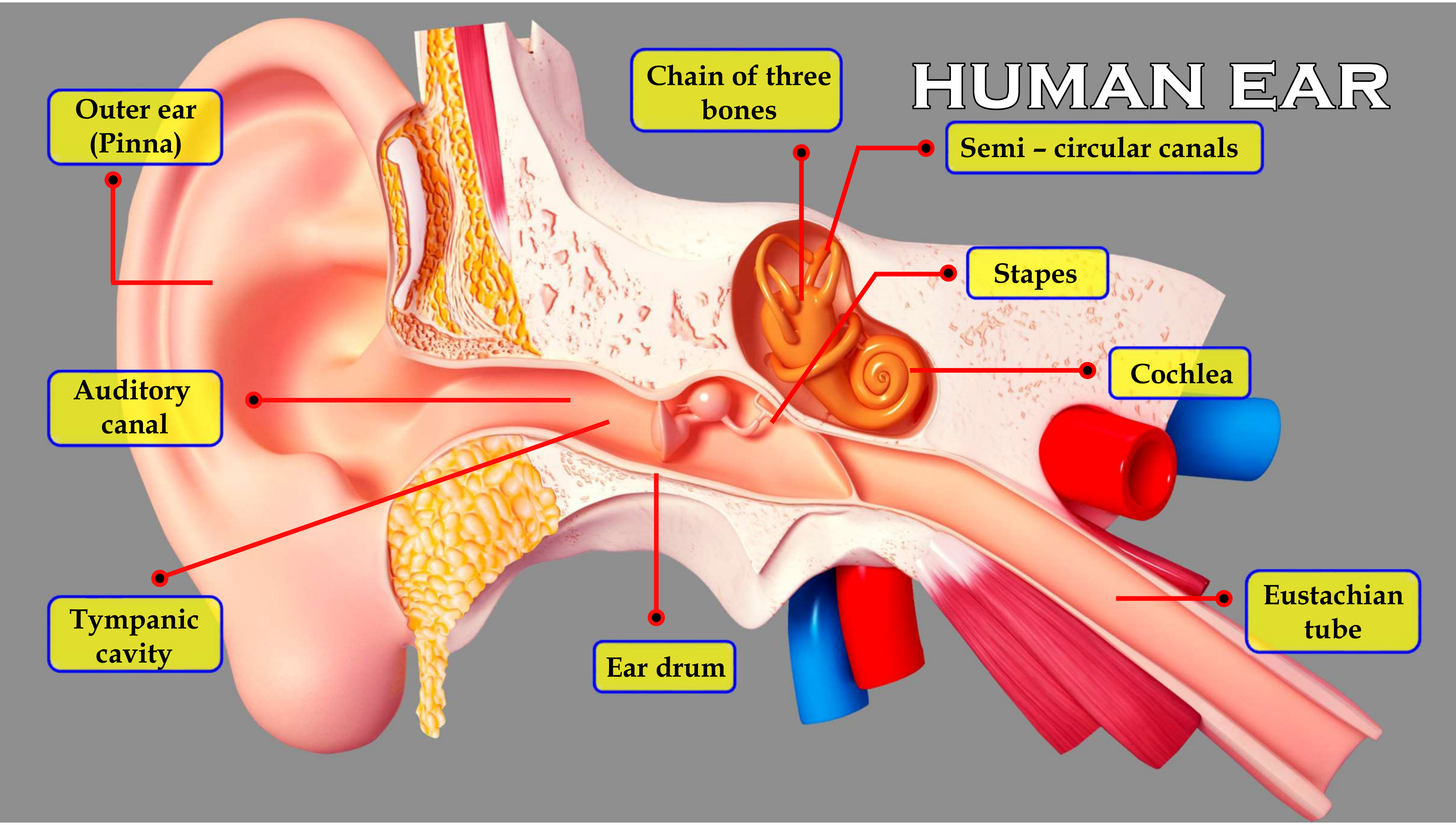



STRUCTURE OF
HUMAN EAR
Auricle
Auditory
Canal
Tymphanic
Membrane


Stapes
Incus
Malleus
Tympanic
Cavity



Semicircular Ducts
Cochlea
Vestibular Nerve
Cochlear
Nerve
Temporal
Bone


HUMAN EAR
Outer ear (Pinna)
Chain of three bones
Semi – circular canals
Stapes
Cochlea
Auditory canal
Tympanic cavity
Ear drum
Eustachian tube

Match the columns

Column 1	Column 2
Pinna	At the end of auditory canal there is a thin membrane.
Ear Drum	The outer ear is called pinna.
Auditory nerve	It converts the pressure variations into electrical signals.
Auditory canal	It sends the electrical signals to the brain.
Cochlea	The collected sound passes through auditory canal.

Module - 16

SOUND

- Numerical based on echo and kinematical equations

TYPE - B

NUMERICAL

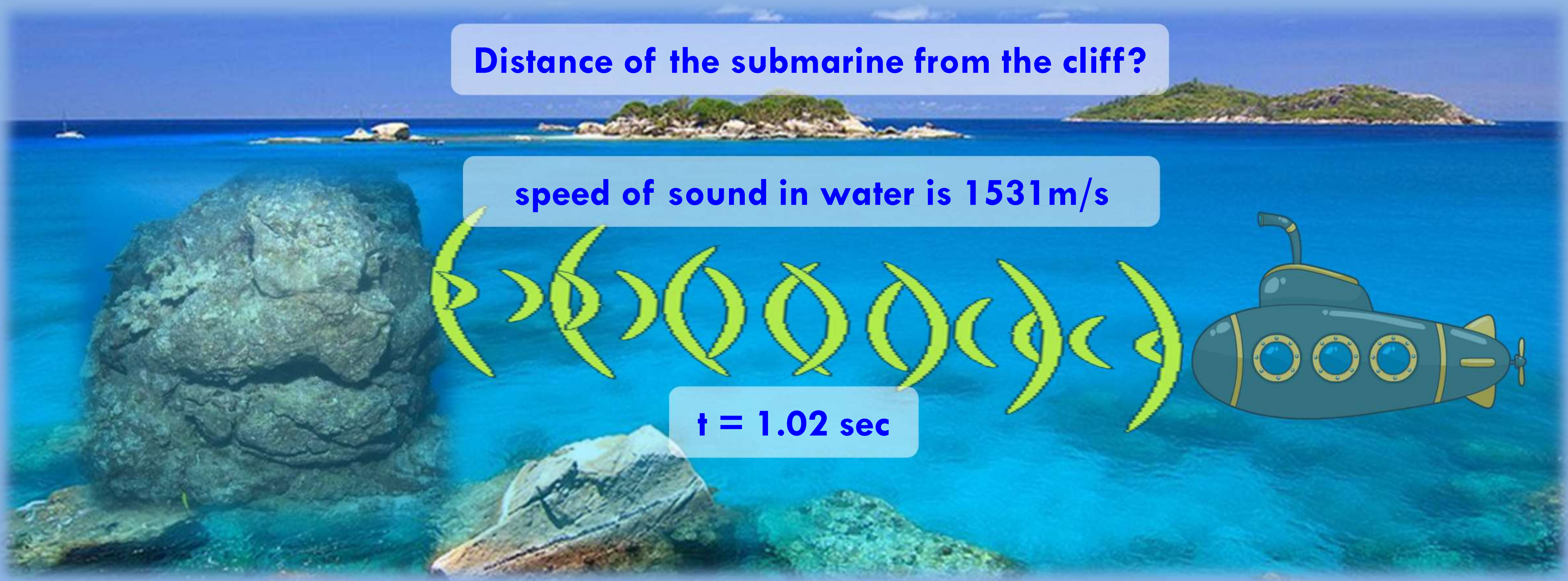
$$v = \frac{2d}{t} \text{ (for Echo)}$$

$$v = u + gt$$

$$s = ut + \frac{1}{2}gt^2$$

$$v^2 = u^2 + 2gs$$

1. 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 1531m/s, how far away is the cliff ?



1. 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 1531m/s, how far away is the cliff ?

Given : velocity of sound in sea water (v) = 1531 m/s

Time to hear echo (t) = 1.02 sec

To find : Distance between cliff and submarine = ?

Formula : $v = \frac{2d}{t}$

Solution : $v = \frac{2d}{t}$

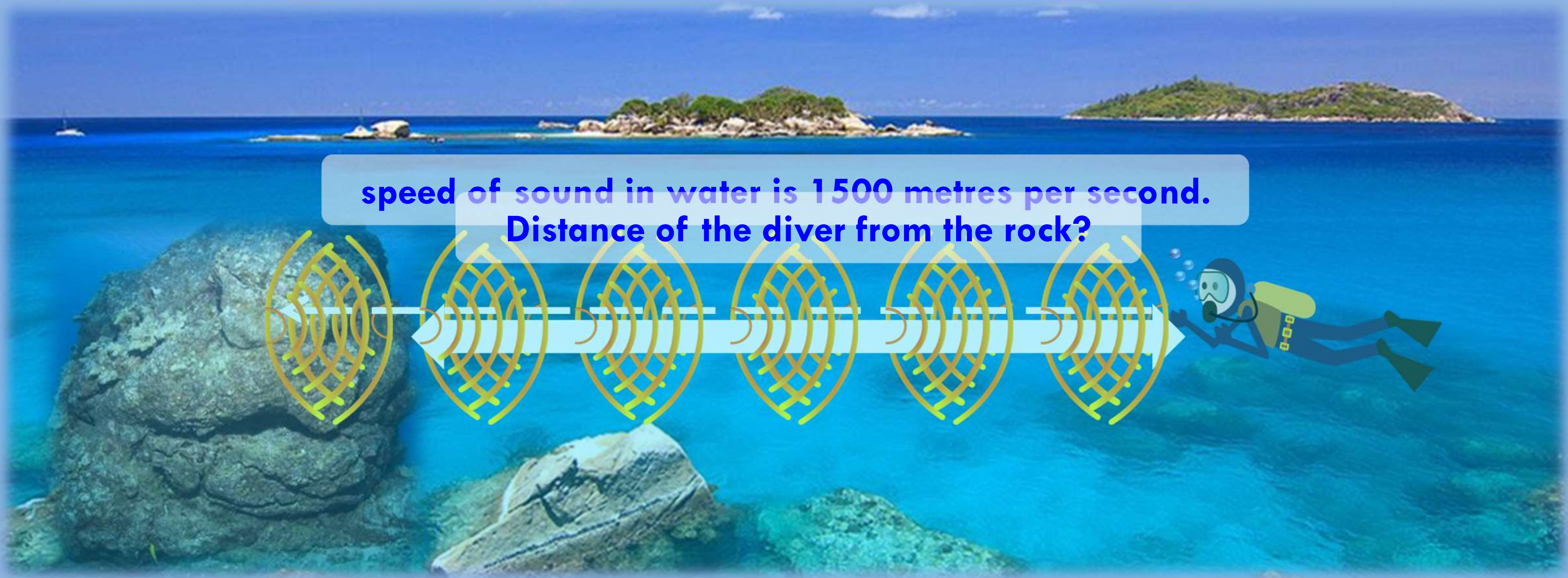
$\therefore \quad d = \frac{v \times t}{2}$

$\therefore \quad d = \frac{1531 \times \cancel{1.02}^{\,0.51}}{\cancel{2}}$

$\therefore \quad d = 780.81 \text{ m}$

Ans : The distance between cliff and submarine is 780.81 m

2. The speed of sound in water is 1500 metres per second. How far away from an under-sea rock should a deep sea diver be so that he can hear his own echo?



2. The speed of sound in water is 1500 metres per second. How far away from an under-sea rock should a deep sea diver be so that he can hear his own echo?

Given : Speed of sound in water = 1500 m/s

Time taken to hear the echo (t) = 0.1 sec

To find : Distance of the diver from the rock = ?

Formula : $v = \frac{2d}{t}$

Solution : $v = \frac{2d}{t}$

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

$\therefore \quad d = \frac{\overset{750}{\cancel{1500}} \times 0.1}{\cancel{2}}$

$\therefore \quad d = 75 \text{ m}$

Ans : The deep sea diver should be 75 m away from the under sea rock so that he can hear his echo.

Module - 17

SOUND

- **Numerical based on echo and kinematical equations**

3. An echo was heard after 3s. What is the distance of the reflecting surface from the source, given that the speed of sound is 342m/s ?

Given : Speed of sound (v) = 342 m/s

Time taken to hear the echo (t) = 3s

To find : Distance = ?

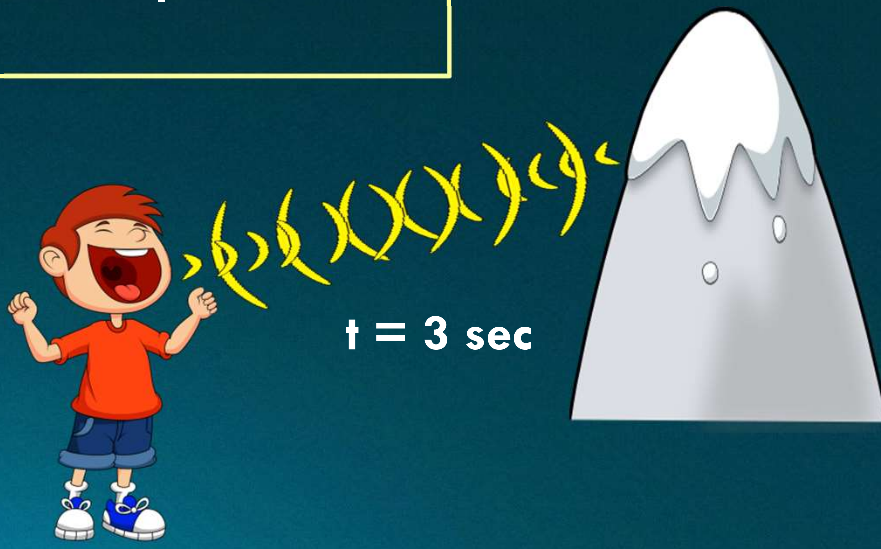
Formula : $v = \frac{2d}{t}$

Solution : $v = \frac{2d}{t}$

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

$\therefore \quad d = \frac{342 \times 3}{2}$

$\therefore \quad d = 513$ m



Ans : The distance from the reflecting surface is 513 m .

4. A person clapped his hands near a cliff and heard the echo after 5 s. What is the distance of the cliff from the person if the speed of the sound, v is taken as 346 ms^{-1}?

Given : Speed of sound (v) = 346 ms^{-1}

Time taken for hearing the echo (t) = 5s

To find : Distance = ?

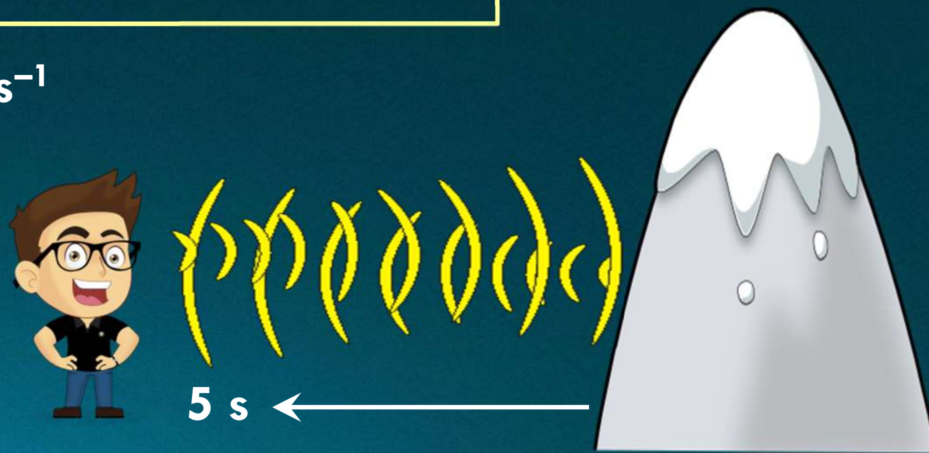
Formula : $v = \frac{2d}{t}$

Solution : $v = \frac{2d}{t}$

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

$\therefore \quad d = \frac{\overset{173}{\cancel{346}} \times 5}{\cancel{2}}$

$\therefore \quad d = 865 \text{ m}$



Ans : Distance of the cliff from the person is 865 m

Module - 18

SOUND

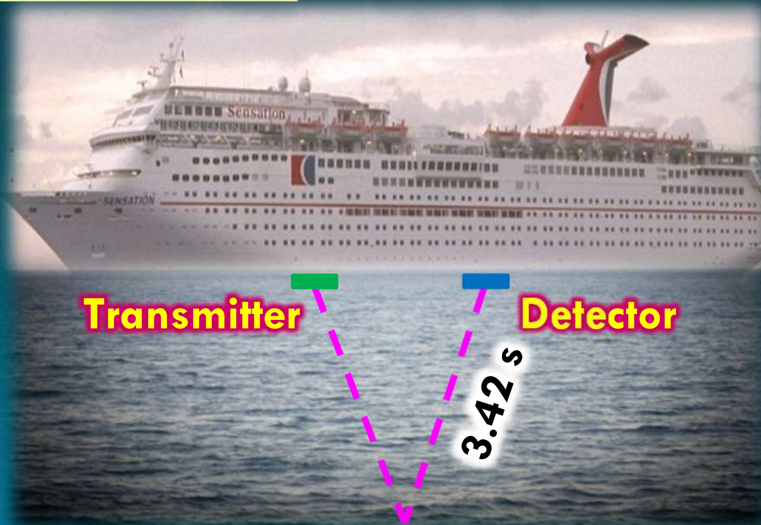
- **Numerical based on echo and kinematical equations**

5. A ship sends out ultrasound that returns from the seabed and is detected after 3.42 s. if the speed of ultrasound through seawater is 1531 m/s.
what is the distance of the seabed from the ship ?

Given : Time between transmission and detection (t) = 3.42 s

Speed of ultrasound in sea water (v) = 1531 m/s

To find : Distance = ?



Formula : $v = \frac{2d}{t}$

Solution : $v = \frac{2d}{t}$

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

$\therefore \quad d = \frac{1531 \times \cancel{3.42}^{1.71}}{\cancel{2}}$

$\therefore \quad d = 2618 \text{ m}$

Ans : The distance of the seabed from the ship is 2618 m or 2.62 km

6. A SONAR device on a submarine sends out a signal and receives an echo after 6sec. Find the distance between the object and the submarine. (speed of ultrasound = 1531 m/s)

Given : Time between transmission and detection (t) = 6 s

Speed of ultrasound in seawater (v) = 1531 m/s

To find : Distance = ?

Formula : $v = \frac{2d}{t}$

Solution : $v = \frac{2d}{t}$

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

$\therefore \quad d = \frac{1531 \times \cancel{6}^{3}}{\cancel{2}}$

$\therefore \quad d = 4593 \text{ m}$

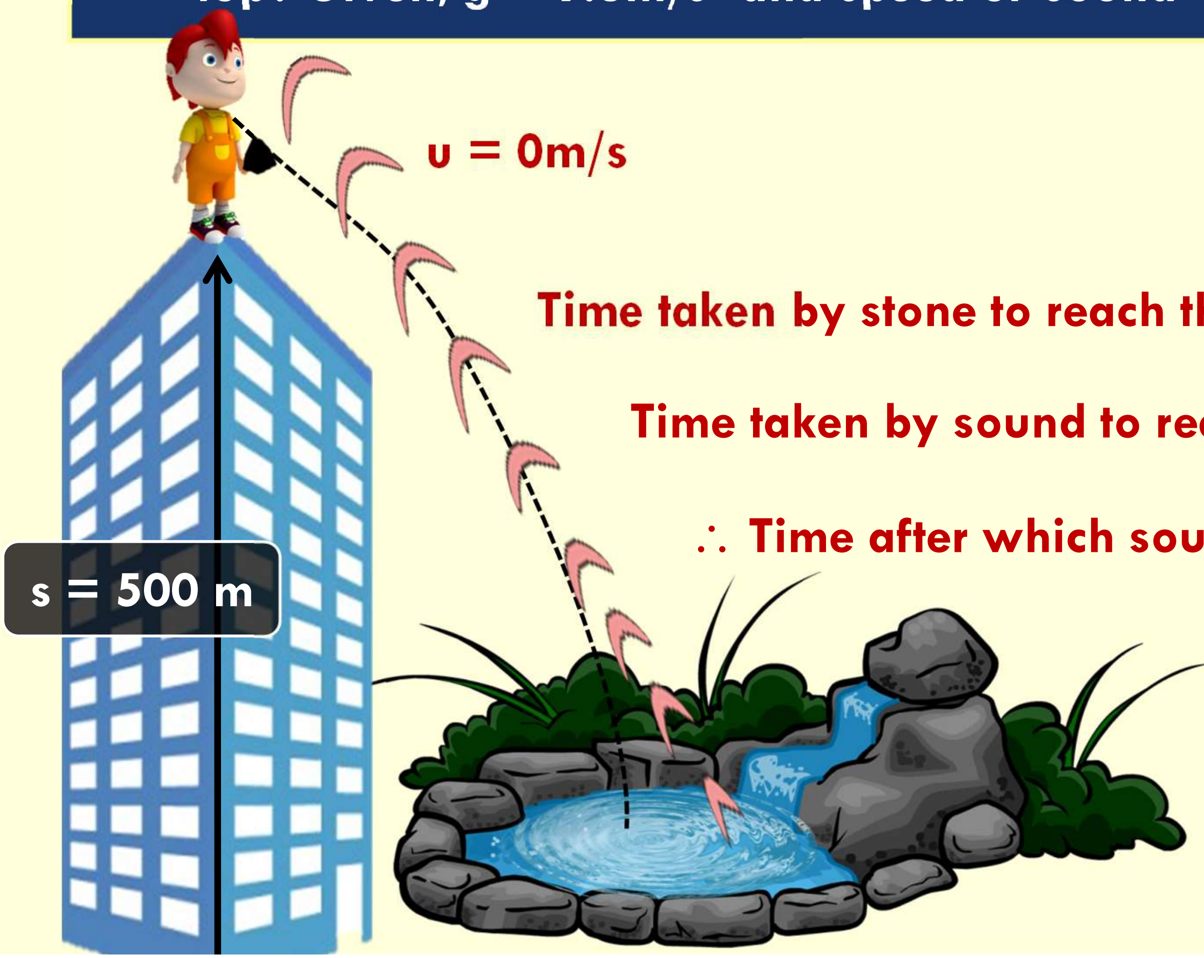
Ans : The distance between the object and the submarine is 4593 m.

Module - 19

SOUND

- **Numerical based on echo and kinematical equations**

7. 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, $g = 9.8 m/s^2$ and speed of sound $= 340 m/s^2$.



Time taken by stone to reach the pond (t_1)

Time taken by sound to reach the man (t_2)

$\therefore$ Time after which sound is heard by man(t) = ($t_1 + t_2$)

7. 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, $g = 9.8 m/s^2$ and speed of sound $= 340 m/s^2$.

Given : height of tower (s) = 500 m

velocity of sound in air (v) = 340 m/s

Acceleration due to gravity (g) = $10 \ m/s^2$

Initial velocity of stone (u) = 0 m/s

To find : Time after which the splash is heard (t) = ?

Formulae : $v = \frac{d}{t}$, $s = ut + \frac{d}{t} gt^2$

Solution : Let t_1 be the time taken by stone to pull from tower.

$\therefore$ From 2nd equation of motion

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

$$500 = 0 \times t_1 + \frac{1}{2} \times 10 \times t_1^2$$

$$500 = 5 t_1^2$$

$$\therefore \quad t_1^2 = \frac{500}{5}$$

$$t_1^2 = 100$$

$$\therefore \quad t_1 = 10 \text{ sec}$$

Let t_2 be the time taken by sound to reach from the pond to the top of tower

$$v = \frac{d}{t_2} \quad \therefore t_2 = \frac{d}{v} = \frac{500}{340} = 1.47 \text{ sec}$$

$\therefore$ The splash is heard at the top after time t :

$$t = t_1 + t_2 = 10 + 1.47 = 11.47 \text{ sec}$$

Ans : The splash is heard after 11.47 sec.

Module - 20

SOUND

- **Numerical based on echo and kinematical equations**

8. A soldier standing between two cliffs X and Y, fires a gun. After firing the gun he hears the first echo after 3.4 seconds and second echo after 4 seconds. Find the distance between the two cliffs. (speed of sound in air = 340 m/s)

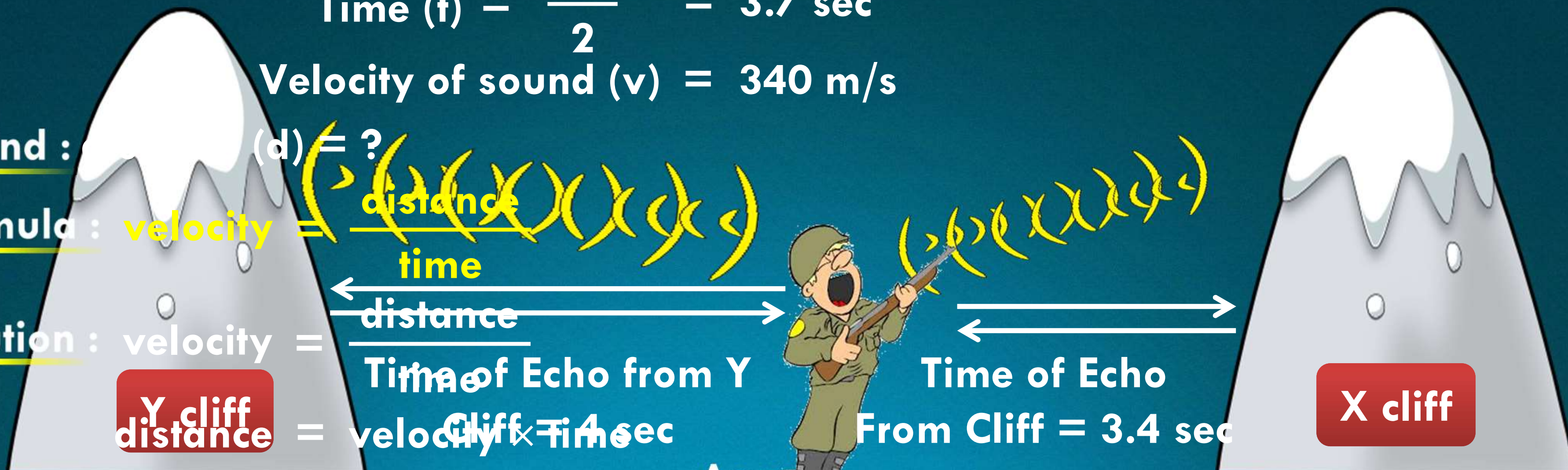
Given : Total Time of echo = 3.4 + 4 = 7.4 sec

$$\text{Time (t)} = \frac{7.4}{2} = 3.7 \text{ sec}$$

Velocity of sound (v) = 340 m/s

To find : (d) = ?

Formula : $\text{velocity} = \dfrac{\text{distance}}{\text{time}}$



Solution : $\text{velocity} = \dfrac{\text{distance}}{\text{time}}$

distance = velocity × time

distance = 340 × 3.7

$\boxed{d = 1258 \text{ m}}$

Ans : The distance between the two cliff is 1258 m.

Module - 21

SOUND

- **Additional Numericals**

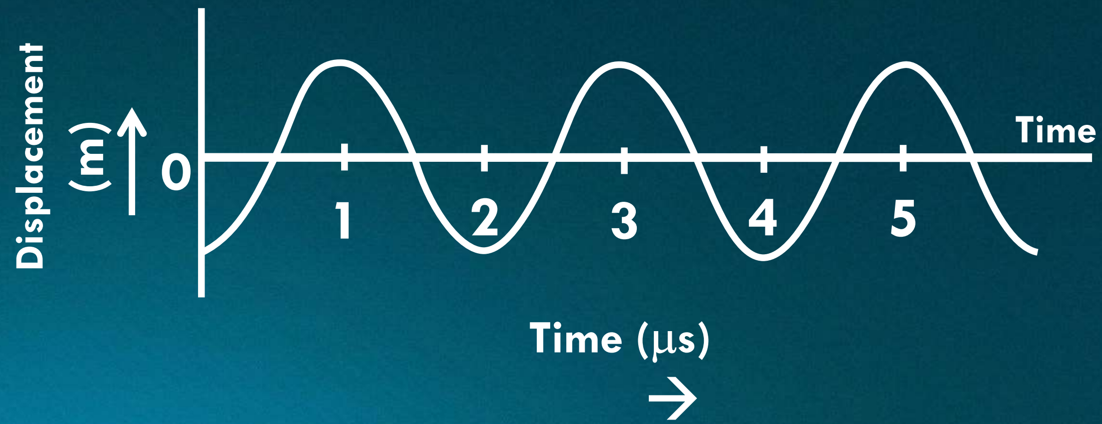
1. The graph shows the displacement versus time relation for a disturbance travelling with velocity 1500 ms^{-1}. Calculate the wavelength of the disturbance.

Given : Velocity (v) = 1500 ms^{-1}

Time period (T) = 2 μs

To find : Wavelength (λ) = ?

Formula : $v = \frac{\lambda}{T}$



Solution : $v = \frac{\lambda}{T}$

$\therefore \quad \lambda = v \times T$

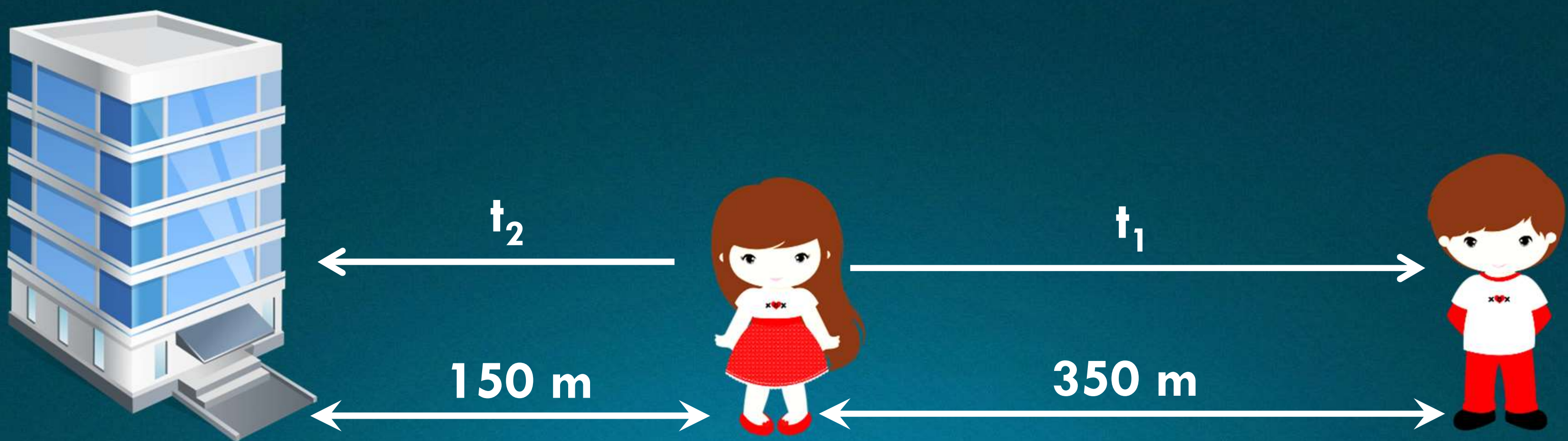
$\therefore \quad \lambda = 1500 \times 2 \times 10^{-6}$

$\therefore \quad \lambda = 3000 \times 10^{-6}$

$\therefore \quad \lambda = 3 \times 10^{-3}$ m

Ans : The wavelength of the disturbance is 3×10^{-3} m

2. A girl standing 150 m in front of tall buildings, fires a shot using a starting pistol. A boy, standing 350 m behind her, hears two bangs 1 s apart. What is the speed of sound ?



2. A girl standing 150 m in front of tall buildings, fires a shot using a starting pistol. A boy, standing 350 m behind her, hears two bangs 1 s apart. What is the speed of sound ?

Solution : Time of sound from girl to boy $= t_1$

Time of sound from girl to building $= t_2$

Case 1

Time of 1^{st} sound (Girl - boy) $= t_1$

Case 2

Time of 2nd sound (Girl - building – boy) $= 2t_2 + t_1$

Time difference = Case 2 – Case 1

$$1 = 2t_2 + t_1 - t_1$$

$$1 = 2t_2$$

$$t_2 = \frac{1}{2} = 0.5 \text{ s}$$

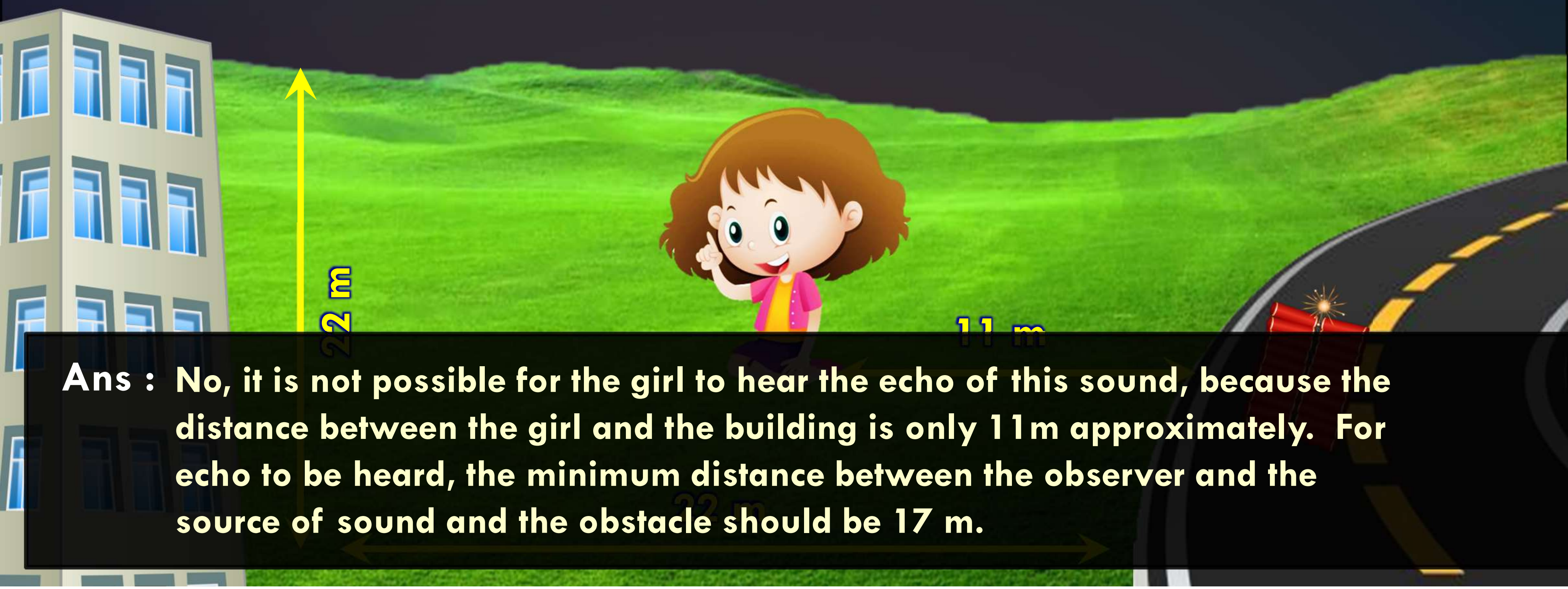
$$\text{Speed} = \frac{\text{distance}}{\text{time}} = \frac{150}{0.5} = 300 \text{ m/s}$$

Module - 22

SOUND

- **Additional Questions**

Q. A girl is sitting in the middle of a park of dimension 22m × 22m. On the left side of it there is a building adjoining the park and on the right side of the park, there is a road adjoining the park. A sound is produced on the road by a cracker. Is it possible for the girl to hear the echo of this sound? Explain your answer.



Ans : No, it is not possible for the girl to hear the echo of this sound, because the distance between the girl and the building is only 11m approximately. For echo to be heard, the minimum distance between the observer and the source of sound and the obstacle should be 17 m.