SOUND

SYNOPSIS

- ***Wave Motion***: A wave is a disturbance which prop agates energy from one place to the other without the transport of matter.
- The wave moves forward with constant velocity without change in its shape.
- The particles of the medium responsible for wave propagation vibrate about their mean positions, without getting permanently displaced.
- The medium itself doesnot move.
- The phase of various particles of the medium Keeps on changing constantly.

Classification on the basis of necessicity of medium.

- ***Mechanical Waves***: These are waves which transfer energy with the help of the particles of the medium. For this propagation the medium must be elastic and it should possess inertia.
- The medium should have low resistance.
  Ex: Sound waves.
- ***Electromagnetic Waves***: These are waves that can transfer energy even in vaccum. They propagate due to variation of electric and magnetic fields.
  Ex: Light waves, X-rays, γ-rays, radio waves. On the basis of energy propagation.
- ***Progressive Wave***: A wave that propagate energy in an infinite medium, starting at a point and never returns to that point is called a Progressive Wave.
- In these waves all the particles of the medium execute SHM with same amplitude and same frequency.
- Velocity of the particle and the strain are proportional to each other.
- Equal changes in pressure and densities occur at all points of the medium.
- All the particles of the medium cross the mean position once in one time period.
- Average energy over one time period is equal to the sum of K.E. and P.E.
- ***Stationary Wave***: When two identical progressive waves moving in opposite directions superpose, stationary waves are formed.
  On the basis of vibration of particles.
- ***Transverse Wave***: In a Transverse wave the particles of the medium vibrate perpendicular to the direction of the propagation of the wave.
  Ex : Waves in Strings.
- It travels in the form of crests and troughs.
- These waves can propagate only in solids and on the surface of water.
- Pressure and densities donot vary.
- These wavs can be represented by

$$Y = a\sin(\omega t \pm kx) \quad Z = a\sin(\omega t \pm kx)$$

$$Z = a\sin(\omega t \pm ky) \quad Y = a\sin(\omega t \pm kz)$$

- These waves can be polarised.
- ***Longitudinal Wave***: In a Longitudinal wave the particles of the medium vibrate in the direction of the propagation of the wave.
  Ex : Sound Waves in air
- Travel in the form of compressions and rarefactions.
- They can be produced in solids, liquids and gases.
- Pressure and density vary.
- These waves can be represented by $x = aSin(\omega t \pm kx)$.
- These waves cannot be polarised.
- ***Equation of Progressive Wave***:
  y= A Sin (ω t $\pm$ kx)
  + sign for a wave travelling along -ve X direction
  - sign for a wave travelling along +ve X direction where,
  y is displacement of the particle after a time t, from mean position.
  x is displacement of the wave.
  A is Amplitude.
  ω is angular frequency or angular velocity

$$\omega = 2\pi / T = 2\pi n$$

  k is propagation constant

$$k = 2\pi/\lambda$$

- **Phase:** Phase gives the state of the vibrating particle as regards to its position and direction of motion.
  ● Phase is the angular displacement from its mean position.

$$\phi = (\omega t \pm kx)$$

  ● Path difference is the difference of distances covered by two vibrating particles.

• Phase difference between two points on a wave = $2\pi/\lambda$ (Path difference)

$\Delta\phi = (2\pi/\lambda)\ \Delta x$

• Time difference is the difference of times taken by the vibrating particle in completing one vibration.

$$\Delta\phi = \frac{2\pi}{T} \times \text{time difference}$$

$$\text{time difference} = \frac{T}{\lambda} \times \text{ path difference.}$$

• If two sources emit waves of frequencies n_1 and n_2 simultaneously, then the phase difference between these two waves after a time Δt is given by

$\Delta\phi = (\omega_2 - \omega_1)\Delta t = 2\pi\ (n_2 - n_1)\Delta t.$

- **a) Wave Velocity :** It is the distance travelled by the wave per unit time.

  Wave velocity, $V = n\lambda = \lambda/T = \omega/k$

  • Wave velocity is constant as it doesnot depend on time.

  b) Particle Velocity: When a wave propagates through a medium, the velocity of the particle in SHM is called particle velocity.

  $V = \omega\sqrt{A^2 - y^2}$

  • At y = 0, V is maximum, $V_{max} = \pm\omega A$

  • At $y = \pm A$, V is minimum, $V_{min} = 0$

  • Particle velocity varies with time.
- **Principle of super position of waves:** When two or more waves propagating in the medium superimpose over a common particle of the medium, then the resultant displacement of the particle is the vector sum of the displacement of the particle due to each wave as if other waves are absent.

  $\vec{y} = \vec{y}_1 + \vec{y}_2 + \vec{y}_3 + ... + \vec{y}_n$
- This law is applicable for all types of waves like light waves, sound waves etc but not applicable to large amplitude waves like shock waves, laser waves etc.

  Phenomena arising due to superposition of waves.

  a) Interference b) stationary waves

  c) Beats d) Lissaous figures
- In superposition phenomena, energy is conserved but it is distributed.
- Superposition is possible only in waves of similar nature.

REFLECTION-REFRACTION OF WAVES

- When a mechanical wave or an electromagnetic wave is reflected from a rigid surface, a phase difference of π is introduced in the reflected wave. $y_1 = a\,S\text{in}(\omega t - kx)$ is the wave propagating along $+ve\ 'x'$ direction

  The reflected wave is $y_2 = a\,Sin[(\omega t + kx) + \pi]$
- When a wave is reflected from free end there is no phase change.

  $y_1 = a\,Sin(\omega t - kx)$ propagating along + x direction $y_2 = a\,Sin(\omega t + kx)$ reflected wave along -x direction.
- When a wave refracts (transmits) there is no phase change
- ***Reflection from Rigid Suface:***

  • Change in phase is π; change in time is $\frac{T}{2}$. Change in path is $\frac{\lambda}{2}$. Compression returns as rarefaction and rarefaction as compression. But crest returns as crest and trough returns as trough.
- ***Reflection from Free End:***

  • Change in phase = 0, change in time = 0, change in path = 0. Compression and rarefaction return as compression and rarefaction respectively. But crest and trough return as trough and crest respectively.

  • Sound produced in air is not heard by a diver inside water since most sound energy is reflected at the surface of water.
- ***Stationary or Standing Wave***:

  • When two identical progressive waves moving in opposite directions superpose, stationary waves are formed.

  • There is no transfer of energy.

  • Nodes are the points where the displacement and velocity are zero. At the nodes, the pressure changes are maximum.

● Antinodes are the points where the displacement and velocity are maximum. At antinodes pressure changes are zero.
● Distance between two successive nodes or antinodes is $\lambda/2$
● Distance between a node and an immediate antinode is $\lambda/4$
● In a loop , all the particles vibrate with same frequency, time period. However, their amplitudes vary ranging from zero to maximum.
● All particles with in a loop are in same phase or phase difference between any two particle with in a loop is zero.
● The Phase difference between any two particle in successive loops is π radian or 180^0
● Amplitude is a function of displacement whereas phase is a function of time.
● Both longitudinal and transverse waves exhibit stationary wave phenomena.
● Strain is maximum at nodes and minimum at antinodes.
● Particles donot execute SHM at nodes whereas they execute SHM at antinodes.
● Nodes are obtained at $x=(2n+1)\frac{\lambda}{4}$ where n = 0, 1, 2 ....
● Antinodes are obtained at $x=\frac{n\lambda}{2}$ where $n=0,1,2......$

● ***Equation of Stationary Wave***:
● If the wave is reflected at free boundary
Y = 2A Cos kx Sin ω t (Where 2 A Cos kx is the amplitude)
or
● If the wave is reflected at fixed boundary
Y = 2A sin kx Cos ω t (Where 2 A Sin kx is the amplitude)
In stationary waves, Amplitude is the function of displacement

● ***Tuning fork:***:
● It is made of steel or aluminium rod of rectangular cross-section and it is U-shaped.
● The prongs of a tuning fork execute transverse vibrations whereas its stem executes longitudinal vibrations.
● The two arms of a tuning fork vibrate in the opposite phase. Transverse stationary waves are produced in U-shaped portion and longitudinal stationary waves are produced in linear portion of a tuning fork.
● Antinodes are formed at the free ends of the arms as well as at the point where the two arms meet whereas nodes are formed in between.
● The frequency of a tuning fork depends on -
i) thickness (t) of the fork i.e. $n\alpha t$.
ii) length of the arm (l) of the fork i.e. $n\alpha\frac{1}{l^2}$.
iii) the modulus of elasticity (E) of the material of the fork i.e. $n\alpha\sqrt{E}$.
iv) the density (ρ) of the material of the fork i.e. $n\alpha 1/\sqrt{\rho}$.
v) the temperature(T) of the medium i.e. $n\alpha\frac{1}{T}$.

● ***Expressions of the frequencies of a fork:***
i) $n=\frac{At}{l^2}\sqrt{\frac{Y}{\rho}}$ here A is a constant.
ii) In longitudinal mode $n_L=\frac{p}{l}\sqrt{\frac{T}{m}}$.
iii) In transverse mode $n_T=\frac{p}{2l}\sqrt{\frac{T}{m}}$.
● The tuning forks of higher frequencies are small and thick whereas those of low frequencies are long and thin.
● Tuning fork is a source of sound which can produce a pure note.

● a) When wax in attached to the prongs, its natural frequency decreases.
b) When the prongs of the tuning fork are filed, its natural frequency increases.
● With rise in temperature, the frequency of a fork decreases.
● The two prongs of a vibrating tuning fork are in a phase difference of π.
● If one of the prongs of a tuning fork is broken, its frequency remains same but intensity of sound increases due to increase in amplitude.
● In a tuning fork, stationary transverse vibrations are set up with two nodes and three

antinodes.

- ***Audible Sound And Audible Limit:***

  ● Sounds produced by all vibrating bodies is not audible. The audible frequency range for a normal human ear is 20 Hz to 20,000 Hz

  ● Sound waves of frequency less than 20 Hz are called Infrasonics.

  Ex : Waves produced during earth quakes.

  ● Sound waves of frequency greater than 20,000 Hz are called Ultrasonics.

  Ex : Sounds produced by bats.

  ● Sound waves cannot propagate through vacuum.

  ● Velocity of sound in air at 0^0 C is 331 ms^{-1}.

  ● Audible wavelength limit of sound in air ($V = 330\ ms^{-1}$) is 16.5 mm to 16.5 m.

- ***Free or Natural Vibrations***: A body is excited once and there after it is made to vibrate freely then those vibrations are called natural vibrations of that body. The frequency with which it vibrates is called Natural Frequency.

- ***Forced Vibrations***: If a body vibrates under the influence of an external periodic force, then the vibrations of that body are called forced vibrations.

- ***Resonance***: When the frequency of the external periodic force acting on the body is equal to the natural frequency of that body, the body vibrates with maximum amplitude. This phenomenon is called Resonance. It is a special case of forced vibrations.

- Velocity of transverse wave along a stretched string:

$$V = \sqrt{\frac{T}{m}} = \sqrt{\frac{T}{A\rho}} = \sqrt{\frac{T}{\pi r^2 \rho}}$$

Where,

'T' is the tension in the string

'm' is linear density or mass per unit length of string

(m= mass of string / length of the string)

ρ is the density of the material of the string

r is the radius of the string

A is the area of cross-section of the string.

- ***Velocity of sound in solids:***

i) $V = \sqrt{\frac{Y}{\rho}}$ ii) $V = \sqrt{\frac{T}{m}}$

- ***Velocity of sound in liquids:***

i) $V_{liquid} = \sqrt{\frac{K}{\rho}} = \sqrt{\frac{E}{\rho}}$

here K = Bulk modulus of elasticity

ρ = density of liquid

- **Sonometer:** Sonometer consists of a stretched wire whose length can be changed and the tension in the wire can also be changed. When the sonometer wire is made to vibrate, transverse stationary waves are produced in it.

● When sonometer wire vibrates in 1 loop then its frequency of vibration is called 1^{st} harmonic. (n_1) (or) Fundamental note

$V = \sqrt{T/m}$ and $\lambda_1 = 2l$

$n_1 = V/\lambda_1$

$$n_1 = \frac{1}{2l}\sqrt{\frac{T}{m}}$$

Where l is the length of the string.

● When the sonometer wire vibrates in 2 loops then its frequency of vibration is called 2^{nd} harmonic (n_2) or 1^{st} overtone

$\lambda_2 = 2l/2.$

$$n_2 = 2\left(\frac{1}{2l}\right)\sqrt{\frac{T}{m}} = 2n_1$$

● When the sonometer wire vibrates in 3 loops, then its frequency of vibration is called 3^{rd} harmonic (n_3) or 2^{nd} overtone.

$\lambda_3 = 2l/3$

$$n_3 = 3\left(\frac{1}{2l}\right)\sqrt{\frac{T}{m}} = 3n_1$$

● When sonometer wire is vibrating in 'x' loops then its frequency of vibration is called x^{th} harmonic or $(x-1)^{th}$ overtone.

$\lambda_x = 2l/x$

$$n_x = x\left(\frac{1}{2l}\right)\sqrt{\frac{T}{m}} = xn_1$$

● The ratio of the frequencies of the various modes of vibration is 1: 2: 3: 4: …….

● The difference in the frequencies of successive overtones is equal to the fundamental frequency.

$$n_2 - n_1 = n_3 - n_2 = n_4 - n_3 = n_1 = \left(\frac{1}{2l}\right)\sqrt{\frac{T}{m}}$$

● Fundamental frequency

$$n_1 = \left(\frac{1}{2l}\right)\sqrt{\frac{T}{m}} = \left(\frac{1}{2l}\right)\sqrt{\frac{T}{A\rho}} = \left(\frac{1}{2l}\right)\sqrt{\frac{T}{\pi r^2\rho}}$$

$$= \left(\frac{1}{2lr}\right)\sqrt{\frac{T}{\pi\rho}} = \frac{1}{ld}\sqrt{\frac{T}{\pi\rho}}$$

Where d is the diameter of the wire.

- Laws of transverse vibrations of stretched strings:

● Law of tension: $n \propto \sqrt{T}$

$$\frac{n_1}{n_2} = \sqrt{\frac{T_1}{T_2}}$$

● Law of length: $n \propto \frac{1}{l}$

$$\frac{n_1}{n_2} = \frac{l_2}{l_1}$$

● Law of linear density : $n \propto \frac{1}{\sqrt{m}}$

$$\frac{n_1}{n_2} = \sqrt{\frac{m_2}{m_1}}$$

These laws can be verified using a sonometer.

- ● If a wire held at the two ends by rigid supports is just taut at $t_1\,^0C$ then the velocity of the transverse wave at $t_2\,^0C$ is given by

$$V = \sqrt{\frac{T}{m}} = \sqrt{\frac{YA\alpha\Delta t}{A\rho}} = \sqrt{\frac{Y\alpha\Delta t}{\rho}}$$

Where Y is the young's modulus and α is the co-efficient of linear expansion of the material of the wire.

$$\Delta t = t_1 - t_2 \quad (t_1 > t_2)$$

● A wire of uniform cross–section is fixed at one end and is attached to a load M passing over a pulley at the other end.

Velocity of the transverse wave, $V = \sqrt{\frac{Mg}{m}}$

● If the load is submerged in a liquid of density d then the velocity of wave is,

$$V_1 = \sqrt{\frac{(Mg - vd_L g)}{m}} = \sqrt{\frac{Mg(1 - \frac{d_L}{d_S})}{m}}$$

Where d_S, is the density of the material of the load suspended

$$\frac{V_1}{V} = \sqrt{\frac{d_S - d_L}{d_S}}$$

● If n and n_1 are the fundamental frequencies of the stretched string with the load in air and when submerged in liquid then,

$$\frac{n_1}{n} = \sqrt{\frac{T_1}{T_2}} = \sqrt{\frac{Mg\left(1 - \frac{d_L}{d_S}\right)}{Mg}} = \sqrt{\frac{(d_S - d_L)}{d_S}}$$

- ***Echo***:

● The sound reflected by an obstacle which is heard by a listener is called an echo.

● Persistence of hearing is the minimum interval of time between two sound notes to distinguish them.

Persistence of hearing is 0.1s

● A person is at a distance 'd' from a reflected surface (a wall, mountain etc). The person sounds a horn and hears its echo at the end of a time 't'. If V is the velocity of sound in air then.

$$d = \frac{Vt}{2}$$

To hear a clear echo, the minimum distance of the obstacle,

$$d_{min} = \frac{V \times 0.1}{2} = \frac{V}{20}$$

If V = 330 ms^{-1} then d_{min} = 16.5m

If V = 340 ms^{-1} then d_{min} = 17 m

● A person in an open car approaching a vertical wall with a velocity V_C, sounds a horn when the car is at a distance 'd' from the wall and listens the echo after a time 't'. If V is the velocity of sound in air then,

$$d=\left(\frac{V+V_C}{2}\right)\times t$$

● If the car is moving away from the mountain then,

$$d=\left(\frac{V-V_C}{2}\right)\times t$$

● A person standing between two parallel cliffs fires a gun and listens to the 1st and 2nd echoes after a time t_1 and t_2 second respectively, then time taken to hear the third echo t_3 is,

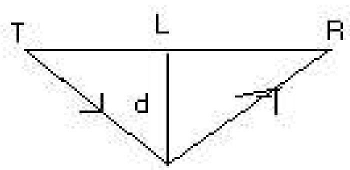
$$t_3=t_1+t_2$$

If d is the distance between the two mountains then

$$d=V\left(\frac{t_1+t_2}{2}\right)$$

● Echo is used to find the depth of the sea, height of the aeroplane. If 'd' is the depth of the sea and L is the distance between transmitter T and receiver R of sound and t is the time interval between transmission and reception of the wave, then

$$d=\sqrt{(V^2t^2-L^2)/4}$$



● **BEATS:**

● It is the phenomenon of periodic change in the intensity of sound when two waves of slightly different frequencies superpose with each other.

● Maximum Intensity of sound is produced in the beats when constructive Interference takes place.

● Minimum Intensity of sound is produced in the beats when destructive Interference takes place.

● If A_1, A_2 are amplitudes of two sound waves that interfere to produce beats then the ratio of maximum and minimum intensity of sound is, $\frac{I_{max}}{I_{min}}=\left(\frac{A_1+A_2}{A_1-A_2}\right)^2$

● The variation in the intensity of sound between successive maxima or minima is called one beat.

● The number of beats per second is called beat frequency. If n_1 and n_2 are the frequencies of the two sound waves that interfere to produce beats then

beats $\rightarrow$ equation

Beat frequency $= n_1 \sim n_2$

● The time period of one beat (or) the time interval between two successive maxima or minima is $\frac{1}{n_1 \sim n_2}$

● The time interval between a minimum and the immediate maximum is $\frac{1}{2(n_1 \sim n_2)}$

● Maximum number of beats that can be heard by a human being is 10 per second.

If more than 10 beats produced then no. of beats produced are same but no. of beats heard are zero

● Frequency of variation of amplitude $=\frac{n_1-n_2}{2}$

● Frequency of resultant wave $=\frac{n_1+n_2}{2}$

In beats, Amplitude is function of time

Uses of Beats:

● To determine unknown frequency of a tuning fork with the help of a standard tuning fork.

● To tune the stretched string of a musical instrument to a particular frequency.

● To detect the presence of dangerous gases in mines.

● ***Doppler Effect:***

● It is the phenomenon of apparent change in the frequency of sound which is heard by a listener when there is a relative motion between listener and source of sound.

In the following cases, apparent frequency is greater than original frequency.

● Listener approaches stationary source of sound.

- Source of sound approaches stationary listener.
- Both listener and source of sound approach each other.

In the following cases apparent frequency is less than actual frequency

- Listener moves away from stationary source of sound.
- Source of sound moves away from stationary listener.
- When the sound source moves towards the observer then the waves contract i.e. the wavelength decreases and consequently frequency increases.
- When the source moves away from the observer, then the waves spread i.e. the wavelength increases and consequently frequency decreases.
- Both, listener and source of sound move away from each other.
- Let V be the velocity of sound in still air and V_W is the velocity of wind.
- If wind is blowing from source of sound to listener then, velocity of sound in air = $V + V_W$.
- If wind is blowing from listener to source of sound then velocity of sound in air= $V - V_W$.
- Doppler effect in sound is asymmetric.
- Doppler effect in light is symmetric.
- Generally, Doppler effect is well applicable when velocity of listener and velocity of source of sound are much less than velocity of sound in air. (Vo <<V>>Vs)
- Doppler effect is not applicable, if velocity of listener is equal to or greater than velocity of sound in air, when listener is moving away from stationary source of sound.
- Doppler effect is not applicable, if velocity of source of sound is equal to or greater than velocity of sound in air, when source of sound is approaching stationary listener.
- **Applications of Doppler effect:**
- To measure the velocity of automobiles by traffic police.
- This effect is used in accurate navigation of air craft and is basis of target bombing techniques.
- To measure velocities of stars relative to earth.
- To measure speed of rotation of the sun.
- To detect double stars and rotation of saturn rings.
- Expressions for apparent frequency (n_1) in terms of actual frequency (n) :

V - Velocity of sound in stationary air

V_0 - Velocity of Listener

V_S - Velocity of source of sound

$$n_1 = \left(\frac{V \pm V_o}{V \mp V_s}\right) n$$

- Listener and source at rest.

$$n_1 = n$$

- Listener moving towards stationary source.

$$n_1 = \left(\frac{V + V_o}{V}\right) n$$

- Listener moving away from stationary source.

$$n_1 = \left(\frac{V - V_o}{V}\right) n$$

- Source moving towards listener at rest.

$$n_1 = \left(\frac{V}{V - V_s}\right) n$$

- Source moving away from listener at rest.

$$n_1 = \left(\frac{V}{V + V_s}\right) n$$

- Source moving towards listener and listener moving away from source.

$$n_1 = \left(\frac{V - V_o}{V - V_s}\right) n$$

- Source moving away from listener and listener moving towards source.

$$n_1 = \left(\frac{V + V_o}{V + V_s}\right) n$$

- Source and listener moving towards each other.

$$n_1 = \left(\frac{V + V_o}{V - V_s}\right) n$$

● Source and listener moving away from each other.

$$n_1 = \left(\frac{V - V_o}{V + V_s}\right) n$$

● Shift in the position of spectral lines of a star towards greater wavelength side (Red shift) indicates that universe is expanding.

● If the source of sound is moving towards a wall and the observer is standing between the source and the wall, no beats are heard by the observer.

● **Conditions when Doppler effect is not observed for sound waves:**

● When the source of sound and the observer both are at rest then Doppler effect in sound is not observed.

● When the source and the observer both are moving with same velocity in same direction, then Doppler effect of sound is not observed.

● When the source and the observer are moving mutually in perpendicular directions then also Doppler effect of sound is not observed.

● When the medium only is moving then Doppler effect is not observed.

● When the distance between the source and the observer is constant then also Doppler effect is not observed.

● ***Acoustics:***

● ***Absorption coefficient (a)***: Sound absorption coefficient of a surface is the ratio of sound energy absorbed by it (E_S) to the sound energy absorbed by an open window (E_W) of same area as that of the surface in the same time.

i.e., a = E_S / E_W

● Absorption coefficient has no dimensions.

● Absorption coefficient of open window is one

● If $a_1, a_2, a_3 \ldots\ldots a_n$ are absorption coefficients of different surfaces of area S_1, S_2, $S_3 \ldots\ldots\ldots S_n$ respectively, then total absorption of sound by all these surfaces is.

A= $a_1S_1 + a_2S_2 + \ldots\ldots\ldots + a_nS_n = \sum a_iS_i$

● ***Reverberation :*** It is the phenomenon of persistence of sound in an enclosure or auditorium due to continuous reflections of sound at walls, roof, even after the source of sound is turned off.

● ***Threshold of audibility (I_O) :*** It is the minimum intensity of sound at which sound is just audible.

● ***Reverberation time (T) :*** It is the interval of time in which the intensity of sound decreases from million times of threshold of audibility ($10^6\, I_O$) to threshold of audibility (I_O) when source of sound in turned off.

● Reverberation time (T) in an auditorium is Directly proportional to volume (V) of auditorium

Inversely proportional to total absorption of sound (A)

i.e., $T \propto \frac{V}{A} \Rightarrow T = \frac{KV}{A}$

Where K is a proportionality constant K = O.17 in SI units.

$$T = \frac{0.17V}{A} = \frac{0.17V}{\Sigma\, a_iS_i}$$

Units of Total absorption $\rightarrow m^2$ or owu or metric sabine

This equation is called Sabine's formula

● Reverberation time is independent of position of source of sound and position of audience.

● Reverberation time in an auditorium or cinema theatre decreases as number of audience increases.

● Absorption coefficient of a surface can be determined by the following two methods.

● ***Stationary wave method :*** If a sound wave is incident on a sheet, the reflected sound wave super imposes on the incident wave then, a stationary wave is produced with increasing and decreasing amplitudes. If the sound energies are converted in to electrical energies by a microphone and i_1 and i_2 are currents corresponding to maximum and minimum amplitudes then

$$a=\frac{4i_1i_2}{(i_1+i_2)^2}$$

● ***Reverberation time method :*** If T_1 is the reverberation time without absorbing materials in the enclosure and T_2 is the reverberation time with absorbing materials pasted on the walls of the enclosure, then

$$a=\frac{0.17V}{S}\left[\frac{1}{T_2}-\frac{1}{T_1}\right]+a_0$$

Where a_0 is the absorption coefficient of the walls of the enclosure, S is the surface area of the walls and V is the volume of the enclosure.

● The subject that deals with construction of good auditorium is called "Architectural accoustics"

● ***Condition for good Auditorium :***

● Sufficient loudness should be present at all places in the auditorium. For this electrically amplified loud speakers should be placed at different places at a height slightly above the person who is giving speech.

● Reverberation time should be neither too large nor too small. It should be optimum. If reverberation time is large then second syllable overlaps with the first syllable and hence clarity of sound is lost.
If reverberation time is too small then sound produced by less energetic sources is not audible at few places in the auditorium.

● Distribution of sound should be uniform. For this the surface of walls, roof, should be parabolic. Spherical surfaces and cylindrical surfaces in the auditorium should be avoided to eliminate focussing effect of sound.

● Care should be taken to avoid formation of stationary waves.

● Echelon effect should be eliminated by covering the stair case with carpets.

● Echelon effect : A sharp sound note incident on stair case and when reflected may produce a musical sound note. This is called echelon effect.

CONCEPTUAL QUESTIONS

1. In a longitudinal plane wave each particle of the medium executes S.H.M with
   1. Same frequency, same amplitude
   2. Same frequency, different amplitude
   3. Different frequency, same amplitude
   4. Different frequency, different amplitude.
2. The phase difference between the particle at one compression and another particle in third compression is
   1. π radian 2. 2π radians
   3. 3π radians 4. 4π radians.
3. During propagation of longitudinal plane wave in a medium the two particles separated by a distance equivalent to one wavelength at an instant will be / have
   1. in phase, same displacement
   2. in phase, different displacement
   3. different phase, same displacement
   4. different phase, different displacement.
4. The equation of a progressive wave is Y=a sin (ωt-kx), then the velocity of the wave is
   1. kω 2. k/ω 3. ω/k 4. aω.
5. When a progressive wave is propagating in a medium, at a given instant, two particles which are separated by three wave lengths will have.....
   1. Different displacement in same direction
   2. Different displacement in opposite direction
   3. Same displacement in opposite direction
   4. Same displacement in same direction.
6. If phase of the particle A at time 't' s is greater than phase of next particle B at that time. The direction of travel of wave is
   1. B to A 2. A to B
   3. Parallel to line BA
   4. Perpendicular to line BA.
7. The essential properties of a medium for the propagation of mechanical waves are.
   1. Inertia and mass 2. Inertia and elasticity
   3. Elasticity and volume 4. Inertia and volume.
8. Sound does not exhibit the property
   1. Reflection 2. Refraction
   3. Diffraction 4. Polarization.
9. If L is the length of a stretched wire, T is tension in the wire, e is linear density of wire, the frequency of transverse vibrations of stretched wire is proportional to
   1. $L^1T^{1/2}e^{-1/2}$ 2. $L^{-1}T^{-1/2}e^{-1/2}$
   3. $L^{-1}T^{1/2}e^{-1/2}$ 4. $L^{1/2}T^1e^{-1/2}$
10. The speed of sound in a medium does not change with the change of
    1. Frequency 2. Wave length
    3. Pressure 4. Density.

11. When a sound wave travels from one medium to another, the quantity that remains unchanged is
1. Speed 2.Amplitude
3. Frequency 4. Wavelength.

12. Phase difference between a particle at a compression and a particle at the next rare faction is
1. Zero 2. $\pi/2$ 3. π 4. $\pi/4$

13. In a stationary wave
1. Phase is same at all points in a loop
2. Amplitude is same at all points
3. Energy is constant at all points
4. Temperature is same at all points.

14. What sort of a stretched wire will produce a note of very high frequency.
1. Thin and short wire of light material under high tension.
2. Thick and short wire of light material under high tension
3. Thin and long wire of light material under high tension
4. Thin and short wire of heavy material under high tension.

15. One similarity between sound and light waves is that.
1. Both can propagate in vacuum
2. Both have same speed
3. Both can show polarization
4. Both can show interference.

16. The interference phenomenon can take place
1. In transverse wave
2. In longitudinal wave
3. In electromagnetic waves
4. In all waves

17. The equation that does not represent, wave motion
1. $y = a\sin(kx - \omega t)$ 2. $y = a\sin k(vt - x)$
3. $y = a\cos(kx - \omega t)$ 4. $y = a\sin(kx^2 - \omega t^2)$

18. When beats are formed by two waves of frequencies n_1 and n_2. The amplitude varies with frequency equal to
1. n_1-n_2 2. 2(n_1-n_2) 3.(n_1-n_2)/2 4.(n_1+n_2)/2

19. The frequency of sound reaching a stationary listener behind a moving source is
1. lower than source frequency
2. Higher than source frequency 3. Zero
4. Same as the frequency of the source

20. When the observer and reflector are at rest , the echo and the original sound differ in
1. Frequency 2. Wavelength
3. Velocity 4. Intensity of sound.

21. A brick is hung from a sonometer wire. If the brick is immersed in oil, then frequency of the wire will
1. Increase due to bouyancy
2. Decrease
3. Remains unchanged
4. Increase due to viscosity of oil.

22. The minimum distance to hear a clear echo is (V is the velocity of sound)
1. 2V/5 2. 5V/2 3. V/20 4. 5V

23. A wave is represented by an equation; Y = A cos kx sin wt, then
1. It is a progressive wave with amplitude A
2. It is a progressive wave with amplitude A cos kx
3. It is a stationary wave with amplitude A
4. It is a stationary wave with amplitude A cos kx.

24. The phenomena responsible for the formation of stationary wave is
1. Diffraction 2. Interference
3. Polarization 4. Dispersion.

25. A sonometer wire is vibrating in the third overtone. There are
1. Two nodes, two antinodes
2. Three nodes, three antinodes
3. Four nodes, three antinodes
4 .Five nodes, four antinodes.

26. Doppler shift in frequency does not depend upon
1. The frequency of wave produced
2. The speed of the source
3. Distance between source and observer
4. The speed of the observer.

27. A source of sound moves away with velocity of sound from a stationary observer. Then the frequency of sound heard by the observer
1. remains same 2. is doubled
3. is halved 4. becomes infinity.

28. An observer is moving away from a source at rest. The pitch of the note heard by the observer is less because
1. The pitch of the source decreases
2. The velocity of sound in air increases
3. Wave length of the wave becomes small
4. Wave length of the wave remains unchanged but observer receives less number of waves.

29. When a source of sound is in motion towards a stationary observer the effect observed is
1. Increase in velocity of sound.
2. Decrease in velocity of Sound
3. Increase in frequency of sound
4. Decrease in frequency of Sound

30. Absorption coefficient can be measured by
1. Microphone 2. Volume resonator
3. Sonometer 4. Megaphone

31. In an experiment to measure the absorption coefficient by stationary method i_1 is the current measured due to maximum amplitude of sound and i_2 is the current due to minimum amplitude of sound, then

1. $a = \frac{i_1 i_2}{(i_1 + i_2)^2}$ 2. $a = \frac{4 i_1 i_2}{(i_1 + i_2)^2}$

3. $a = \frac{(i_1 - i_2)^2}{(i_1 + i_2)^2}$ 4. $a = \frac{(i_1^2 - i_2^2)}{(i_1^2 + i_2^2)}$

32. Threshold of audibility for normal human ear is
1. The maximum intensity of sound audible
2. The minimum intensity of sound below which it is inaudible
3. The pitch of the sound inaudible
4. The pitch of the sound audible

33. Absorption coefficient is
1. Ratio of amplitudes
2. Ratio of wave lengths
3. Ratio of intensities 4. Ratio of frequencies

34. Reverberation of sound is due to
1. Multiple Refractions 2. Multiple Reflections
3. Multiple Diffractions 4. Multiple Polarization

35. Reverberation means
1. Persistence of sound when intensity of sound from the source is increased.
2. Persistence of sound when intensity of sound from the source is decreased.
3. Persistence of sound even when source is turned off.
4. Persistence of sound when source is moved away.

36. To hear a clear echo in air at 0^0c, the reflecting surface must be at a minimum distance of
1. 10 m 2. 16.5 m 3. 33 m 4. 66m

37. A source of sound is in the middle of the line joining the position of two persons 'A' and 'B' Air is blowing from 'B' to 'A'. Then
1. A will hear first 2. B will hear first
3. both will hear at a time
4. Sound is heard by neither A nor B

38. The amplitude of vibration of any particle in a standing wave, produced along a stretched string depends on
1. Frequency of incident wave
2. Time period of selected wave
3. Location of particle 4. Time

39. In a stationary wave
1. There is no net transfer of energy
2. Energy is constant at all points
3. Amplitude is same for all points
4. Energy and amplitude is same at all points

40. When a body is in resonance, following physical quantity of the body gradually increases
1. Frequency 2. Wave length
3. Amplitude 4. All the above

41. The velocity of a transverse wave in a stretched wire depends upon
1. Stretching force in the wire
2. Density of material
3. Radius of wire 4. All the above

42. L is length of the stretched wire whose two ends are fixed. If V is the velocity of transverse wave along this wire then, its minimum frequency is
1. 2V/L 2. V/L 3. V/2L 4. V/4L

43. λ is maximum wavelength of a transverse wave that travels along a stretched wire whose two ends are fixed. The length of that wire is
1. 2λ 2. λ 3. $\lambda/2$ 4. $3\lambda/2$

44. When a body is undergoing vibration, the physical quantity that remains constant is
1. Amplitude 2. Velocity
3. Acceleration 4. Phase

45. Restoring force acting on a particle executing undamped forced vibrations is directly proportional to,
1. Amplitude 2. Displacement
3. Velocity 4. Third harmonic

46. In the case of a vibrating string, the frequency of the first overtone is equal to the frequency of the
1. Fundamental 2. First Harmonic
3. Second Harmonic 4. Third Harmonic

47. Two wires are producing fundamental notes of same frequency. The change in which of the following factors of one wire does not produce beats between them
1. Stretching force
2. Diameter of the wire
3. Material of the wire
4. Amplitude of the vibrations

48. The string of a Sonometer is plucked so as to make it to vibrate in one segment The frequency produced in called.
1. First Harmonic 2.First Overtone
3. Second Harmonic 4. Second Overtone

49. Waves produced in the sonometer wire are
1. Transverse and progressive
2. Transverse and stationary
3. Longitudinal and progressive
4. Longitudinal and stationary

50. A sonometer wire of density 'ρ' and radius 'a' is held between two bridges at a distance 'L' apart. Tension in the wire is 'T' the fundamental frequency of the wire will be

1. $\frac{1}{2L}\sqrt{\frac{\pi a^2}{T\rho}}$ 2. $\frac{1}{2L}\sqrt{\frac{T\rho}{\pi a^2}}$

3. $\frac{1}{2L}\sqrt{\frac{T}{\pi a^2}}$ 4. $\frac{1}{2L}\sqrt{\frac{T}{\pi a^2 \rho}}$

51. When two sound waves of frequency differing by more than 10 Hz reach our ear simultaneously
1. Interference of sound does not take place
2. Beats are not produced
3. Beats are produced but we cannot identify them
4. The waves destructively interfer.

52. Radio waves of wave length λ are sent from a RADAR towards an aeroplane. If the aeroplane is moving towards the RADAR station the wave length of the radio waves, recieved after reflection from the aeroplane will be,
1. λ 2. $> \lambda$ 3. $< \lambda$
4. λ depends on speed of Aeroplane.

53. Doppler effect is applicable to
1) Sound Waves 2) Light Waves
3) Radio Waves 4) All the above

54. Which of the following in correct ?
1) Doppler effect in sound and light is asymmetric.
2)Doppler effect in sound and light is symmetric.
3) Doppler effect in sound is asymmetric and light is symmetric.
4) Doppler effect in sound is symmetric and light is asymmetric.

55. In Doppler effect, when a source moves towards a stationary observer, the apparent increase in frequency is due to,
1) Increase in wavelength of sound received by observer.
2) Decrease in wavelength of sound received by observer.
3) Increase in number of waves received by observer in one second.
4) Decrease in number of waves received by observer in one second..

56. Sound waves can diffract easily because,
1) Their wavelength is very small
2) Their wavelength is large
3) It can reflect 4) It can refract

57. Which of the following does not effect the reverberation time
1) Size of the auditorium
2) Frequency of sound
3) Nature of the walls
4) Area of the walls, ceiling and floor

58. A travelling wave along a stretched string is given by $Y = A \sin(Kx - \omega t)$ the maximum velocity of a particle is
1) A ω 2) ω / K
3) dω / dk 4) x/t

59. To increase the frequency of a stringed musical instrument, one should
1) Loosen and shorten the string
2) Tighten and loosen the string
3) Shorten and tighten the String
4) Lengthen and loosen the string

60. In a stationary wave :
1) Strain is maximum at antinodes
2) Strain is minimum at nodes
3) Strain is maximum at nodes
4) Amplitude is zero at all points.

61. If n_1, n_2, n_3 be the frequency of the segments of a stretched string, then the frequency 'n' of the string itself in terms of n_1, n_2 and n_3 is
1. $(n_1n_2 + n_2n_3 + n_1n_3)/n_1n_2n_3$
2. $(n_1n_2 + n_3n_1)/n_1n_2n_3$
3. $n_1n_2n_3/(n_1n_2 + n_3n_1)$
4. $n_1n_2n_3/(n_1n_2 + n_2n_3 + n_3n_1)$

62. A metal string is fixed between rigid supports. It is initially at negligible tension. It's Young's modulus is 'Y' density is ρ and coefficient of linear expansion is α . It is now cooled through a temperature 't', transverse waves will move along it with a speed.

1. $\sqrt{\frac{Y\alpha t}{\rho}}$ 2. $Y\sqrt{\frac{\alpha t}{\rho}}$ 3. $\alpha\sqrt{\frac{Yt}{\rho}}$ 4. $t\sqrt{\frac{\rho}{Y\alpha}}$

63. The following has largest absorption coefficient
1) Heavy curtain 2) Cork
3) Marble 4) Open window

64. In an auditorium, when a speech is going on, a window is opened beside the audience, then the absorption coefficient
1) Increases 2) Decreases
3) Remains Same 4) Becomes zero

65. In an auditorium the big curtain when falls suddenly then the reverberation time,
1) Increases 2) Decreases
3) Remains same 4) Becomes zero

66. In a meeting hall which is initially half filled with participants after some time it becomes full to capacity, then the clarity of speech
1) Increases 2) Decreases
3) Remain Same 3) Becomes zero

67. Perforated card boards are used in halls, for
1) reflection of sound
2) absorption of sound
3) refraction of sound
4) as a decorative material

68. For good absorption of sound in auditorium it requires
1) A few windows to be opened
2) All closed windows
3) Maps hanging from walls
4) Hanging light curtains.

69. Upholstered seats in cinema halls are arranged for
1) Absorption of sound 2) Reflection of sound
3) Diffraction of sound 4) To hear an echo

70. A sharp sound becomes a musical note in an auditorium then, it is called.
1. Echo 2. Echelon effect
3. Reverberation 4. Shrillness

71. In a stationary wave
1. Pressure change is maximum at nodes
2. Pressure change is maximum at antinodes
3. Pressure change is minimum at nodes
4. amplitude is zero at all points

72 For a stretched string of given length, the tension ' T' is plotted on the X-axis and the frequency ' f' on the Y -axis. The graph is
1. rectangular hyperbola
2. straight line through the origin 3. parabola
4. straight line not through the origin

73. The equation of a stationary wave in a medium is given as $y = \sin \omega t \cos kx$. The length of a loop in fundamental mode is
1. $\frac{\pi}{2K}$ 2. $\frac{\pi}{K}$ 3. $\frac{2\pi}{K}$ 4. $\frac{K}{\pi}$

74. For superposition of two waves, the following is correct
1) they must have the same frequency and wavelength
2) they must have equal frequencies but may have unequal wavelengths
3) they must have the same wavelength, but may have different frequencies
4) they may have different wavelength and different frequencies

75. The amplitude of a wave is presented by $A = \frac{c}{a+b-c}$ then resonance will occur when
1. $b = \frac{-c}{2}$ 2. b=0, a=c
3. $b = \frac{-c}{2a}$ 4. a = b

KEY

1)1	2)4	3)1	4)3
5)4	6)2	7)2	8)4
9)3	10)1	11)3	12)3
13)1	14)1	15)4	16)4
17)4	18)3	19)1	20)4
21)2	22)3	23)4	24)2
25)4	26)3	27)3	28)4
29)3	30)1	31)2	32)2
33)3	34)2	35)3	36)2
37)1	38)3	39)1	40)3
41)4	42)3	43)3	44)1
45)2	46)3	47)4	48)1
49) 2	50)4	51)3	52)3
53)4	54)3	55)2	56)2
57)2	58)1	59)3	60)3
61) 4	62)1	63)4	64)1
65)2	66)1	67)2	68)1
69)1	70)2	71)1	72) 3
73)2	74)4	75)2	

NEW PATTERN QUESTIONS

a) If both assertion and reason are true and reason is the correct explanation of assertion

b) If both assertion and reason are true but reason is not the correct explanation of assertion.

c) If assertion is true but reason is false

d) If both assertion and reason are false

1. **Assertion (A)**: A vibrating tuning fork sounds louder when its stem is pressed against a desk top.
Reason (R): When a wave reaches another denser medium, part of the wave is reflected.
1. a 2. b 3. c 4. d

2. ***Assertion (A):*** On reflection from a rigid boundary (denser medium), there is a complete reversal of transverse wave.
Reason (R): Reflection at a denser medium, both the particle velocity and amplitude are reversed in sign.
1. a 2. b 3. c 4.d

3. ***Assertion (A):*** A standing wave is produced in a string clamped at one end and free at the other end. The length of string is odd multiples of $\frac{\lambda}{4}$
Reason (R): Distance between successive node and antinode is $\lambda/4$.
1. a 2. b 3. c 4.d

4.

List - I	***List - II***
a) Phase difference between two particles in alternative loops.	e) π
b) Phase difference between two particles in successive loops	f) $\frac{\pi}{2}$
c) Phase difference between two particles in the same loop	g) 2π
d) Phase difference between $Y_1 = a\sin(\omega t - Kx)$ *and* $Y_2 = a\cos(\omega t - Kx)$	h) 0

1. a-g, b-e, c-h, d-f 2. a-e, c-f, d-g, e-h
3. a-f, b-e, c-g, d-h 4. a-g, b-e, c-f, d-h

5. Standing waves can be produced.
a) On a string clamped at both the ends.
b) On a string clamped at one end and free at the other
c) When incident wave gets reflected from a wall
d) When two identical waves with a phase difference of π are moving in the same direction.
1. a and b are correct
2. a and c are correct
3. a,b and c are correct
4.b and d are correct

6. For a beats wave
a) amplitude of vibration at any point changes simple harmonically.
b) The particles vibrating frequency and amplitude frequency are equal.
c) The frequency of beats depends on the position of the observer, where he is standing.
1) Both a, c are correct
2) only a is correct 3) only c is correct
4) all are collect

7. Match the phenomenon to its property

i) Beats	a) apparent change in pitch
ii) Standing wave	b)frequencies are in uni son
iii) Doppler effect	c) modification of inten sities occur periodi cally when the waves interfere in same direction.
iv) Resonance	d) Superposition of two similar waves travelling in opposite direction.

	(i)	(ii)	(iii)	(iv)
1)	c	d	a	b
2)	a	b	c	d
3)	b	c	d	a
4)	d	a	b	c

8. Identify the statements with no Doppler effect
a) Source of sound and listener both are at rest but a strong wind is blowing
b) A whistle is being revolved in a horizontal circle with the observer standing outside the circle.
c) Source of sound and observer are moving relatively perpendicular to one another.
1) only 2) both a and b
3) only c 4) a, b, c

9. Arrange the wavelengths of the following sounds in ascending order.
a) Ultraronics b) Infraronics
c) Audible range
1) b, c, a 2) c, a, b
3) c, b, a 4) a, c, b

10. T_1, T_2, T_3 be the reverberation times for an empty auditorium, when the hall has curtains, and when curtains are made to fall respectively. Arrange the reverberation times in ascending order.
1) $T_3T_2T_1$ 2) $T_1T_2T_3$ 3) $T_2T_3T_1$ 4) $T_1T_3T_2$

11. A uniform long rope is suspended from roof . A transverse wave pulse is produced at its lower end . As the wave travels upward along the suspended rope then
A) Velocity of wave increases
B) Wavelength of wave increases
C) frequency of wave remains constant
1) only A and B are true
2) only B and C are true
3) only A and C are true
4) A,B and C all are true

12. There are four possible relative motions between the source of a sound and the listner
a) source moves towards stationary listener
b) source moves away from stationary listner
c) listner moves towards stationary source
d) listener moves away from stationary source
In which of the cases, the change in frequency is same. The magnitude of velocity of source or listener being the same.
1) a and b 2) b and c 3) c and d 4) d and a

13. The equation of a progressive wave is $y = 0.05\sin\left(200t - \frac{x}{2}\right)$ where x,y are in metres and t is seconds, then
a) velocity of wave is 100 ms^{-1}
b) maximum velocity of particle in the wave is 10 ms^{-1}
c) wavelength of wave is $4\pi\ m$
1) only a and c are true
2) only b and c are true
3) only a and b are true
4. a,b,c are true

KEY

1) 1	2)1	3)1	4)1
5) 2	6) 2	7) 1	8) 2
9) 4	10) 1	11)4	12)3
13)2			

NUMERICAL QUESTIONS
LEVEL - I

Wave Motion

1. The frequency of a fork is 500 Hz. Velocity of sound in air is 350ms^{-1}. The distance through which sound travels by the time of the fork makes 125 vibrations is
1. 87.5 m 2.700 m
3. 1400m 4.1.75 m

2. Standing waves are produced in 10m long stretched wire. If the wire vibrates in 5 segments and wave velocity is 20m/s, then the frequency is
1. 2 Hz 2. 4 Hz 3. 5 Hz 4. 10Hz

3. A body is dropped into a deep well. Sound of splash is heard after 4.23 s. If the depth of the well is 78.4m, the velocity of sound in air is
1. 330 m/s 2. 341 m/s
3. 380 m/s 4. 540 m/s

4. Human audible frequency range is 20Hz to 20KHz. If velocity of sound in air is 340ms^{-1}, the minimum wavelength of audible sound wave is
1. 0.17mm 2. 1.77mm 3. 17mm 4. 170mm

5. The equation y = 4 Sin π [200t-(x/25)] represents a transverse wave that travels in a stretched wire, where x, y are in cm and t in second. Its wavelength and velocity are
1. 0.5m, 25ms^{-1} 2. 0.5m, 50ms^{-1}
3. 1m, 50ms^{-1} 4. 1m, 25ms^{-1}

6. The equation y = 5 Sin (3x/50) Cos (450t) represents the stationary wave setup in a vibrating sonometer wire, where x, y are in cm and t in second. The velocity of one of the two progressive waves in that stationary wave is
1. 2.7 ms^{-1} 2. 27 ms^{-1} 3. 7.5 ms^{-1} 4. 75 ms^{-1}

7. The length of a sonometer wire is 90 cm and the stationary wave setup in the wire is represented by an equation y = 6sin(πx/30) cos (250πt) where x, y are in cm and t is in second. The distances of successive antinodes from one end of the wire are
1. 22.5 cm, 67.5 cm
2. 15 cm, 30 cm, 60cm
3. 15 cm, 45 cm, 75cm
4. 30 cm, 45 cm, 60cm

8. In the above problem number of loops is
1. 1 2. 2 3. 4 4. 3

9. Two waves produce displacements at a point given by Y_1 = a Sin wt and Y_2 =a Sin $\left[\omega t+(\pi/2)\right]$. The resultant amplitude is

1. 0 2. 2a 3. $a\sqrt{2}$ 4. $\frac{a}{\sqrt{2}}$

10. A transverse wave is described by the equation Y= Y_0 Sin 2 π (ft-x/ λ). The maximum particle velocity is equal to four times the wave velocity if

1. $\lambda=\pi Y_0/4$ 2. $\lambda=\pi Y_0/2$

3. $\lambda=\pi Y_0$ 4. $\lambda=2\pi Y_0$

11. The equation of a travelling wave is y = a sin 2 π [t-(x/5)], then the ratio of maximum particle velocity and wave velocity is

1. $\frac{2\pi a}{\sqrt{5}}$ 2. $\frac{2\pi a}{5}$ 3. $\frac{a}{5}$ 4. $2\pi a\sqrt{5}$

Stretched Strings

12. The speed of transverse waves in a stretched string is 700cm/s. If the string is 2m long, the frequency with which it resonates in fundamental mode is
1. (7/12)Hz 2. (7/4)Hz
3. 14Hz 4. (2/7)Hz

13. A stretched string of length 1 m has a frequency of 256 Hz. If length of the string is decreased by 0.36m, then the frequency will be.
1. 200Hz 2. 400Hz 3. 100Hz 4. 512Hz

14. A string of length l hangs freely from a rigid support. The time required by a transverse pulse to travel from bottom to top of the string is

1. $\sqrt{lg}$ 2. $\sqrt{(l/g)}$ 3. $\sqrt{2l/g}$ 4. $2\sqrt{\frac{l}{g}}$

15. The difference between frequencies of successive overtones of a sonometer wire is 150Hz. The frequency of its first overtone is
1. 150Hz 2. 200Hz 3. 250Hz 4. 300Hz

16. The length of sonometer is 1 m and its mass is 4gm. The velocity of transverse wave that travels along this wire when tension in the wire is 2 kg.wt is
1. 7 ms^{-1} 2. 14 ms^{-1} 3. 70 ms^{-1} 4. 140 ms^{-1}

17. The velocity of a transverse wave that travels along a stretched wire is 50 ms^{-1} when stretching force in it is 10N. The linear density of that wire is
1. 0.4×10^{-3} kgm^{-1} 2. 4×10^{-2} kgm^{-1}
3. 0.4g cm^{-1} 4. 0.04g cm^{-1}

18. The velocity of a transverse wave in a stretched wire is 100ms^{-1}. If the length of wire is doubled and tension in the string is also doubled, the final velocity of the transverse wave in the wire is
1. 100 ms^{-1} 2. 141.4 ms^{-1}
3. 200 ms^{-1} 4. 282.8 ms^{-1}

19. The frequency of fundamental note of a sonometer wire is 120 Hz. The two bridges of sonometer are displaced away from each other so that the length of wire is doubled and weight suspended to the wire is increased to 4 times, the frequency of fundamental note is
1. 120Hz 2. 180Hz 3. 240Hz 4. 480Hz

20. The length of a sonometer wire is 75 cm and frequency of its 2nd overtone is 300 Hz. The velocity of transverse wave that travels in the wire is
1. 150ms^{-1} 2. 200ms^{-1} 3. 100ms^{-1} 4. 300ms^{-1}

21. A sonometer consists of two wires of same material whose radii are in the ratio 2:3. The tension in thick wire is 4 times the tension in thin wire. If V is velocity of transverse wave in thin wire, then the velocity of transverse wave in thick wire is
1. 3V/4 2. 3V/2 3. 2V/3 4. 4V/3

22. A sonometer consists of two wires of lengths 1.5 m and 1m made up of different materials whose densities are 5 g/cc, 8g/cc and their respective radii are in the ratio 4:3. The ratio of tensions in those two wires if their fundamental frequencies are equal is
1. 5:3 2. 5:2 3. 2:5 4. 3:5

23. The bridge of a sonometer is slightly displaced so that the length of wire is decreased by 0.5% and tension in the wire is increased by 1%. The fundamental frequency of wire
1. increases by 1% 2. decreases by 1%
3. increases by 1.5% 4. decreases by 1.5%

24. A wire under a load has a frequency n_1. When the load is completely immersed in water,its frequency is n_2. The relative density of the material of the load is
1. $n_1^2/(n_1^2-n_2^2)$ 2. $n_2^2/(n_1^2-n_2^2)$
3. $n_1/(n_1+n_2)$ 4. $n_2/(n_1+n_2)$s

25. A wire produces a fundamental frequency n under a tension T. The wire is stretched to twice its length and kept under the same tension. The fundamental frequency of the wire is.

1. 2 n 2. n 3. $n\sqrt{2}$ 4. $\frac{n}{\sqrt{2}}$

26. The linear density of a vibrating string is 1.3×10^{-4} kg/m. The transverse wave propagating along the string is described by y = 0.021 sin (x+30t) where x is in meter and t is in second. The tension in the string is
1. 0.12 N 2. 0.48 N 3. 1.2N 4. 4.8N

Beats

27. Two waves of wavelengths 2m and 2.02 m respectively moving with the same velocity superpose to produce 2 beats /s. The velocity of the wave is
1. 400 m/s 2. 402 m/s
3. 404 m/s 4. 406 m/s

28. The natural frequency of a tuning fork P is 432 Hz. 3 beats/s are produced when tuning fork P and another tuning fork Q are sounded together. If P is loaded with wax, the number of beats increases to 5 beats/ s. The frequency of Q is
1. 429 Hz 2. 435 Hz 3. 437 Hz 4. 427 Hz

29. 8 beats / s are produced when two tuning forks A, B are made to vibrate together. The number of beats decreases to 5 beats/s when prongs of B are filed. If natural frequency of A is 282 Hz, the frequency of B before and after filing is
1. 274 Hz, 277 Hz 2. 290 Hz, 287 Hz
3. 290 Hz, 277 Hz 4. 274 Hz, 290 Hz

30. Two sound waves of amplitudes 3 cm, 5 cm, travelling in the same direction superpose with each other to produce beats. If I is minimum intensity of sound, in these beats the maximum intensity of sound is
1. 4I 2. 9I 3. 16I 4. 25I

31. Two sound waves travelling in the same direction are represented by equations $Y_1 = A_1 \sin 504\pi t$; $Y_2 = A_2 \sin 512\pi t$. These two sound waves superpose to produce beats. The intensity of sound changes from minimum to maximum in a time of
1. 1/2 s 2. 1/4s 3. 1/8 s 4. 1/16 s

32. A tuning fork is in resonance with a sonometer wire. The same tuning fork produces 3 beats in 2 s, when tension in the wire is increased by 2%. The frequency of wire before increasing tension is
1. 100Hz 2. 150Hz 3. 200Hz 4. 300Hz

33. The frequency of a tuning fork P is less by 1% than the frequency of a standard tuning fork S while the frequency of another tuning fork Q is more by 2% than the frequency of S. If 9 beats/s are produced when P and Q are sounded together, the frequency of P and Q are respectively.
1. 148.5Hz, 153 Hz 2. 198Hz, 204 Hz
3. 297 Hz, 306 Hz 4. 396 Hz, 408 Hz

34. A tonometer has 25 forks. Each produces 4 beats with the next one. If the maximum frequency is 288 Hz, the lowest frequency is
1. 72 Hz 2. 96 Hz
3. 128 Hz sec 4. 192 Hz

35. A tuning fork vibrating with a sonometer wire of length 20cm produces 5 beats per s. The beat frequency does not change if the length of the wire is changed to 21 cm. The frequency of the tuning fork must be
1. 200 Hz 2. 210 Hz
3. 205 Hz 4. 215 Hz

36. Two tuning forks of frequencies 250 and 256 Hz produce beats. If maximum is produced now, after how much time the minimum is produced at that same place
1. (1/18)s 2. (1/24)s 3. (1/6)s 4. (1/12)s

37. A bat flies perpendicular to a wall at 6m/s, emitting a sound of frequency 4.5×10^4 Hz. The number of beats it hears per second is (velocity of sound in air = 340 m/s)
1. 21.37 2. 1200 3. 1616 4. 92.7

Doppler Effect

38. A person in an open car is approaching a vertical mountain with uniform velocity 90 kmph. The person blows horn, then hears its echo after a time 4 s. The distance of the car from the mountain when the horn was blown is. (Velocity of sound in air is $335 ms^{-1}$)
1. 1440m 2. 1240 m
3. 720m 4. 620m

39. A person in a vehicle is moving away from a vertical mountain with uniform velocity. When the vehicle is at a distance 975m from mountain, the person blows a horn and hears its echo after 6 s. If velocity of sound in air is $340 ms^{-1}$, the velocity of the vehicle is
1. 36kmph 2. 54 kmph
3. 72 kmph 4. 90kmph

40. Apparent frequency of sound is 505 Hz when the listener is approaching a stationary source of sound with a velocity 1% of the velocity of sound in air. The actual frequency of sound is
1. 470 Hz 2. 480 Hz 3. 490 Hz 4. 500 Hz

41. What is the velocity of a listener who is moving away from a stationary source of sound such that the listener notices 5% apparent decrease in frequency of sound

(Velocity of sound in air = 340 m/s)
1. 12.5 ms^{-1} 2. 17 ms^{-1}
3. 25 ms^{-1} 4. 34 ms^{-1}

42. A train is approaching a station with a uniform velocity of 72 kmph and the frequency of the whistle of that train is 480 Hz. The apparent increase in the frequency of that whistle heard by a stationary observer on the platform is (Velocity of sound in air is 340m/s)
1. 60 Hz 2. 45 Hz
3. 30 Hz 4. 15 Hz

43. Two trains are approaching each other on parallel tracks with same velocity. The whistle sound produced by one train is heard by a passenger in another train. If actual frequency of whistle is 620Hz and apparent increase in its frequency is 100Hz, the velocity of one of the two trains is (Velocity of sound in air = 335 ms^{-1})
1. 90kmph 2. 72 kmph
3. 54kmph 4. 36 kmph

44. The frequency of the sound of a car horn as recorded by an observer towards whom the car is moving differs from the frequency of the horn by 10%. Assuming the velocity of sound in air to be 330ms^{-1}, the velocity of the car is
1. 36.7ms^{-1} 2. 40 ms^{-1}
3. 30 ms^{-1} 4. 33 ms^{-1}

45. A whistling engine is approaching a stationary observer with a velocity of 110m/s. The velocity of sound is 330m/s. The ratio of frequencies as heard by the observer as the engine approaches and receedes is
1. 4:3 2. 4:1 3. 3:6 4. 2:1

46. The frequency of a radar is 780 MHz. The frequency of reflected wave from an aeroplane is increased by 2.6KHz. The velocity of the aeroplane is
1. 2km/s 2. 1km/s
3. 0.5km/s 4. 0.25km/s

47. A siren of frequency n approaches a stationary observer and then receedes from the observer. If the velocity of source(V) << the velocity of sound (C), the apparent change in frequency is
1. 2 n V/C 2. 2 n C/V
3. n/V 4. 2 VC/n

ECHOES

48. A person is infront of a fort wall. The person can hear echo of sound produced by him when minimum distance between person and wall is 16.75 m. The velocity of sound in air is
1. 330 m/s 2. 335 m/s
3. 337.5 m/s 4. 345 m/s

49. A person is in between two vertical mountains. The person fires a gun then hears the first echo from the nearby mountain in a time 3 s and hears second echo from far mountain in a time 4 s. The person hears the third echo after
1. 5 s 2. 6 s 3. 7 s 4. 8 s

50. In above problem if velocity of sound in air is 340ms^{-1} the distance between the two mountains is
1. 850 m 2. 1020 m 3. 1190 m
4. 1360 m

51. A person is infront of a vertical mountain fires a bullet and hears its echo after a time 3s. The person walks a distance 'd' towards mountain then fires another bullet and hears its echo after a time 2 s. If velocity of sound in air is 340ms^{-1}, the value of 'd' is
1. 85cm 2. 170m 3. 255m 4. 340m

52. A staircase has a large number of steps each of width 25 cm and height 20 cm. A sharp sound is made at a distance in front of the staircase. The frequency of the musical note produced by the echelon effect is (take speed of sound in air as 350 m/s).
1. 700 Hz 2. 350 Hz 3. 437.5 Hz 4. 875 Hz

Acoustics

53. The reverberation time of a room is t second. Another room of double the dimensions with the walls of the same absorption coefficient will have a reverberation time.
1. t^2 2. 2 t 3. t/2 4. t^3

54. The volume of an auditorium is 100m x 50m x 15m. The reverberation time in that auditorium is 2 s when the person who is giving a speech is at a distance of 5m from a wall. The reverberation time if the same person gives speech at a distance 10m from the wall is
1. 1 s 2. 2 s 3. 0.5 s 4. 4 s

55. The volume of a lecture hall is 60m x 40 m x 10m and there are 200 audience in that hall. Absorption coefficients of walls, roof, floor, are 0.1, 0.05, 0.5 respectively. The absorption of each person is 0.6 metric sabine. The total absorption of sound in that hall is
1. 1640metric sabine 2. 1820metric sabine
3. 2060metric sabine 4. 2480metric sabine

56. The volume of a cinema theatre is 100m x 60m x 20m and total acoustic absorption in it is 6800metric sabine. The reverberation time in that theatre is
1. 1.5 s 2. 2 s 3. 3 s 4. 4 s

57. The reverberation times in a cinema theatre are 3 s, 2 s when it is empty, filled with audience respectively. The reverberation time when the theatre is half filled with audience is
1. 2.3 s 2. 2.4 s 3. 2.5 s 4. 2.6 s

Key

1) 1	2) 3	3) 2	4) 3
5) 2	6) 4	7) 3	8) 4
9) 3	10) 2	11) 2	12) 2
13) 2	14) 4	15) 4	16) 3
17) 4	18) 2	19) 1	20) 1
21) 4	22) 2	23) 1	24) 1
25) 4	26) 1	27) 3	28) 2
29) 1	30) 3	31) 3	32) 2
33) 3	34) 4	35) 3	36) 4
37) 3	38) 3	39) 2	40) 4
41) 2	42) 3	43) 1	44) 3
45) 4	46) 3	47) 1	48) 2
49) 3	50) 3	51) 2	52)1
53) 2	54) 2	55) 1	56) 3
57) 2			

LEVEL - II

1. A uniform rope of length 12m and mass 6 kg hangs vertically from a rigid support . A block of mass 2kg is attached at the free end of the rope. A transverse pulse of wavelength 0.06m is produced at the lower end of the rope. The wavelength of the pluse when it reaches the top of the rope is
1. 0.06 m 2. 0.12 m 3. 0.24 m 4. 0.03 m

2. A wire of mass $9.8X10^{-3}$kg per meter passes over a frictionless pully fixed on the top of an inclined plane which makes an angle of 30^0 with horizontal.Two masses M_1, M_2 are attached to the two ends of wire. M_1 is at rest on an inclined plane and M_2 is hanging vertically downwards.The system is in equillibrium.If a transverse wave progresses with a velocity of 100 m/s in the wire then the values of M_1,M_2 are
1. 20 kg, 40kg 2. 10 kg, 30kg
3. 20 kg, 10kg 4. 10 kg, 40kg

3. A uniform rope of mass 0.1 kg and length 2.45 m hangs from a ceiling i) Find the speed of transverse wave in the rope at a point 0.5 m distant from the lower end ii) Calculate the time taken by a transverse wave to travel the full length of the rope ($g = 9.8\ m/s^2$)
1. 2.21 m/s, 1 s 2. 4.22 m/s, 2 s
3. 8.44 m/s, 4 s 4. 12 m/s, 6 s

4. A man standing infront of a mountain at a certain distance beats a drum at regular intervels. The drumming rate is gradually increase and he finds that the echo is not heard distinctly when the rate becomes 40 per minute. He then moves nearer to the mountian by 90 m and finds the echo is again not heard when the drumming rate becomes 60 per minute. (a) Find the distance between the mountain and the initial position of the man and (b) the velocity of sound.
1. 360 m, 270 m/s 2. 270 m, 360 m/s
3. 72 m, 360 m/s 4. 150 m, 360 m/s

5. A road runs midway between two parallel rows of buildings. A motorist moving with a speed of 36 km/hour sounds the horn. He hears the echo one second after he has sounded the horn. The distance between the 2 rows of buildings is (Velocity of sound is 330 m/s)
1.300 m 2. 150 m
3. 1080 m 4. 330 m

6. A man is travelling towards east at 20 ms^{-1} and sound waves are moving towards east at $340\,ms^{-1}$ .He finds that 500 waves cross him in 2 seconds, the wave length ofthe sound wave received by the man is
1. 1.28 m 2. 2.28 m 3. 3.28 m 4. 4.28 m

7. A sonometer wire under tension of 64 N vibrating in its fundamental mode is in resonance with a vibrating portion of the sonomenter wire has a length of 10 cm and mass 1 g. The vibrating tuning fork is now moved away farom the vibrating wire at a constant speed and an observer standing near the sonometer heres one beat per sec. Calculate the speed with which the tuning fork is moved, if the speed of sound in air is 330 m/s
1. 0.75 m/s 2.1.5 m/s 3. 3 m/s
4. 6 m/s

8. The displacement equation of a stationary wave formed on a string is given by $: y = (4\,mm)\sin(314t)\cos(\pi x)$, where "$x$" is distance in meter measured from the origin and " t " is time expressed in seconds. The amplitude of vibrations at a distance of ¼ meter from the origin will be
1. 2 mm 2. $2\sqrt{2}mm$ 3. 1 mm4. zero

9. Two wires of same materiel and radii r and 2r respectively are welded together end to end. The combination is used as a sonometer wire under tension T. If welded point lies in mid-way then the ratio of the number of loops formed in thinner and thicker wire is
1. 1:2 2 . 2:1 3. 1:3 4. 3:1

10. A body emitting sound of frequency 350 Hz is dropped from a balloon rising vertically upwards with constant velocity 5 m/s. The frequency of sound as felt by the observer in the balloon 2s after the release is (Velocity of sound in air is 335m/s ; acceleration due to gravity is $10 ms^{-2}$)
1. 330 Hz 2. 235 Hz 3. 340 Hz
4. 355 Hz

11. A girl swings in a cradle with period $\pi/4$ second and amplitude 2m. A boy standing infront of it blows a whistle of natural frequency 1000 Hz. The minimum frequency as heard by the girl is (Velocity of sound in air is $320 ms^{-1}$)
1. 850 Hz 2. 1000 Hz
3. 750 Hz 4. 950 Hz

12. A streched string of length 2m is found to vibrate in resonance with a tuning fork of frequency 420 Hz. The next higher frequency for which resonance occurs is 490 Hz. The velocity of the transverse wave along this string is
1. 140 m/s 2. 360 m/s
3. 340 m/s 4. 280 m/s

13. A sound wave of frequency 1360 Hz falls normally on a perfectly reflecting wall. The shortest distance from the wall at which the air particles have maximum ampitude of vibration is (V = 340 m/s)
1. 25 cm 2. 6.25 cm
3. 62.5 cm 4. 2.5 cm

14. In stationary wave method of measuring absorption coefficients, the electric current when measured with maximum and minimum amplitudes the sum is 5 ampere and the difference is 1 ampere, then the absorption coefficient is
1. 4 2. 0.4 3. 9.6 4. 0.96

15. The stationary wave in a vibrating wire of sonometer is represented by an equation y=2Asin(kx) cos (200t) where all physical quantities in the equation are in M.K.S. units. If velocity of particle of wire at antinode is 10m/s, what is the amplitude of particle at antinode
1. 0.04m 2. 0.05m 3. 0.08m 4. 0.1m

16. A tuning fork produces 4 beats/s with a sonometer wire when its length are 50 cm, 51cm. The frequency of that tuning fork is
1. 400 Hz 2. 404 Hz
3. 408 Hz 4. 412 Hz

17. The extension in a string, obeying Hooke's law is x.The speed of sound in the stretched string is V. If the extension in the string is increased to 1.5 x the speed of the sound will be
1. 1.22V 2. 0.61V 3. 1.50V 4. 0.75V

18. The equation y=4+2sin(6t–3x) represents a wave motion with amplitude of
1)6units 2)2units 3) $\sqrt{20}$ units 4)8units

19. The ratio of the absorption of a person to that of an auditorium is 1/1200. In order to make the reverberation time 3/4th of the initial value, the number of persons to be accommodated in the auditorium are
1) 200 2) 400 3) 100 4) 700

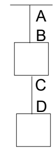
20. s_1 and s_2 are two sound sources of frequencies 338 Hz and 342 Hz respectively placed at a large distance apart. The velocity with which an observer should move from s_2 to s_1 so that we may hear no beats will be.....(velocity of sound in air=340 m/s)
1) 1 m/s 2) 2 m/s 3) 3 m/s 4) 4 m/s

21. A man sets his watch by the noon whistle of a factory at a distance of 1.5 km. By how many seconds is his watch slower than the clock of the factory (velocity of sound = 332 m/s)
1) 4.52 sec 2) 5.35 sec
3) 2.18 sec 4) 3.76 sec

22. A tuning fork produces 3 beats /s with a sonometer wire. If tension in the wire is increased by 1% and its length is decreased by 0.5% again it produces 3 beats/s with same tuning fork. The frequency of that tuning fork is
1. 397 Hz 2. 403 Hz 3. 597 Hz 4. 603 Hz

23. Apparent frequencies of source are n_1, n_2 when observer approaches and recedes with a velocity $50 ms^{-1}$ with respect to stationary source . Apparent frequencies of source are n_3, n_4 when same source of sound approaches and recedes with same velocity $50 ms^{-1}$ with respect to stationary observer. If the velocity of sound in air is $350 ms^{-1}$, the increasing order of apparent frequencies is
1. n_1, n_2, n_3, n_4 2. n_1, n_2, n_4, n_3
3. n_4, n_3, n_2, n_1 4. n_2, n_4, n_1, n_3

24. Two blocks each having a mass of 3.2kg are connected by a wire CD and the system is suspended from the ceiling by another wire AB. The linear density of wire AB is 10gm/m and that of CD is 8 gm/m. The speed of transverse pulse in AB is



1) 63 m/s 2) 49 m/s 3) 42m/s 4) 80 m/s

25. A wire under load emits fundamental frequencies f, f_1, f_2 when the load is suspended in air, in water and in liquid completely immersed. The specific gravity of the liquid is

1) $\frac{f^2 - f_1^2}{f^2 - f_2^2}$ 2) $\frac{f^2 - f_2^2}{f^2 - f_1^2}$

3) $\frac{f^2 - f_2^2}{f^2}$ 4) $\frac{f^2}{f^2 - f_1^2}$

KEY

1) 2	2) 3	3) 1	4) 2
5) 4	6) 1	7) 1	8) 2
9) 1	10) 1	11) 4	12) 4
13) 2	14) 4	15) 2	16) 2
17) 1	18) 2	19) 2	20) 2
21) 1	22) 4	23) 4	24) 4
25)2			

HINTS

1. Tension at the bottom =2kg.Wt= T_b

Tension at the top =(2+6)=8 kgwt= T_t

$$\frac{V_1}{V_b} = \frac{n\lambda_1}{n\lambda_b} = \sqrt{\frac{T_1}{T_b}}$$

2. $n = \frac{1}{2l}\sqrt{\frac{T}{m}}$, *find T*

but T=M_2g= $M_1 g \sin 30^0$

3. $V = \sqrt{\frac{T}{m}} = \sqrt{\frac{\left(\frac{M}{L}\right)gx}{\frac{M}{L}}} = \sqrt{gx}$ *where x* is the distance of the point from the bottom.

time= $2\sqrt{\frac{L}{g}}$

4. $d = \frac{Vt_1}{2} = \frac{V}{2} \times \left[\frac{60}{40}\right]$

$d - x = \frac{Vt_2}{2} = \frac{V}{2} \times \left[\frac{60}{60}\right]$

5. $d = 2\sqrt{\left[\frac{Vt}{2}\right]^2 - \left[\frac{ut}{2}\right]^2}$

6. $V_s = \sqrt{2gl(1-\cos\theta)}$

$n^1_{\max} = \frac{V}{V - V_s} n$ *and* $n^1_{\min} = \frac{V}{V + V_s} n$

7. $n = \frac{1}{2l}\sqrt{\frac{T}{m}}$ *And* $n^1 = \left[\frac{V}{V + V_s}\right] n$

no. of beats per second = $n - n^1$

8. *no.of beats* $= \frac{2V_s n}{V}$

9. $n = \frac{P}{2l}\sqrt{\frac{T}{\pi r^2 d}} = \frac{p}{2lr}\sqrt{\frac{T}{\pi d}}$

. As l, T and m are same $\frac{p_1}{p_2} = \frac{r_1}{r_2}$

10. $V_0 = 5ms^{-1}, V_s = u - gt = 5 - 10 \times 2 = 15ms^{-1}$

$n^1 \left[\frac{v - v_0}{v + v_s}\right] n = \left[\frac{335 - 5}{335 - 15}\right] \times 350 = 330Hz$

11. $V_0 = a\omega = 2 \times \frac{2\pi}{\pi} \times 4 = 16ms^{-1}$

12. Difference of frequencies =n=490-420=70Hz

$n = \frac{1}{2l}\sqrt{\frac{T}{m}} \Rightarrow 70 = \frac{1}{2 \times 2}(V)$

14. $i_1 + i_2 = 5,\ i_1 - i_2 = 1, a = \frac{4i_1 i_2}{(i_1 + i_2)^2}$

LEVEL - III

1. A car approaching a crossing at a speed of 20 m/s sounds a horn of frequency 628 Hz when 80m from the crossing. The apparent frequency heard by an observer 60m from the crossing on the straight road which crosses the road at right angles is (velocity of sound = 330 m/s)

1) 660 Hz 2) 680 Hz 3) 640 Hz 4) 690 Hz

2. A stationary source emitting sound of frequency 680Hz is at the origin. An observer is moving with the velocity $\sqrt{2}\left(\bar{i}+\bar{j}\right)m/s$ at a certain instant. If the speed of sound in air is 340 m/s, then the apparent frequency received by him at that instant is
1) 680Hz 2) 676Hz 3) 684Hz
4) Any value between 676Hz and 684Hz

3. A tuning fork produces 8 beats /s with a sonometer wire. When tension in the wire is increased by 21% again 8 beats/s produced with same tuning fork, the frequency of the tuning fork is
1. 168 Hz 2. 176 Hz
3. 328 Hz 4. 336 Hz

4. The fundamental frequency of a sonometer wire of length l is f_o. A bridge is now introduced at a distance of Δl from the centre of the wire ($\Delta l << l$). The number of beats heard per second if both sides of the bridge are set to vibrate in their fundamental mode is
1) $\frac{8f_o\Delta l}{l}$ 2) $\frac{f_o\Delta l}{l}$ 3) $\frac{2f_o\Delta l}{l}$ 4) $\frac{4f_o\Delta l}{l}$

5. An engine whistling at a constant frequency 'n_0' and moving with a constant velocity goes past a stationary observer. As the engine crosses him, the frequency of the sound heard by him changes by a factor 'f'. The difference in the frequencies of the sound heard by him before and after the engine crosses him is
1) $\frac{1}{2}n_0(1-f^2)$ 2) $\frac{1}{2}n_0\left(\frac{1-f^2}{f}\right)$
3) $n_0\left(\frac{1-f}{1+f}\right)$ 4) $\frac{1}{2}n_0\left(\frac{1-f}{1+f}\right)$

6. The frequency of 1^{st} harmonic of a sonometer wire is 160Hz. If the length of wire is increased by 50% and tension in the wire is decreased by 19%, the frequency of its first overtone is
1.180 Hz 2. 192 Hz 3. 220 Hz 4. 232 Hz

7. The fundamental frequency of a sonometer wire is 200Hz when a body whose relative density 4 is suspended at the free end of wire. What will be the fundamental frequency of the same wire when the suspended body is made to immerse in water
1. $100\sqrt{2}\ Hz$ 2. $100\sqrt{3}\ Hz$
3. $50\sqrt{2}\ Hz$ 4. $50\sqrt{3}\ Hz$

8. The fundamental frequency of a sonometer wire decreases by 25% when the body suspended at free end of wire is totally immersed in water. The specific gravity of that suspended body is
1. 25/9 2. 16/7 3. 7/3 4. 4

9. A person in an open vehicle is travelling with uniform velocity 54kmph towards a fortwall. The person blows horn and hears its echo from the fortwall. If the apparent frequency of the echo is 437.5Hz, the actual frequency of horn is (Velocity of sound in air=335 ms^{-1})
1. 387.5 Hz 2. 400 Hz
3. 412.5 Hz 4. 425 Hz

10. A whistle of frequency 500Hz tied to the end of a string of length 1.2 m revolves at 400 rev/minute. A listener standing some distance away in the plane of rotation of whistle hears frequencies in the range (v = 340 m/s)
1. 486 to 586 Hz 2. 436 to 586 Hz
3. 436 to 574 Hz 4. 445 to 570 Hz

11. A source is emitting sound of a single frequency. A wall is advancing towards the source at a speed of 3cm/s. If the velocity of sound in air is 330m/s the percentage change of wavelength of the note as perceived by an observer near the source is
1. 20% 2. 2% 3. 0.2% 4. 12.2%

12. The length of a sonometer wire is 65 cm. This wire is made to vibrate in three segments of lengths l_1, l_2, l_3, by keeping 4 bridges in a row what are the lengths l_1, l_2, l_3, if their fundamental frequencies are in the ratio 2:3:4
1. 15cm, 20cm, 30cm
2. 30cm, 20cm, 15cm
3. 12.5cm, 20cm, 32.5cm
4. 32.5cm,20cm, 12.5cm

13. Two aeroplanes are travelling along parallel lines with same velocity. The person in one aeroplane is hearing the sound of another aeroplane. If the ratio of actual frequency, apparent frequency of sound when two aeroplanes are approaching to each other is 4:5, the ratio of actual frequency and apparent frequency of same sound when same two aeroplanes are moving away from each other is
1. 5:6 2. 6:7 3. 7:9 4. 4:5

14. A person in topless jeep is travelling with uniform velocity 20 ms^{-1} away from a vertical mountain. The person blows horn of the jeep and hears its echo from the mountain.

If actual frequency of horn is 630Hz, the apparent decrease in the frequency of echo with respect to actual frequency of the horn is (velocity of sound in air = 340 ms^{-1})
1. 35 Hz 2. 45 Hz 3. 70 Hz 4. 90 Hz

15. A bat is travelling with uniform velocity 20 ms^{-1} towards a wall in between two parallel walls. The bat produces ultrasonic sound note and it hears echoes from both walls. If minimum apparent frequency of echo is 32 KHz, the maximum apparent frequency of echo is (velocity of sound in air = 340 ms^{-1})
1. 34KHz 2. 36KHz
3. 40.5KHz 4. 45K Hz

16. A source of sound vibrating with a frequency 510Hz is in between a stationary observer and a fortwall. If the source is moving towards wall with a velocity 3 ms^{-1},the number of beats heard by the observer is (velocity of sound in air = 340 ms^{-1})
1. 3 beats/s 2. 6 beats/s
3. 9 beats/s 4. 4.5 beats/s

17. In the above problem, if source of sound is stationary and observer is moving with a velocity 2 ms^{-1} towards source, the number of beats heard by the observer is
1. 2 beats/s 2. 4 beats/s
3. 6 beats/s 4. zero

18. In the above problem, if source is moving towards observer with same velocity, the number of beats produced by the observer is
1. 9 beats/s 2. 4.5 beats/s
3. 6 beats/s 4. 3 beats/s

19. A boy sitting on a swing which is moving to an angle of 30^0 from the vertical is blowing a whistle which is of frequency 1000 Hz. The whistle is 2 m from the point of support of the swing. If a girl stands infront of the swing, the maximum and minimum frequencies she will here are
(velocity of sound = 330 m/s, g = 9.8 m/s^2)
1. 1000, 990 Hz 2. 1007, 1000 Hz
3. 1007,993 Hz 4. 1100, 900 Hz

20. A source of sound of frequency 256 Hz is moving rapidly towards a wall with a velocity of 5 m/s (sound travels at a speed of 330 m/s) Among the following choose the wrong statement.
1. If the observer is in between the source and the wall he hears no beats
2. If the sourcs is between the observer and the reflecting surface he hears beats at the frequence of 7.7 Hz.
3. If the obsever and the source are moving towards the wall, he hears beats at the frequency of 7.9 Hz.
4. If the observer is in between the source and the wall he hears beats at the frequency of 7.7 Hz

21. A string fixed at both ends has consecutive standing wave modes for which the distances between adjacent nodes are 18cm and 16cm respectively. The minimum possible length of the string is
1) 72 cm 2) 144 cm 3) 108 cm 4) 216 cm

22. Apparent change in wavelength of sound waves is 2.5 cm when the source of sound is approaching stationary listener with a velocity 17 m/s. Apparent decrease in the frequency of source when observer recedes from the same source at rest with a velocity of 25 m/s is (Velocity of sound = 340m/s)
1) 20 Hz 2) 25 Hz 3) 40 Hz 4) 50 Hz

23. A train moves towards a stationary observer with a speed 34 ms^{-1} The train sounds a whistle and its frequency registered by the observer is f_1. If the train's speed is reduced to 17 ms^{-1}, then the frequency registered is f_2. If the speed of the sound is 340 ms^{-1} then the ratio f_1 / f_2 is
1) 18/19 2) 1/2 3) 2
4) 19/18

24. A standing wave set up in a medium is $y = 4\cos\left(\frac{\pi x}{3}\right)\sin 40\pi t$ where x, y are in cm and t in sec The velocity of medium particle at x = 3cm at t=1/8 sec is
1) 40π cm/s 2) 80π cm/s
3) 120π cm/s 4) 160π cm/s

25. An additional bridge is kept below a sonometer wire so that it is divided into two segments of lengths in the ratio 2 : 3 and n_1, n_2 are their respective fundamental frequencies. If the additional bridge is removed then the fundamental frequency of that sonometer wire is n, the ratio of n, n_1, n_2 is
1) 2 : 3 : 5 2) 2 : 5 : 3
3) 4 : 9 : 25 4) 6 : 15 : 10

26. A heavy ball is suspended from the ceiling of a motor car through a light string. A transverse pulse travels at a speed of 60 cm/s on the string when the car is at rest and 66cm/s when the car accelerates on a horizontal road. The acceleration of car is ($g=10\ m/s^2$)
1) $6.7\ m/s^2$ 2) $3.6\ m/s^2$
3) $8.5\ m/s^2$ 4) $1.5\ m/s^2$

27. You are given four tuning forks, the lowest frequency of the fork is 300 Hz. By striking two tuning forks at a time 1, 2, 3, 5, 7 and 8 beats are heard per second. The possible frequencies of other forks are
1) 300Hz, 302 Hz, 307 Hz
2) 301Hz, 303 Hz, 308 Hz
3) 301Hz, 304 Hz, 307 Hz
4) 302Hz, 304 Hz, 309 Hz

28. A string of length 100cm and mass 0.5 gm is streched with a force of 20N. It is pulled at a distance of 12.5 cm from one end. The frequency of the note emitted by it is
1) 100Hz 2) 200 Hz 3) 400Hz 4) 800Hz

29. Three waves of same frequency having amplitudes 10mm, 4mm and 7mm arrive at a given point with successive phase difference of $\pi/2$. The amplitude of the resultant wave is
1) 7mm 2) 6mm 3) 5 mm 4) 4 mm

30. A piano wire 0.5m long and mass 5gm is stretched by a tension of 400N. The number of highest overtone that can be heared by a person is
1) 160 2) 99 3) 140 4) 120

31. The fundamental frequency of certain string under some tension is n . If 25 such similar strings but half length each are twisted together and stretched under same tension. Then the fundamental frequency of the system becomes
1) 5n/2 2) 5n 3) n/5 4) 2n/5

32. A sonometer wire of length L is plucked at a distance L/8 from one end then it vibrates with a minimum frequency n . If the same wire plucked at a distance L/6 from another end the minimum frequency with which it vibrates is

1) $\frac{\sqrt{3}}{2}n$ 2) $\frac{3}{2}n$ 3) $\frac{3n}{4}$ 4) $\frac{4n}{3}$

KEY

1) 1	2) 4	3) 1	4) 1
5) 2	6) 2	7) 2	8) 2
9) 2	10) 2	11) 3	12) 2
13) 4	14) 3	15) 3	16) 3
17) 4	18) 1	19) 3	20) 3
21) 2	22) 4	23) 4	24) 4
25) 4	26) 1	27) 2	28) 2
29) 3	30) 2	31) 4	32) 3

HINTS

7. $n_1 = \frac{1}{2l}\sqrt{\frac{T}{m}} = 160 Hz$

$$n_2 = \frac{2}{2(3/2)l}\sqrt{\frac{81}{100}\frac{T}{m}} \ (Ist\ Overtone)$$

$= 96 \times 2 = 192\ Hz$

9. $\frac{n_1}{n} = \sqrt{\frac{d_1 - d}{d_1}} = \sqrt{1 - \frac{d}{d_1}}$

But $\frac{d_1}{d}$ = specific gravity (s)

$\frac{n_1}{n} = \sqrt{1 - \frac{1}{s}} \Rightarrow \left(\frac{75}{100}\right)^2 = 1 - \frac{1}{s}$. Find s

11. $V_s = r\omega$; $n_1 = \left(\frac{V}{V - V_s}\right)n$

$$n_2 = \left(\frac{V}{V + V_s}\right)n$$

17. No. of beats/sec $= \frac{2nV_s}{V} = 9$

18. $n_1 = n_2$ *and* $n_1 \sim n_2 = 0$

19. $\frac{2nV_s}{V} = \frac{2 \times 510 \times 3}{340} = 9$

LEVEL - IV

1. The apparent frequency of sound detected by an observer depends on relative motion between source and observer. This effect is known as Doppler's effect. Consider a police car moving on a straight road with a speed of 28 m/s emitting sound from its siren at 1200 Hz. This means that the siren is oscillating 1200 times a second. A man 'M' is standing on the road in front of the car and the other person 'N' is at the backside of the car. The siren sound is getting reflected from a building directly in front of the car. Man 'M' is standing between the car and the building. You may assume car, N,M and building all to lie on a straigh line and the speed of sound in air = 340m/s. Now answer the following questions .

1. Which of the following statement(s) is / are correct?
a) The wavefronts are closer together infront of the car
b) The wavefronts are farther apart infront of the car
c) The wavefronts are farther apart behind the car
d) The wavefronts are closer together behind the car
1) a & c 2) a & b 3) a, b & c 4) a,c & d
2. The wave lengths of sound reaching M and N (directly from the car) respectively are
1) 0.26 m, 0.306m 2) 0.26m, 0.406m
3) 0.306m, 0.26m 4) 0.306m, 0.206m
3. The frequency detected by man M of the sound reflected from the building is
1) 1208 Hz 2) 1111Hz
3) 1308 Hz 4) 1415 Hz
4. The apparent frequency of the reflected sound as heard by the police in car is
1) 1208 Hz 2) 1111Hz
3) 1308 Hz 4) 1415 Hz
5. What is the difference between the apparent frequency of direct siren sound and apparent frrequency of reflected sound as heard by some one in car that is trailing the police car at speed of 16 m/s^2
1) direct sound has higher frequency with $\Delta\upsilon = 260\,Hz$
2) direct sound has lower frequency with $\Delta\upsilon = 260\,Hz$
3) reflected sound has higher frequency with $\Delta\upsilon = 106\,Hz$
4) reflected sound has lower frequency with $\Delta\upsilon = 106\,Hz$

KEY
1) 1 2) 1 3) 3 4) 4
5) 2

QUESTIONS FROM PREVIOUS EAMCET EXAMS

1. A vehicle moving on a straight road sounds a whistle of frequency while nearing a hill with a velocity $10ms^{-1}$. The number of beats per second observed by a person travelling in the vehicle is $\left(V = 330ms^{-1}\right)$. (ENG 2005)
1. zero 2. 10 3. 14 4. 16
2. A transverse wave propagating on a stretched string of linear density $3\times10^{-4}kgm^{-1}$ is represented by the equation $y = 0.2\,Sin\left(1.5x + 60t\right)$ where x is in metre and t is in seconds. The tension in the string in N. (ENG 2005)
1. 0.24 2. 0.48 3. 1.20 4. 1.80
3. A source of sound and an observer are approaching each other with the same speed which is equal to $\frac{1}{10}$ times the speed of sound.
The apparent change in the frequency of the source is (MED 2005)
1. 22.2% increase 2. 22.2% decrease
3. 18.2% decrease 4. 18.2% decrease
4. Consider the following statements A and B given below and identify the correct answer:
(A). The reverberation time is dependent on the shape of the enclosure, position of the sources and observer.
(B) The unit of absorption coefficient in MKS system is metric sabine. (MED 2004)
1. both (A) and (B) are true
2. both (A) and (B) are false
3. (A) is true but (B) is false
4. (A) is false but (B) is true
5. Two identical strings of the same material, same diameter and same length are in unison when stretched by the same tension. If the tension on one string is increased by 21%, the number of beats heard per second is ten. The frequency of the note in Hertz when the strings are in unison, is: (MED 2004)
1) 210 2) 200 3) 110 4) 100
6. The wavelength of two notes in air are 36/196 m and 36/193 m. Each note produces 10 beats per second separately with a third note of fixed frequency. The velocity of sound in air in m/s is :
(ENG 2004)
1. 330 2. 340 3. 350 4. 360
7. An iron load of 2 kg is suspended in air from the free end of a sonometer wire of length one meter. A tuning fork of frequency 256 Hz is in resonance with $1/\sqrt{7}$ times the length of the sonometer wire. If the load is immersed in water, the length of the wire in meter that

will be in resonance with the same tuning fork is : (Specific gravity of iron = 8)(ENG 2004)

1. $\sqrt{8}$ 2. $\sqrt{6}$ 3. $\frac{1}{\sqrt{6}}$ 4. $\frac{1}{8}$

8. Two uniform wires are vibrating simultaneously in their fundamental modes. The tensions, lengths, diameters and the densities of the two wires are in the ratio 8: 1, 36: 35, 4:1 and 1:2 respectively. If the note of the higher pitch has a frequency 360 hertz, the number of beats produced per second is: (MED 2003)

1. 5 2. 10 3. 15 4. 20

9. A radar sends a radio signal of frequency $9\times10^9\ Hz$ towards an aircraft approaching the radar. If the reflected wave shows a frequency shift of $3\times10^3\ Hz$, the speed with the aircraft is approaching the radar, in m/s $\left(velocity\ of\ radio\ signal\ is\ 3\times10^8\ ms^{-1}\right)$.

(MED 2003)

1. 150 2. 100 3. 50 4. 25

10. Two uniform strings A and B made of steel are made to vibrate under the same tension. If the first overtone of A is equal to the second overtone of B and if the radius of A is twice that of B, the ratio of the length of the strings is: (ENG 2003)

1. 1:2 2. 1:3 3. 1:4 4. 1:5

11. If the length of a stretched string is shortened by 40% and the tension is increased by 44%, then the ratio of the final and initial fundamental frequencies is: (ENG 2003)

1. 2:1 2. 3:2 3. 3:4 4. 1:3

12. A stretched wire of some length under a tension is vibrating with its fundamental frequency. Its length is decreased by 45% and tension is increased by 21%. Now its fundamental frequency: (MED 2002)

1. increases by 50% 2. increases by 100%
3. decreases by 50%4. decreases by 25%]

13. One train is approaching an observer at rest and another is receding him with same velocity 4 m/s. Both the trains blow whistles of same frequency of 243 Hz. The beat frequency in Hz as heard by the observer is : (Speed of sound in air =320 m/s) (MED 2002)

1. 10 2. 6 3. 4 4. 1

14. An auditorium has volume of $10^5\,m^3$ and surface area of absorption $2\times10^4\,m^2$. Its average absorption coefficient is 0.2. The reverberation time of the auditorium is seconds is: (ENG 2002)

1. 6.5 2. 5.5 3. 4.25 4. 3.25

15. A metallic wire with tension T and at temperature 30^0C vibrates with its fundamental frequency of 1 kHz. The same wire with the same tension but at 10^0C temperature vibrates with a fundamental frequency of 1.001 kHz. The coefficient of linear expansion of the wire is : (ENG 2002)

1. $2\times10^{-4}\,/^0C$ 2. $1.5\times10^{-4}\,/^0C$
3. $1\times10^{-4}\,/^0C$ 4. $0.5\times10^{-4}\,/^0C$

16. In order to double the frequency of the fundamental note emitted by a stretched string, the length is reduced to 3/4th of the original length and the tension is changed. The factor by which the tension is to be changed is (2001)

1. 3/8 2. 2/3 3. 8/9 4. 9/4

17. Two sound waves of wavelengths 5m and 6m formed 30beats in 3sec. The velocity of sound is (2001)

1. 300m/s 2. 310m/s
3. 320m/s 4. 330m/s

18. Two stretched strings of same material and same radius having lengths 75cm and 150cm are in resonance when they are stretched by masses 1kg and 2kg respectively.The velocities of transverse waves in these strings are in the ratio (2001)

1. 1:4 2. $\sqrt{3}:1$ 3. . $1:\sqrt{2}$ 4. 1:2

19. If a vibrating tuning fork of frequency 255Hz is approaching with a velocity 4m/s perpendicular to a wall. The number of beats produced per sec is (speed of sound in air = 340m/s) (2000)

1. 3 2. 4 3. 5 4. 6

20. A source producing sound of frequency 170Hz is approaching a stationary observer with a velocity 17m/s. The apparent change in the wave length of sound heard by the observer is (speed of the sound in air=340m/s) (2000)

1. 0.1m 2. 0.2m 3. 0.4m 4. 0.5m

21. In a medium in which a transverse progressive wave is travelling the phase difference between two points with a distance of separation 1.25cm is $\pi/4$. If the frequency of the wave is 1000Hz, its velocity will be (1999)
1. 10^4 m/s 2. 125m/s 3. 100 m/s 4. 10m/s.

22. A car with a horn of frequency 620Hz travels towards a large wall at a speed of 20m/s. If the velocity of sound is 330m/s, the frequency of echo of sound of horn observed by the driver is (1999)
1. 700Hz 2. 660Hz 3. 620Hz 4. 580Hz

23. The equation of a wave is y =1.0 cos 2π (t/0.02+x/10) where t is in second. The frequency of the wave is (1998)
1. 50Hz 2. 315Hz 3. 10Hz 4. 63Hz.

24. A string on musical instrument is 50cm long and its fundemental frequency is 270Hz. If the desired frequency of 1000Hz is to be produced, the required string length in cm is (1998)
1. 13.5 2. 2.7 3. 5.4 4. 10.8

25. A man stands infront of a hill rock and fires a gun. He hears an echo after 1.5 sec. The distance of the hill rock from the man is (velocity of sound in air=330m/s) (1998)
1. 220m 2. 247.5m 3. 268.5m 4. 292.5m

26. A source and an observer move away from each other with speed of 10m/s with respect to ground. Apparent frequency of the source is 1950Hz. The natural frequency of the source is (velocity of sound is 340m/s) (1997)
1. 2068Hz 2. 1832Hz
3. 1950Hz 4. 1650Hz

27. An observer is moving away from a sound source of frequency 100Hz. If the observer is moving with a velocity 49m/s and the speed of sound in air is 330m/s,the observed frequency is (1996)
1. 85Hz 2. 91Hz 3. 100Hz 4. 149Hz

28. Two identical stringed instruments have frequency 100Hz. If tension in one of them is increased by 4% and they are sounded together, then number of beats in one second is (1995)
1. 1 2. 8 3. 4 4. 2

29. A stretched string is in unison with a tuning fork of frequency 392Hz. If the length of the string is decreased by 2%, the number of beats heard per sec is nearly. (1994)
1. 2 2. 4 3. 8 4. 16

30. The phase difference between two points distant 11m apart is 1320^0. The frequency of the wave is 105Hz. The velocity is (1994)
1. 315m/s 2. 4235m/s
3. 1155m/s 4. 380m/s

31. Let Vs be the speed of the source emitting sound waves, n the actual frequency of the source of sound, V the speed of the sound in the medium and n_1 the frequency of sound waves as perceived by a stationary observer to whom the source of sound is approaching. The formula for calculating n_1 is (1992)
1. n_1=n(1-V_s/V) 2. n_1= n/(1-Vs/V)
3. n_1= n/(1+V_s/V) 4. n_1 = n

32. A certain number of beats are heard when two tuning forks of natural frequencies n_1 and n_1 are sounded together. The number of beats when one of the forks is loaded (1992)
1. increases 2. decreases
3. remains same
4. may increase or decrease

33. Amplitude of vibration of any particle in a standing wave produced along a stretched string depends on (1991)
1. frequency of incident wave
2. time of reflected wave
3. location of the particle 4. time

34. The frequency of sound reaching a stationary listener behind a moving source is (1990)
1. Lower than the source frequency
2. Higher than the source frequency
3. Same as the source frequency
4. Zero

35. Y= 0.05 sin2π (0.1x+ 2t) represents a wave equation in which the distances are measured in metres and time in secs. The wave speed is (1990)
1. 20m/s 2. 10m/s 3. 40m/s 4. 330m/s.

36. The frequency of tuning forks A and B are respectively 3% more and 2% less than the frequency of tuning fork C, when A and B are simultaneously excited, 5 beats/sec are produced, then the frequency of the tuning fork A(in Hz) is (2001)
1. 98 2. 100 3. 103 4. 105

37. A man is standing between two parallel cliffs and fires a gun. If he hears the echoes after 1.5s and 3.5s respectively, the distance between the cliffs is (velocity of sound in air = 340m/s) (2000)
1. 1190m 2. 850m
3. 595m 4. 510m

38. The frequency of transverse vibrations in a stretched string is 200Hz. If the tension is increased 4 times and the length is reduced to one fourth the original values, the frequency of vibrations will be (1999)
1. 25 Hz 2. 200Hz 3. 400Hz 4. 1600Hz

39. Equation of a stationary wave is given by (1999)
1. y= Asin(kx-wt)
2. y = 2Asin kx.coswt
3. y = A cos 2 π (kx/l - t/T)
4. y = A cos 2 π t/l

40. Two tuning forks A and B produce 6 beats/sec when sounded together. When B is slightly loaded with wax, the beats are reduced to 4beats/sec. If the frequency of A is 512Hz, the frequency of B is (1999)
1. 506 Hz 2.516hz 3.508Hz 4.518Hz

41. In a transverse wave of amplitude A, the maximum particle velocity is four times wave velocity, then the wave length of the wave is (1999)
1. (π A)/42. (π A)/2 3. π A 4. 2 π A

42. The frequency of vibration of a rod is 200Hz. If the velocity of sound in air is 340m/s, the wave length of the sound produced is (1995)
1. 1.7m 2. 6.8 m 3. 3.4 m 4. 13.6 m

43. To hear a clear echo, the reflecting surface must be at a minimum distance of (1995)
1. 10m 2. 16.5m 3. 33m 4. 66m

44. Frequency range of audible sound is(1995 M)
1. 0 Hz- 30kHz 2. 20Hz-20KHz
3. 20KHz- 20,000KHz
4. 20KHz-20MHz

45. A wave has a frequency of 120Hz. Two points at a distance of 9m apart have a phase difference of 1080°. The velocity of the wave is (1994)
1. 340m/s 2. 300m/s
3. 330m/s 4. 360m/s

46. Two progressive waves each of frequency 10Hz travelling at 20cms^{-1} are superposed. In the resulting stationary wave, the distance between the successive nodes is (1994)
1. 1 cm 2. 2cm 3. 0.5cm 4. zero

47. The equation of a progressive wave is y=0.002 sin 2π (2t-0.01x). Its wavelength is (1994)
1. 100 units 2. 10 units
3. 200 units 4. 20 units0

48. The equation of a progressive wave is y= 0.5 sin 2 π (t/0.004 - x/50) where x is in cm. The phase difference between two points separated by a distance 5cm at any instant is (1993)
1. π/5 2. π/3 3. π/2 4. π

KEY

1)4	2)2	3)1	4)2
5)4	6)4	7) 4	8)2
9)3	10)2	11)1	12)2
13)2	14)3	15)3	16) 4
17) 1	18) 3	19) 4	20) 2
21) 3	22) 1	23) 1	24) 1
25) 2	26) 1	27) 1	28) 4
29) 3	30) 1	31) 2	32) 4
33) 3	34) 1	35) 1	36) 3
37) 2	38) 4	39) 2	40) 4
41) 2	42) 1	43) 2	44) 2
45) 4	46) 1	47) 1	48) 1

QUESTIONS FROM OTHER COMPETITIVE EXAMS

1. Two waves of lengths 50cm and 51cms produce 12 beats/sec. The velocity of sound is (AIIMS 2000, CBSE 1999)
1. 360m/s 2. 340m/s
3. 331m/s 4. 306m/s

2. A whistle giving out 450Hz approaches a stationary observer at a speed of 32m/s. The frequency heard by the observer in Hz is nearly (velocity of sound in air =330m/s) (AIIMS 2000)
1. 500 2. 517 3. 429 4. 409

3. The tones that are separated by three octaves have a frequency ratio (AFMC 2000)
1. 6 2. 3 3. 16 4. 8

4. If n_1,n_2,n_3 are the three fundamental frequencies of three segments into which a string is divided, then the original fundamental frequency 'n' of the string is given by (CBSE 2000)

1. $\sqrt{n} = \sqrt{n_1} + \sqrt{n_2} + \sqrt{n_3}$

2. $\frac{1}{\sqrt{n}} = \frac{1}{\sqrt{n_1}} + \frac{1}{\sqrt{n_2}} + \frac{1}{\sqrt{n_3}}$

3. $n = n_1 + n_2 + n_3$

4. $\frac{1}{n} = \frac{1}{n_1} + \frac{1}{n_2} + \frac{1}{n_3}$

5. If the length of the wire of a sonometer is halved the value of resonant frequency will be (PMT (raj)1996)

1. double 2. half
3. four times 4 eight times

6. A string of length 36cms was in unison with a fork of frequency 256Hz. It was in unison with another fork when the vibrating length was 48cm, the tension being unaltered. The frequency of second fork is (AFMC 1999)

1. 212Hz 2. 320Hz
3. 384Hz 4. 192Hz

7. A steel wire of length 1.5m has density 7.7×10^3 kg/m³ and young's modulus 2.2×10^{11} N/m². It is subjected to a tension which produces an elastic strain of 1%. Its fundamental frequency of vibration must be (AIIMS 1999)

1. 256 Hz 2. 178Hz 3. 170Hz 4. 200Hz.

8. A damped source of sound is set into vibration by an external force with a frequency 'f'. When 'f' is much larger than the natural frequency of the source, the average energy stored in the source is (IAS 1988)

1. mostly in the form of heat energy
2. mostly in the form of potential energy
3. mostly in the form of kinetic energy
4. equally divided among kinetic and potential energies

9. Two sirens situated one kilometre apart are producing sound of freqency 330 Hz. An observer starts moving from one siren to the other with a speed of 2m/s. If the speed of sound be 330m/s, the beat frequency heard by the observer is (PMT (Raj)1996)

1. 8 2. 4 3. 6 4. 1

10. At what speed should a source of sound move so that a stationary observer finds the apparent frequency equal to half of the original frequency: (PMT(Raj)1996)

1. $\frac{V}{2}$ 2. $2V$ 3. $\frac{V}{4}$ 4. V

11. Two waves are represented by $y_1 = a \sin(\omega t + \pi/6)$ and $y_2 = a \cos \omega t$, if they super pose then their resultant amplitude is (PMT (Raj) 1996)

1. a 2. $a\sqrt{2}$ 3. $a\sqrt{3}$ 4. 2a

12. If $x = a \sin(\omega t + \pi/6)$ and $x_1 = a \cos \omega t$, then the phase difference between the two waves is

1. $\pi/3$ 2. $\pi/6$ 3. $\pi/2$ 4. π

13. A string oscillating at fundamental frequency under a tension of 225 N produces 6 beats/sec with a sonometer. If the tension is 256 N, then again oscillating at fundamental note it produces 6 beats per second with the same sonometer. The frequency of the sonometer is (PET (Raj) 1996)

1. 256 2. 225 3. 280 4. 186

14. Two whistles A and B produces notes of frequencies 600 Hz and 596 Hz respectively. There is a listener at the midpoint of the line joining them. Both the whistles A, B and the listener start moving with speed 30m /s in same direction. If speed of the sound be 330m/s, the number of beats will be heard by the listener are (PET (Raj) 1996)

1. 2 2.4 3.6 4.8

15. A couple of tuning forks produce 2 beats in the time interval of 0.4 sec so the beat frequency is (CPMT 1996)

1.8 Hz 2.5 Hz 3.2 Hz 4.8 Hz

16. The equation of a sound wave is $y = 0.0015 \sin(62.8x + 316t)$, the wave length of this wave is

1. 0.2 unit 2. 0.1 unit
3. 0.3 unit 4. 0.5 unit

17. Two sound waves having a phase difference of 60^0 have path difference of (CBSE1996)

1. 2λ 2. $\lambda/2$ 3. $\lambda/6$ 4. $\lambda/3$

18. A source of sound gives five beats per second, when sounded with another source of frequency $100 s^{-1}$. The second harmonic of the source together with a source of frequency $205 s^{-1}$ gives five beats /sec. The frequency of the source is
(CBSE 1995)

1. $105 s^{-1}$ 2. $205 s^{-1}$ 3. $95 s^{-1}$ 4. $100 s^{-1}$

19. The length of a sonometer wire AB is 110 cm. The distance at which two bridges should be placed from A to divide the wire in to 3 segments whose fundamental frequencies are in the ratio of 1:2:3 is (CBSE 1995)

1. 30cm, 90cm 2. 60cm, 90 cm
3. 40 cm,80 cm 4. 50cm, 90 cm

20. In a stationary wave the strain is (BHU 1995)

1. Maximum at nodes
2. maximum at antinode
3. constant throughout
4. varying

21. The waves are represented by the following equations $y_1 = 5 \sin 2\pi(10t-0.1x)$

$y_2 = 10 \sin 2\pi(20t-0.2x)$ ratio of intensities I_2/I_1 will be

(AIIMS 1995)

1. 1
2. 2
3. 4
4. 16

22. These waves of equal frequency having amplitudes 10mm, 4mm and 7mm arrive at a given point with successive phase difference $\pi/2$. The amplitude of the resulting wave in mm is given by (AIIMS 1995)

1. 7
2. 6
3. 5
4. 4

KEY

1) 4	2) 1	3) 4	4) 4
5) 1	6) 4	7) 2	8) 1
9) 2	10) 4	11) 3	12) 1
13) 4	14) 2	15) 4	16) 2
17) 3	18) 1	19) 2	20) 1
21) 3	22) 3		

* * *

ADDITIONAL POINTS IN SOUND

Wave Motion:

- The wave moves forward with constant velocity without change in its shape.
- The particles of the medium responsible for wave propagation vibrate about their mean positions, without getting permanently displaced.
- The medium itself doesnot move.
- The phase of various particles of the medium Keeps on changing constantly.

Classification on the basis of necessicity of medium.

Mechanical Waves:

- The medium should have low resistance.

Ex: Sound waves.

Electromagnetic Waves:

Ex: Light waves, X-rays, γ-rays, radio waves. On the basis of energy propagation.

Progressive Wave:

- In these waves all the particles of the medium execute SHM with same amplitude and same frequency.
- Velocity of the particle and the strain are proportional to each other.
- Equal changes in pressure and densities occur at all points of the medium.
- All the particles of the medium cross the mean position once in one time period.
- Average energy over one time period is equal to the sum of K.E. and P.E.
- ***Stationary Wave***: When two identical progressive waves moving in opposite directions superpose, stationary waves are formed.

On the basis of vibration of particles.

- ***Transverse Wave***:
- It travels in the form of crests and troughs.
- These waves can propagate only in solids and on the surface of water.
- Pressure and densities donot vary.
- These wavs can be represented by

$$Y = a\sin(\omega t \pm kx) \quad Z = a\sin(\omega t \pm kx)$$

$$Z = a\sin(\omega t \pm ky) \quad Y = a\sin(\omega t \pm kz)$$

- These waves can be polarised.
- ***Longitudinal Wave***:
- Travel in the form of compressions and rarefactions.
- They can be produced in solids, liquids and gases.
- Pressure and density vary.
- These waves can be represented by $x = a\sin(\omega t \pm kx)$.
- These waves cannot be polarised.
- **Phase:**

● Path difference is the difference of distances covered by two vibrating particles.

● Time difference is the difference of times taken by the vibrating particle in completing one vibration.

$$\Delta\phi = \frac{2\pi}{T} \times \text{time difference}$$

$$\text{time difference} = \frac{T}{\lambda} \times \text{ path difference.}$$

Wave Velocity :

● Wave velocity is constant as it doesnot depend on time.

b) Particle Velocity:

● Particle velocity varies with time.

- **Principle of super position of waves:** When two or more waves propagating in the medium superimpose over a common particle of the medium, then the resultant displacement of the particle is the vector sum of the displacement of the particle due to each wave as if other waves are absent.

$\vec{y} = \vec{y}_1 + \vec{y}_2 + \vec{y}_3 + ... + \vec{y}_n$

- This law is applicable for all types of waves like light waves, sound waves etc but not applicable to large amplitude waves like shock waves, laser waves etc. Phenomena arising due to superposition of waves.

  a) Interference b) stationary waves
  c) Beats d) Lissaous figures
- In superposition phenomena, energy is conserved but it is distributed.
- Superposition is possible only in waves of similar nature.

REFLECTION-REFRACTION OF WAVES

- ***Reflection from Rigid Suface:***

  ● Change in phase is π ; change in time is $\frac{T}{2}$. Change in path is $\frac{\lambda}{2}$. Compression returns as rarefaction and rarefaction as compression. But crest returns as crest and trough returns as trough.
- ***Reflection from Free End:***

  ● Change in phase = 0, change in time = 0, change in path = 0. Compression and rarefaction return as compression and rarefaction respectively. But crest and trough return as trough and crest respectively.

  ● Sound produced in air is not heard by a diver inside water since most sound energy is reflected at the surface of water.
- ***Tuning fork:***:

  ● It is made of steel or aluminium rod of rectangular cross-section and it is U-shaped.

  ● The prongs of a tuning fork execute transverse vibrations whereas its stem executes longitudinal vibrations.

  ● The two arms of a tuning fork vibrate in the opposite phase. Transverse stationary waves are produced in U-shaped portion and longitudinal stationary waves are produced in linear portion of a tuning fork.

  ● Antinodes are formed at the free ends of the arms as well as at the point where the two arms meet whereas nodes are formed in between.

  ● The frequency of a tuning fork depends on

  i) thickness (t) of the fork i.e. $n \alpha t$.

  ii) length of the arm (l) of the fork i.e. $n \alpha \frac{1}{l^2}$.

  iii) the modulus of elasticity (E) of the material of the fork i.e. $n \alpha \sqrt{E}$.

  iv) the density (ρ) of the material of the fork i.e. $n \alpha 1/\sqrt{\rho}$.

  v) the temperature(T) of the medium i.e. $n \alpha \frac{1}{T}$.

  ● ***Expressions of the frequencies of a fork:***

  i) $n = \frac{At}{l^2}\sqrt{\frac{Y}{\rho}}$ here A is a constant.

  ii) In longitudinal mode $n_L = \frac{p}{l}\sqrt{\frac{T}{m}}$.

  iii) In transverse mode $n_T = \frac{p}{2l}\sqrt{\frac{T}{m}}$.

  ● The tuning forks of higher frequencies are small and thick whereas those of low frequencies are long and thin.

  ● Tuning fork is a source of sound which can produce a pure note.
- ***Velocity of sound in solids:***

  i) $V = \sqrt{\frac{Y}{\rho}}$ ii) $V = \sqrt{\frac{T}{m}}$
- ***Velocity of sound in liquids:***

  i) $V_{liquid} = \sqrt{\frac{K}{\rho}} = \sqrt{\frac{E}{\rho}}$

  here K = Bulk modulus of elasticity
  ρ = density of liquid
- ***Doppler Effect:***

  ● When the sound source moves towards the observer then the waves contract i.e. the wavelength decreases and consequently frequency increases.

  ● When the source moves away from the observer, then the waves spread i.e. the wavelength increases and consequently frequency decreases.

$$n_1 = \left(\frac{V \pm V_o}{V \mp V_s}\right) n$$

● Conditions when Doppler effect is not observed for sound waves:

● When the source of sound and the observer both are at rest then Doppler effect in sound is not observed.

● When the source and the observer both are moving with same velocity in same direction, then Doppler effect of sound is not observed.

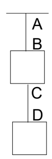
● When the source and the observer are moving mutually in perpendicular directions then also Doppler effect of sound is not observed.

● When the medium only is moving then Doppler effect is not observed.

● When the distance between the source and the observer is constant then also Doppler effect is not observed.

Only Figure

24. Two blocks each having a mass of 3.2kg are connected by a wire CD and the system is suspended from the ceiling by another wire AB. The linear density of wire AB is 10gm/m and that of CD is 8 gm/m. The speed of transverse pulse in AB is



1) 63 m/s 2) 49 m/s 3) 42m/s 4) 80 m/s