विध्न विचारत भीरु जन, नहीं आरम्भे काम,
विपति देख छोड़े तुरंत मध्यम मन कर श्याम।
पुरुष सिंह संकल्प कर, सहते विपति अनेक,
'बना' न छोड़े ध्येय को, रघुबर राखे टेक।।

रचितः मानव धर्म प्रणेता
सद्गुरु श्री रणछोड़दासजी महाराज

SOUND AND WAVES

Some questions (Assertion–Reason type) are given below. Each question contains STATEMENT – 1 (Assertion) and STATEMENT – 2 (Reason). Each question has 4 choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct. So select the correct choice :

Choices are :

(A) Statement – 1 is True, Statement – 2 is True; Statement – 2 **is** a correct explanation for Statement – 1.
(B) Statement – 1 is True, Statement – 2 is True; Statement – 2 **is NOT** a correct explanation for Statement – 1.
(C) Statement – 1 is True, Statement – 2 is False.
(D) Statement – 1 is False, Statement – 2 is True.

283. **STATEMENT – 1**
Waves generated in a metal piece can be transverse or longitudinal.

STATEMENT – 2
Waves generated depend upon the method of creating waves in the metal.

284. **STATEMENT – 1**
Doppler effect can be seen in sound and light both.

STATEMENT – 2
Light waves are transverse.

285. **STATEMENT – 1**
The intensity of a plane progressive wave does not change with change in distance from the source.

STATEMENT – 2
The wavefronts associated with a plane progressive wave are planar.

286. **STATEMENT – 1**
A balloon filled with CO_2 gas acts as a converging lens for a sound wave.

STATEMENT – 2
Sound waves travel faster in air than in CO_2.

287. **STATEMENT – 1**
Beats are not observed in case of light waves from independent sources.

STATEMENT – 2
The phase difference between two light sources changes randomly.

288. **STATEMENT – 1**
Sound waves cannot be polarized.

STATEMENT – 2
Polarization can occur only in transverse waves.

289. **STATEMENT – 1**
An 80dB sound has twice the intensity of a 40 dB sound.

STATEMENT – 2
Loudness of a sound of a certain intensity I is defined as

$$L(\text{in dB}) = 10 \log_{10} \frac{I}{I_0}$$

290. **STATEMENT – 1**
Whether an observer moves with a certain velocity towards a stationary source of sound, or the source moves towards the stationary observer with the some velocity, the frequency heard would be the same. The two situations are relatively the same.

STATEMENT – 2
The two situations are relatively speaking not the same on account of difference in wind speeds.

291. **STATEMENT – 1**
The more the velocity of a simple harmonic wave in a string, the more is the maximum velocity of the particles of string.

STATEMENT – 2
$v_{max} = \omega A$

292. **STATEMENT – 1**
For a traveling wave in a string, for small amplitudes the instantaneous values of kinetic and potential energies of any element are equal.

STATEMENT – 2

$$dU = \frac{1}{2} T\, dx \left(\frac{\partial y}{\partial x}\right)^2$$

$$d(KE) = \frac{1}{2}(\mu\, dx)\left(\frac{\partial y}{\partial t}\right)^2$$

Where T is the tension and is mass per unit length of the string.

293. **STATEMENT – 1**
Node of pressure wave is formed at the open end of an organ pipe.

STATEMENT – 2
Due to huge volume of the atmosphere outside the tube, deformation in its volume is negligible.

294. **STATEMENT – 1**
If transverse waves are produced in a very long string fixed at one end. Near the free end only progressive wave is observed.

STATEMENT – 2
Energy of reflected wave does not reach the free end.

295. **STATEMENT – 1**
The quality of sound depends on the number of overtones produced by the instrument.

STATEMENT – 2
The pitch of sound depends on fundamental frequency of the sound.

296. **STATEMENT – 1**
In a stationary wave, on an average there is no transfer of energy.

STATEMENT – 2
When two identical waves travelling in opposite directions superimpose, the net propagation of energy from a place is stopped.

297. **STATEMENT – 1**

A plane wave of sound travelling in air is incident upon a plane water surface. Angle of incidence is θº. If Snell's law is valid for sound waves, it follows that sound will be refracted into water away from normal.

STATEMENT – 2
From Snell's law, angle of refraction is more than angle of incidence when wave travel from denser to rarer medium.

298. **STATEMENT – 1**
When two tuning fork of frequency 256 Hz and 324 Hz are vibrating together. Beats will not be heard.

STATEMENT – 2
Superposition of sound waves is possible for all frequencies of sound.

299. **STATEMENT – 1 :** A train is moving in straight line, and its frequency of whistle is f. An observer which lies on a line perpendicular to path of train. Observer is stationary; frequency heard by observer will be continuously increasing.

STATEMENT – 2 : If relative motion occur between source and observer then frequency observed by observer will be different from frequency produced by source.

300. **STATEMENT – 1 :** Intensity of light from a point source of power 80 watt depends inversely on the square of the distance.

STATEMENT – 2 : Intensity varies with distance r as r^{-1} for a cylindrical source.

301. **STATEMENT – 1 :** A plane progressive harmonic wave is propagating in a string. If tension in the string is made two times then average power transmitted through the string becomes two times.

STATEMENT – 2 : Average power transmission in a string is given by $P = \frac{\omega^2 A^2 F}{2V}$.

302. **STATEMENT – 1 :** A person is standing near a railway track A train is moving on the track. As train is approaching the person, apparent frequency keeps on increasing and when train has passed the person then apparent frequency keeps on decreasing.

STATEMENT – 2 : When train is approaching the person then $f = f_0\left[\frac{c}{c-u}\right]$ and when train is moving away from person $f = f_0\left[\frac{c}{c+u}\right]$. c is velocity of sound, u is velocity of train and f_0 is original frequency of whistle.

303. **STATEMENT – 1 :** Velocity of particles, while crossing mean position (in stationary waves) varies from maximum at antinodes to zero at nodes.

STATEMENT – 2 : Amplitude of vibration at antinodes is maximum and at nodes, the amplitudes is zero and all particles between two successive nodes cross the mean position together.

304. **STATEMENT – 1 :** Sound travel faster in solids than gases.

STATEMENT – 2 : Solids possess greater density than gases.

305. **STATEMENT – 1 :** Transverse waves are possible both in solids and fluids.

STATEMENT – 2 : Transverse waves require rigidity in the medium for the propagation.

306. **STATEMENT–1 :** When two waves interfere, one wave alters the progress of the other wave.

STATEMENT – 2 : In interference there is no loss of energy.

307. **STATEMENT – 1 :** The phase difference between two medium particles having path difference λ is 2π.

STATEMENT – 2 : The phase difference is inversely proportional to path difference of a particle.

308. **STATEMENT – 1 :** When two vibrating tuning forks have f_1 = 300 Hz and f_2 = 350 Hz and held close to each other; beats cannot be heard.

STATEMENT – 2
The principle of superposition is valid only when $f_1 - f_2 < 10$ Hz.

309. **STATEMENT – 1 :** For a closed pipe the first resonance length is 60 cm. The second resonance position will be obtained at 120 cm.

STATEMENT – 2 : In a closed pipe $n_2 = 3n_1$

310. **STATEMENT – 1 :** The speed of sound in solids is maximum though their density is large.

STATEMENT – 2 : This is because their coefficient of elasticity is large.

311. **STATEMENT – 1 :** When there is no relative velocity between source and observer then observed frequency is the same as emitted.

STATEMENT – 2 : Velocity of sound when there is no relative velocity between source and observer is zero.

312. **STATEMENT – 1 :** In wave motion there is transfer of energy without transfer of particle.

STATEMENT – 2 : When temperature of medium increases then speed of sound increases.

313. **STATEMENT – 1 :** Waves produced on the water surface are always transverse in nature.

STATEMENT – 2 : Surface tension in water opposes the motion of particle at surface perpendicular to the surface.

314. **STATEMENT – 1 :** Longitudinal waves can be produced in solid, liquid and gasses.

STATEMENT – 2 : Bulk modulus of elasticity is present in all three.

315. **STATEMENT – 1 :** Compressions and rarefactions involve changes in density and pressure.

STATEMENT – 2 : When particles are compressed, density of medium increases and when they are rarefied, density of medium decreases.

316. **STATEMENT – 1 :** The fundamental frequency of an organ pipe increases as the temperature increases.

STATEMENT – 2 : As the temperature increases, the velocity of sound increases more rapidly than length of the pipe.

317. **STATEMENT – 1 :** Sound would travel faster on a hot summer day than a cold winter day.

STATEMENT – 2 : Velocity of sound is directly proportional to the square of its absolute temperature.

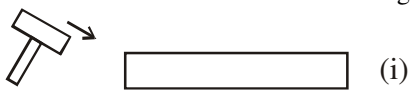
318. **STATEMENT – 1 :** If two waves of same amplitude, produce a resultant wave of same amplitude, then the phase difference between then will be 120°.

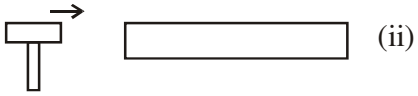
STATEMENT – 2 : Velocity of sound is directly proportional to the square of its absolute temperature.

Hint & Solution

283.	(A)	284.	(B)				
285.	(A)	286.	(A)	287.	(A)	288.	(A)
289.	(D)	290.	(D)	291.	(D)	292.	(A)
293.	(A)	294.	(A)	295.	(B)	296.	(A)
297.	(A)	298.	(B)	299.	(D)	300.	(B)
301.	(D)	302.	(D)	303.	(A)	304.	(B)
305.	(C)	306.	(D)	307.	(C)	308.	(C)
309.	(D)	310.	(A)	311.	(C)	312.	(B)
313.	(D)	314.	(A)	315.	(A)	316.	(A)
317.	(C)	318.	(C)				

283. In 1st case the waves produced are transverse and in 2nd case the waves generated are longitudinal.


(i)

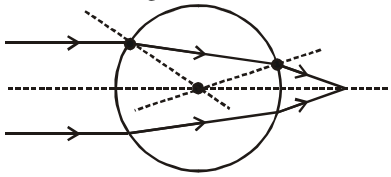

(ii)

284. Conceptual.
Light waves are transverse.

285. Since the wavefronts are plane, the amount of energy passing per unit time per unit area remains same.

286. Speed of sound $= \sqrt{\frac{\gamma RT}{M}}$ $\because$ $M_{air} < M_{CO_2}$

Sound travels faster in air $\Rightarrow$ air is rarer and CO_2 is denser.
$\therefore$ waves will bend towards the normal (see figure).



287. To observe beats in light, the phase difference between the sources should change regularly but as the ultimate source of light is the atom this is not possible.

289. $L \text{ (in dB)} = 10 \log_{10} \frac{I}{I_0}$

$$\Rightarrow \quad I = I_0 \, 10^{\frac{L}{10}}$$

$$\therefore \quad \frac{I_{80}}{I_{40}} = \frac{10^8}{10^4} = 10^4.$$

291. For a given velocity v_{max} depends on the frequency of the wave.

292. The potential energy of the element is the work done to stretch it from dx to dl.

$$DU = F(dl - dx)$$

$$= F\left(\sqrt{(dx)^2 + (dy)^2} - dx\right)$$

$$= F\,dx\left[\left(1 + \frac{dy}{dx}\right)^{\frac{1}{2}} - 1\right]$$

$$= \frac{1}{2} F\,dx \left(\frac{\partial y}{\partial x}\right)^2,$$

Assuming that the disturbance is small.

300. $I = \frac{P}{\text{area}}$; for point source $I = \frac{P}{4\pi r^2}$ for cylindrical source $\left(\frac{P}{2\pi r\ell}\right)$.

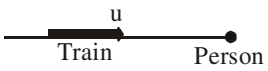
301. $P = \frac{\omega^2 A^2 F}{2V}$

But $V = \sqrt{\frac{F}{\mu}}$

$\Rightarrow \quad P = \frac{\omega^2 A^2 F}{2\sqrt{F}/\sqrt{\mu}} = \omega^2 A^2 \sqrt{\mu F}$

$\Rightarrow \quad P \propto \sqrt{F}$.

302.



$$f = f_0\left[\frac{c+o}{c-u}\right]$$

$$f = f_0\left[\frac{c}{c+u}\right]$$

So, when train is approaching frequency has constant value $= f_0\left[\frac{c}{c-u}\right]$.

303. A node is a place of zero amplitude and an anti-node is a place of maximum amplitude.

304. Since velocity of sound $v = \sqrt{\frac{E}{\rho}}$

As the elasticity of solid is large than that of gases. Hence it is obvious that velocity of sound is greater in solids than in gases.

305. Fluids do not have rigidity, hence transverse waves cannot propagate through them.

306. Each wave continues to move onwards in its respective direction in interference.

307. $\Delta\phi = \frac{2\pi}{\lambda}(\Delta x)$.

308. Superposition principle is valid for other frequencies also; like standing wave or interference phenomena.

309. In a closed organ pipe $l_2 = 3l_1$
$l_2 = 3 \times 60 = 180$ cm
i.e., statement I is false and statement II is true.

310. $V = \sqrt{\frac{E}{\rho}}$. Through ρ is large for solid, their coefficient of elasticity E is much larger as compared to liquid and gases i.e., V is more.

311. Velocity of source = velocity of observer.

$$f' = f_0\left[\frac{v - v_0}{v - v_s}\right] \quad v_0 = v_s$$

$f' = f_0$.

312. Speed of sound in air $= \sqrt{\frac{\gamma RT}{M}}$.

313. Waves produced at the surface may be combination of transverse and longitudinal wave.

314. In longitudinal waves, compression and rarefaction takes place. i.e., it must have compressibility therefore bulk modulus of elasticity.

315. A compression is a region of medium in which particles come closer means distance between the particles become less than the normal distance between them. Thus there is a temporary decrease in volume and a consequent increase in density of medium.
Similarly, in rarefaction particles get farther apart and a consequent decrease in density.

316. The fundamental frequency of an organ pipe is $n = \frac{V}{2\ell}$. As temperature increases, both V and ℓ increases but V increases more rapidly than ℓ. Hence fundamental frequency increases as the temperature increases.

317. The velocity of sound in a gas is directly proportional to the square root of its absolute temperature $v = \sqrt{\frac{\gamma RT}{M}}$.
Since temperature of a hot day is more than cold winter day, therefore sound would travel faster on a hot summer day than on a cold winter day.

318. The resultant amplitude of two waves is given by $A = \sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\theta}$.

Here $a_1 = a_2 = A = a$ or $\frac{1}{2} = 1 + \cos\theta$

or $\cos\theta = \frac{1}{2}$ or $\theta = 120^o$