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

SIMPLE HARMONIC MOTION

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.

249. **STATEMENT – 1 :** Any oscillatory motion cannot be treated as simple harmonic.

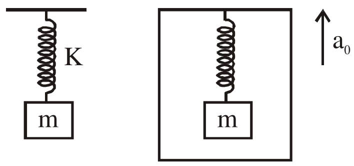
STATEMENT – 2 : Even under larger amplitude restoring force should be proportional to displacement for being classified as SHM.

250. **STATEMENT – 1 :** When two SHMs in the same direction with amplitude A_1 and A_2 are superimposed, the resultant amplitude will be between $|A_1 - A_2|$ and $(A_1 + A_2)$ is $0 \le \delta \le I$; δ is phase difference between two SHM.

STATEMENT – 2 : At any instant energy will be conserved of system undergoing SHM.

251. **STATEMENT – 1 :** Frequency of spring mass system in two cases shown in the figure is same.

STATEMENT – 2 : Frequency of a spring mass system $f = \frac{1}{2\pi}\sqrt{\frac{K}{M}}$, which does not depend upon acceleration due to gravity.



(1) (2)

252. **STATEMENT – 1 :** A particle is performing simple harmonic motion along X axis with amplitude A. If a graph is plotted between velocity of particle and its X coordinate then graph will be elliptical.

STATEMENT – 2 : Velocity of particle in SHM as a function of position is given by $v = \omega\sqrt{A^2 - x^2}$.

253. **STATEMENT – 1 :** The graph of total energy of a particle in S.H.M. w.r.t. position is a straight line with zero slope.

STATEMENT – 2 : Total energy of particle in S.H.M. remains constant throughout its motion.

254. **STATEMENT – 1 :** The amplitude of an oscillating pendulum in air decrease gradually with time.

STATEMENT – 2 : The frequency of the pendulum decreases with time.

255. **STATEMENT – 1 :** In simple harmonic motion, at extreme position the velocity and acceleration of object is zero.

STATEMENT – 2 : In simple harmonic motion at mean position ?

256. **STATEMENT – 1 :** The phase difference between acceleration and velocity in simple harmonic motion is 90º.

STATEMENT – 2 : The time period in case of simple harmonic motion is independent of amplitude of vibration.

257. **STATEMENT – 1 :** The time period of a spring mass system is greater at equator than at poles.

STATEMENT – 2 : Time period of spring mass system is independent of gravity.

258. **STATEMENT – 1 :** The time period of a simple pendulum is independent of its amplitude of vibration.

STATEMENT – 2 : If the amplitude of a simple pendulum is doubled; its v_{max} is also doubled.

259. **STATEMENT – 1 :** The height of a liquid column in a U-tube is 0.3 m. If the liquid in one of the limbs is depressed, and then released, the time period of liquid column will be 1.1 sec.

STATEMENT – 2 : This follows from the relation.

$$T = 2\pi\sqrt{\frac{h}{g}}$$

260. **STATEMENT – 1 :** If a hole were drilled through the centre of the earth and a ball dropped into the hole at one end, it will not pop out of other end of the hole.

STATEMENT – 2 : It should come out of the other end normally.

261. **STATEMENT – 1 :** An oscillatory motion is always simple harmonic motion.

STATEMENT – 2 : A simple harmonic motion is always oscillatory motion.

262. **STATEMENT – 1 :** In simple harmonic motion graph between velocity (v) and displacement (x) from mean position is elliptical.

STATEMENT – 2 : Relation between v and x is given by $\frac{v^2}{\omega^2 A^2} + \frac{x^2}{A^2} = 1$.

263. **STATEMENT – 1 :** In oscillatory motion, displacement of a body from equilibrium can be represented by sin or cos function.

STATEMENT – 2 : The body oscillates to and fro about its mean position.

264. **STATEMENT – 1 :** In simple pendulum performing S.H.M., net acceleration is always between tangential and radial acceleration except at lowest point.

STATEMENT – 2 : At lowest point tangential acceleration is zero.

265. **STATEMENT – 1 :** If the amplitude of a simple harmonic oscillator is doubled, its total energy becomes four times.

STATEMENT – 2 : The total energy is directly proportional to the square of the amplitude of vibration of the harmonic oscillator.

266. **STATEMENT – 1 :** The spring constant of a spring is K. When it is divided into n equal parts, then spring constant of one piece is K/n.

STATEMENT – 2 : The spring constant is independent of material used for the spring.

267. **STATEMENT – 1 :** Acceleration is proportional to the displacement this condition is not sufficient for motion in simple harmonic.

STATEMENT – 2 : In simple harmonic motion direction of displacement is also considered.

268. **STATEMENT – 1 :** When a girl sitting on a swing stands up, the periodic time of the swing will increase.

STATEMENT – 2 : In standing position of a girl, the length of the swing will decrease.

269. **STATEMENT – 1**
All simple harmonic motions are periodic.

STATEMENT – 2
Periodic motion is the motion in which the particle repeats its position in a fixed time interval.

270. **STATEMENT – 1**

The time period of a simple pendulum whose length is equal to the radius of Earth (R_e) will be $2\pi\sqrt{\frac{R_e}{2g}}$.

STATEMENT – 2
At a height equal to R_e, the acceleration due to gravity will be g/4.

271. **STATEMENT – 1**
For a system executing SHM, the mechanical energy remains constant.

STATEMENT – 2
Non–conservative force can cause SHM.

272. **STATEMENT – 1**
A block oscillates at the end of a spring suspended from the roof of an elevator. The period of its oscillation increases when the elevator accelerates up.

STATEMENT – 2
This increases the effective value of g, from the elevator frame.

273. **STATEMENT – 1**
In simple harmonic motion the total energy is proportional to the square of the amplitude.

STATEMENT – 2

Total energy is given by $\frac{1}{2}kA^2$.

274. **STATEMENT – 1**
A small body suspended by a light spring performing SHM. When the entire system is immersed in a non–viscous liquid period of oscillation does not change.

STATEMENT – 2
The angular frequency of oscillation of the particle does not change.

275. **STATEMENT – 1**
Time taken by a particle performing SHM, to cover a distance between any two fixed point is independent of the amplitude of oscillation.

STATEMENT – 2
Period of oscillation is independent of amplitude.

276. **STATEMENT – 1**
The graph between velocity and displacement for a harmonic oscillator is an ellipse.

STATEMENT – 2
Velocity does not change uniformly with displacement in harmonic motion.

277. **STATEMENT – 1**
During the oscillations of simple pendulum, the direction of its acceleration at the mean position is directed towards the point of suspension and at extreme position it is directed towards the mean position.

STATEMENT – 2
The direction of acceleration of a simple pendulum at the mean position or at the extreme position is decided by the tangential and radial components of force by gravity.

278. **STATEMENT – 1**
The graph of potential energy and kinetic energy of a particle in SHM with respect to position is a parabola.
STATEMENT – 2
The potential energy and kinetic energy of a particle in SHM, don't vary linearly with position.

279. **STATEMENT – 1**
Time period of simple ideal pendulum is independent of amplitude provided amplitude is small.
STATEMENT – 2
For ideal simple pendulum.
Acceleration $\propto$ g sin θ
For small θ,
Acceleration $\propto$ g θ.

280. **STATEMENT – 1**
A spring block watch gives the correct time in orbiting satellite.
STATEMENT – 2
Time period of a spring block watch is independent of g and depends only on spring factor and mass of the block.

281. **STATEMENT – 1**
A simple pendulum attached on a roof of a elevator. Time period of SHM is T when elevator is in rest. Time period of SHM must be greater than T if elevator start moving upward.
STATEMENT – 2
Time period of SHM depends on acceleration due to gravity.

282. **STATEMENT – 1**
Mechanical energy of a particle executing SHM is E. Maximum KE of particle may be greater than E.
STATEMENT – 2
Potential energy of a system may be negative.

Hint & Solution

249.	(B)	250.	(A)	251.	(A)	252.	(A)
253.	(A)	254.	(C)	255.	(C)	256.	(B)
257.	(D)	258.	(B)	259.	(A)	260.	(C)
261.	(D)	262.	(A)	263.	(B)	264.	(D)
265.	(A)	266.	(D)	267.	(A)	268.	(D)
269.	(A)	270.	(B)	271.	(D)	272.	(D)
273.	(A)	274.	(A)	275.	(D)	276.	(B)
277.	(A)	278.	(B)	279.	(A)	280.	(A)
281.	(D)	282.	(A)				

251. Frequency of a spring mass system does not depend upon acceleration due to gravity.

252. $V^2 = \omega^2 (A^2 - x^2)$
$V^2 = \omega^2 A^2 - \omega^2 x^2$
$\Rightarrow V^2 + \omega^2 x^2 = \omega^2 A^2$
$$\Rightarrow \frac{V^2}{\omega^2 A^2} + \frac{x^2}{A^2} = 1.$$

253. The total energy of SHM = Kinetic energy of particle + potential energy of particle.

254. The amplitude of an oscillating pendulum decreases with time because of friction due to air. Frequency of pendulum is independent of amplitude. $\nu = \frac{1}{2\pi}\sqrt{\frac{g}{l}}$.

255. $\left| \begin{array}{l} V = \omega\sqrt{A^2 - x^2} \\ a = \omega^2(x) \end{array} \right.$

Thus at x = A V = 0 and a ≠ 0
At x = 0
⇒ V ≥ 0 but a = 0.

256. When velocity is maximum, acceleration is minimum and vice–versa. Both are in 180º out of phase.

257. $T = 2\pi\sqrt{\frac{m}{K}}$.

259. h = 0.3 m

$$T = 2\pi\sqrt{\frac{h}{g}} = 2\times\frac{22}{7}\sqrt{\frac{0.3}{9.8}} = 1.1\text{sec}$$

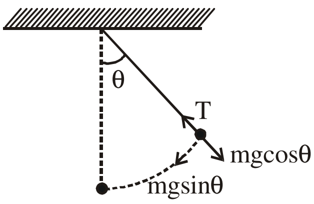
260. The ball will not out of the other end of the hole, because it will execute S.H.M. on reaching the other end the hole its velocity becomes zero and acceleration of ball is maximum and directed towards the centre of earth.

261. A simple harmonic motion must be oscillatory.

262. Graph of equation $\frac{v^2}{\omega^2 A^2} + \frac{x^2}{A^2} = 1$.

263. y = A sin (ωt + ϕ) in SHM.

264.



$$T - mg\cos\theta = \frac{mv^2}{r}$$

mg sin θ = F_T.

265. Total energy,

$$E = \frac{1}{2}m\omega^2 a^2 \text{ i.e., } E \propto a^2.$$

$$\frac{E'}{E} = \left(\frac{2a}{a}\right)^2$$

E′ = 4E.

266. Spring constant $\propto \frac{1}{\text{length of spring}}$

$\Rightarrow \quad K' = \frac{K}{n}$.

Also, spring constant depends on material properties of the spring.

267. In simple harmonic motion the acceleration is always in a direction opposite to that of the displacement. i.e., proportional to $(-y)$.

268. When a girl stands up on a swing. The position of centre of gravity of girl is raised up. Due to which the effective length of pendulum decrease hence the time period of swing decreases and becomes $T \propto \sqrt{l}$.

269. Conceptual.

270. $\because \quad T = 2\pi\sqrt{\dfrac{1}{g\left(\dfrac{1}{\ell} + \dfrac{1}{R_e}\right)}}$.

272. Although, effective value of g increases from the elevator frame it has no effect on the period of oscillation which is determined safely by the values of spring constant and mass of the oscillating body.

273. Total energy = maximum potential energy $= \frac{1}{2}kA^2$.

276. In SHM $v = \omega\sqrt{a^2 - y^2}$

$\Rightarrow \quad \frac{v^2}{\omega^2 a^2} + \frac{y^2}{a^2} = 1$

Which is the equation of ellipse.

277. Tangent component of weight = mg sin θ
and radial component of weight = mg cos θ
at mean position, θ = 0,
⇒ tangent component = 0
∴ direction of acceleration is along radial component of weight.
At extreme position, tangent component is maximum. Hence direction of acceleration is along tangent component.

278. $PE = \frac{1}{2}m\omega^2 y^2$ $\qquad KE = \frac{1}{2}m\omega^2(\omega^2 - y^2)$

Which represents parabola.