CBSE Board
Class XI Physics
Sample Paper-7 Solution

1.

Second is the fundamental unit of time and is now defined as the duration of 2,192,631770 vibrations of caesium -133.

2.

By lowering his hands, the cricket player increases the interval in which the catch is taken. This increase in time interval results in the lesser rate of change of momentum. Therefore, in accordance with Newton's second law of motion, lesser force acts on his hands and the player saves himself from being hurt.

3.

In fact friction is necessary evil. In case friction is not there, we cannot walk, we cannot travel in vehicles, we cannot light a match-stick, etc. Thus friction plays a very important role in our daily life.

4.

$1\,J = 10^7$ erg

$$\therefore \frac{\text{SI unit of work}}{\text{CGS unit of work}} = 10^7$$

5.

Angular momentum and linear momentum remain constant.

6.

Steel is more elastic than rubber, because the inter-atomic bonding strength is more in steel than that of rubber.

7.

Yes, during the change of state (such as melting of ice, boiling of water, etc.) the system absorbs heat but its temperature does not change. In this case, only the internal energy changes.

8.

$$PE_{max} = \frac{1}{2} m a \omega^2 A^2$$
$$= \frac{1}{2} k A^2, \text{ where } k = m\omega^2$$

9.

The tip of the sharp pin is in the range of 10^{-5} to 10^{-4} m. The size of the nucleus is of the order of 10^{-15} to 10^{-14} m. Therefore, when the size of the nucleus is scaled up to the tip, we are scaling by a factor of 10^{10}. Accordingly, the size of the atom will become $10^{10} \times 10^{-10} = 1$ m.

10.

Let 2S be the total distance covered in time t,
S in time t_1 and S in time t_2, such that $t = t_1 + t_2$.

$$\therefore \quad t_1 = \frac{S}{40}, \; t_2 = \frac{S}{60}$$
$$t_1 + t_2 = t = S\left(\frac{1}{40} + \frac{1}{60}\right)$$
$$= S\left(\frac{100}{40 \times 60}\right)$$
$$\text{or, } \frac{S}{t} = \frac{40 \times 60}{100} = 24 \text{ m s}^{-1}$$
$$\therefore \text{Average speed} = \frac{\text{total distance covered}}{\text{total time taken}} = \frac{2S}{t} = 2 \times 24 = 48 \text{ m s}^{-1}$$

11.

The resultant displacement due to 12 m towards east and 5 m towards north (which are at 90^o to each other) lies in the plane of paper and is given by.

$$R_1 = \sqrt{(12)^2 + (5)^2} = \sqrt{144 + 25} = 13 \text{ m}$$

Displacement 6 m is vertically upward perpendicular to the plane of paper. Therefore, the angle between R_1 and 6 m is 90Âº.The resultant of these to (say R_2) will be

$$R_2 = \sqrt{(13)^2 + (6)^2} = \sqrt{169 + 36}$$
$$= \sqrt{205} = 14.32 \text{m}$$

12.

(i) Work done by the centripetal force is always zero.

(ii) When a person does not move from his position, but he may be holding any amount of load, the work done is zero. Similarly, when a coolie travels on a platform with some load on his head, work done by him is zero.

13.

(a) 6.67×10^{-11} Nm^2kg^{-2}

(b) It is defined as the gravitational force of attraction between two bodies, each of mass 1 kg, separated by a distance of 1 m.

14.

(a) Pressure x Volume = Constant

Or PV = Constant

(b) Work done is

$W = 2.3026 \, nRT \log_{10}(V_2/V_1)$

Where R is the universal gas constant, n is the number of moles of gas, T is the absolute temperature,V_1 is the initial volume and V_2 is the final volume of the gas.

OR

We know that, $PV = RT$

We are given $VP^2 = \text{costant}$

$$\therefore \quad V\left(\frac{RT}{V}\right)^2 = \text{constant}$$

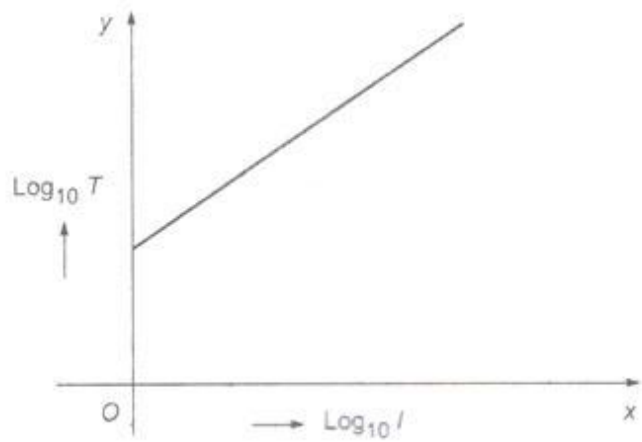
$$\frac{T^2}{V} = \text{constant}$$

Using $\frac{T_1^2}{V_1} = \frac{T^2}{V}$

We get, $T_1^2 = 2V \times \frac{T^2}{V} = 2T^2$

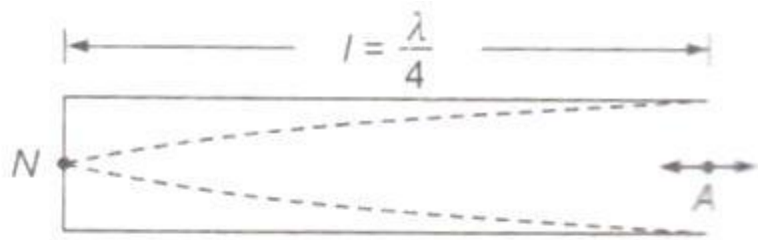
$$T_1 = \sqrt{2}T$$

15.

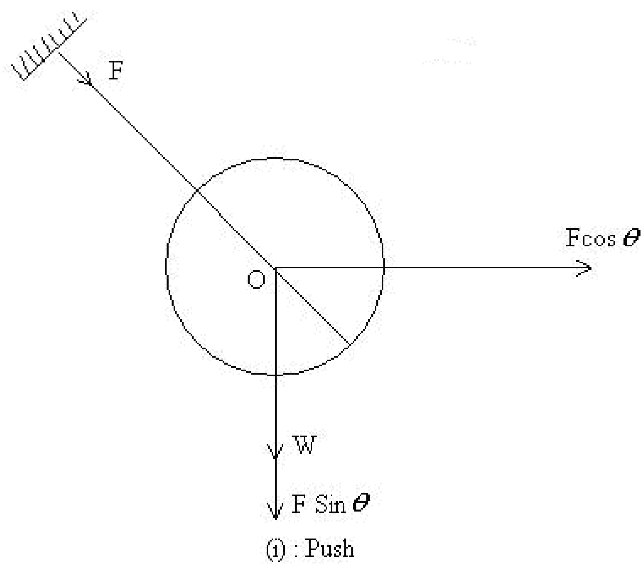


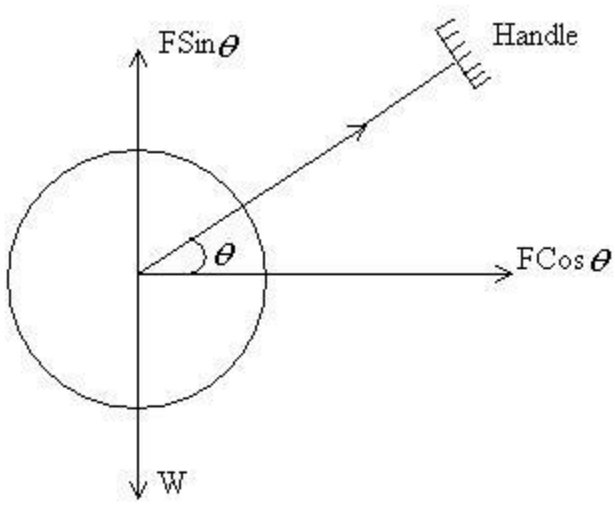
16.

In the case of a closed organ pipe, one of the ends is open and the other is closed. In the case of a closed organ pipe, since one of the ends is open and the other is closed, the amplitude of vibrations of air particles is maximum at the open end and goes on decreasing till there is no vibration at the closed end. Therefore when the air column in a closed organ pipe vibrates in resonance, an antinode is formed at the open end and a node at the closed end.



17.





(ii) Pull

W is weight of the lawn roller. When pushed by applying a force $\vec{F}$ at an angle θ. $F\cos\theta$ moves it forward while the apparent weight becomes $W + F\sin\theta$.

However when pulled, the apparent weight becomes $W - F\sin\theta$.
Since the force of friction is directly proportional to normal reaction (equal to apparent weight of the roller), it is more when it is pushed than when is pulled.

18.
Coefficient of restitution: Ratio of relative speed of separation to relative speed of approach.

No, not for each body separately. Total energy and total momentum of the whole isolated system will be conserved.

Heavy water is chosen because collision between fast neutron and near stationary deuterons in heavy water results in maximum exchange of kinetic energy as their masses are comparable.

19.

$u = 0\ ; h = 12\,m.$

$a = g = 9.8\,m\,s^{-2}, v = ?$

$v^2 = u^2 + 2gh;$

$v^2 = 2 \times 9.8 \times 12$ ....(i)

$v^2 = 235.2$

Kinetic energy of the ball when it just hits the ground

$= \frac{1}{2} m v^2 = \frac{1}{2} m \times 235.2\,J$

Since 25% of K.E is lost on striking, therefore, K.E retained after the impact

$= \frac{75}{100}\left(\frac{1}{2} m \times 235.2\right) J = \left(\frac{3}{8} m \times 235.2\right) J$

Let v_2 be the upward velocity just after the collision with the ground, therefore,

$K.E = \frac{1}{2} m v_2^2$

$= \frac{3}{8} m \times 235.2;$

or $v_2^2 = \frac{3}{4} \times 235.2$ ....(ii)

Let h' be the required height to which the ball bounces, therefore, putting various values we have,

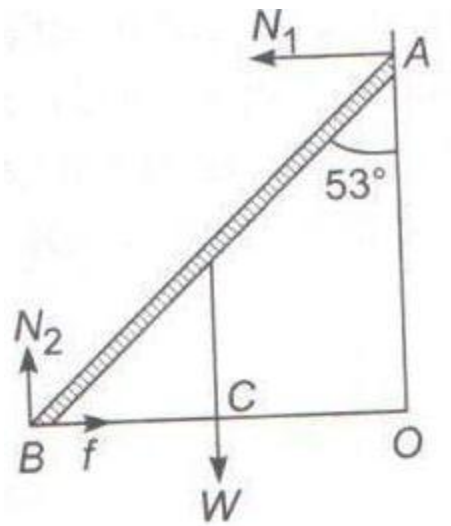
$v = 0, u = v_2$

$h' = ?, v^2 = u^2 + 2gh'$

or $0 = \frac{3}{4} \times 235.2 + 2(-9.8)h'$

or $h' = \frac{3 \times 235.2}{4 \times 2 \times 9.8} = 9m$

20.



The forces acting on the ladder are

1. Weight W
2. Normal force N_1 by vertical wall.
3. Normal force N_2 by the floor
4. Frictional force F by the floor.

Taking horizontal and vertical components, we have

$N_1 = F$

$N_2 = W$

Taking torque about B, we have

N_1 (AO) = W (CB)

N_1 (AB cos 53) = W (AB/2) sin 53

$N_1 = 2/3\ W$

$N_2 = W = 10 \times 9.8 = 98$ N

$F = N_1 = 2/3\ W = 65$ N

21.

(i) It is man-made satellite that remains at a fixed position at a definite height above the surface of the earth. Yes, it is same as a synchronous satellite.

(ii) It is about 36000 km.

(iii) The orbit of the geostationary satellite is called a parking orbit.

OR

The change in total energy is

$$E_f - E_i$$

$$E_i = -\frac{GmM}{2(R+h)} = -\frac{GmM}{2(R+R)} = -\frac{GmM}{4R}$$

$$E_f = -\frac{GmM}{2(R+h)} = -\frac{GmM}{2(R+3R)} = -\frac{GmM}{8R}$$

$$\text{change in total energy} = \frac{GmM}{8R} = \frac{gmR}{8} = 3.13\times10^9\ \text{J}$$

The kinetic energy of the satellite reduces and it is given by -3.13×10^9 J.

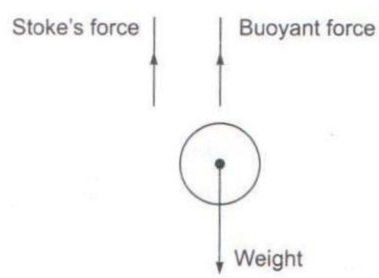
The change is potential energy is twice the change in the total energy so change in potential energy is -6.26×10^9 J.

22.

When a body falls through a viscous fluid, the relative motion produced between the layers of the fluid is opposes by its viscosity and the opposing force increases with the increase in the velocity of the body.

After sometime at a certain stage, the viscous force just balances the driving force (i.e., weight of the body). There onwards, the body moves with a constant velocity, called the terminal velocity.

Let the terminal velocity be V.



Radius of the ball = r

Coefficient of viscosity= η

Density of ball= ρ

Density o fliquid= σ

Weight of ball= $\frac{4}{3}\pi r^3 \rho g$

Buoyant force acting vertically = $\frac{4}{3}\pi r^3 \sigma g$

$\therefore$ Net weight of the ball= $\frac{4}{3}\pi r^3 (\rho - \sigma) g$

This is equal to the net upward force due to the viscosity= $6\pi\eta rv$

$$6\pi\eta rv = \frac{4}{3}\pi r^3 (\rho - \sigma) g$$

$$v = \frac{2}{9}\frac{r^2 g(\rho - \sigma)}{\eta}$$

23.

(a) No, it is in conformity with the law of conservation of energy.

(b)

(i) There is no indication available as regards the direction in which the change takes place.

(ii) It does not give any idea about the extent to which the change takes place.

24.

(a) Kinetic energy will become four times.

(b) root mean-square velocity becomes twice.

(c) pressure is directly proportional to square of r.m.s velocity, hence pressure becomes four times.

25.

Pascal's law states that whenever external pressure is applied on any part of a fluid contained in a vessel, it is transmitted undiminished and equally in all directions.

Pressure = atmospheric pressure + pressure due to the water.

$$P = 1.01 \times 10^5 + 10(1000)(10) = 2.01 \times 10^5 \, Pa$$

26.

(a) Gita has a caring attitude and concern for others.

(b)

(i) Taking x, y, z-axis as described in the question, the co-ordinates of

Starting point of the mosquito = (0,0,0)

The last point of the mosquito = (7,4,3)

Thus, the displacement of mosquito, **s** = 7**i** + 4**j** + 3**k**

Magnitude of displacement = $\sqrt{74}$

(ii) Also, the x, y, z components are 7, 4 and 3 respectively.

27.

(i) Mass of the particle, m = 4 kg

(a) Force acting on the particle for the interval t < 0, is zero as the body is not moving during this interval.

For t > 4 s, the body is again at rest, therefore, no force is acting on the body.

During the interval, 0 < t < 4 s shown by OA in the Figure 1, the speed is constant, and hence acceleration is zero. Therefore, no force acts on the body.

(b) Impulse = (final momentum - initial momentum)

Initial momentum just before t = 0 is 0

Final momentum just after t = 0 is = 3 kg ms^{-1}

$(Impulse)_{t=0}$ = 3-0 = 3 kg ms^{-1}

Similarly, $(Impulse)_{t = 4s}$ = (final momentum - initial momentum)

= 0 - 3 = -3 kg ms^{-1}

(ii) It is clear from the figure that the particle moves between two walls, 2 cm distance after each 2 seconds, and each time rebounds with a constant speed of 1 cms^{-1} after each collision.

Impulse = change in momentum

= final momentum - initial momentum

= 0.04 × 2 × 10^{-2} kg ms^{-1}

= 8 × 10^{-4} $kgms^{-1}$

Thus, the particle receives an impulse of 8 × 10^{-4} $kgms^{-1}$ after every two seconds.

OR

The equation of displacement of a particle executing SHM at an instant *t* is given as:

$$x = A\sin\omega t$$

Where, A = Amplitude of oscillation; ω = Angular frequency $\sqrt{\frac{k}{m}}$

The velocity of the particle is:

$$v = \frac{dx}{dt} = A\omega\cos\omega t$$

The kinetic energy of the particle is:

$$E_k = \frac{1}{2}Mv^2 = \frac{1}{2}MA^2\omega^2\cos^2\omega t$$

The potential energy of the particle is:

$$E_p = \frac{1}{2}kx^2 = \frac{1}{2}M\omega^2A^2\sin^2\omega t$$

For time period T, the average kinetic energy over a single cycle is given as:

$$(E_k)_{Avg} = \frac{1}{T}\int_0^T E_k \; dt$$

$$= \frac{1}{T}\int_0^T \frac{1}{2} MA^2\omega^2 \cos^2 \omega t \; dt$$

$$= \frac{1}{2T} MA^2\omega^2 \int_0^T \frac{(1+\cos 2\omega t)}{2} dt$$

$$= \frac{1}{4T} MA^2\omega^2 \left[t + \frac{\sin 2\omega t}{2\omega} \right]_0^T$$

$$= \frac{1}{4T} MA^2\omega^2 (T) \quad = \frac{1}{4} MA^2\omega^2 \qquad \ldots (i)$$

And, average potential energy over one cycle is given as:

$$(E_p)_{Avg} = \frac{1}{T}\int_0^T E_p \; dt$$

$$= \frac{1}{T}\int_0^T \frac{1}{2} M\omega^2 A^2 \sin^2 \omega t \; dt$$

$$= \frac{1}{2T} M\omega^2 A^2 \int_0^T \frac{(1-\cos 2\omega t)}{2} \; dt$$

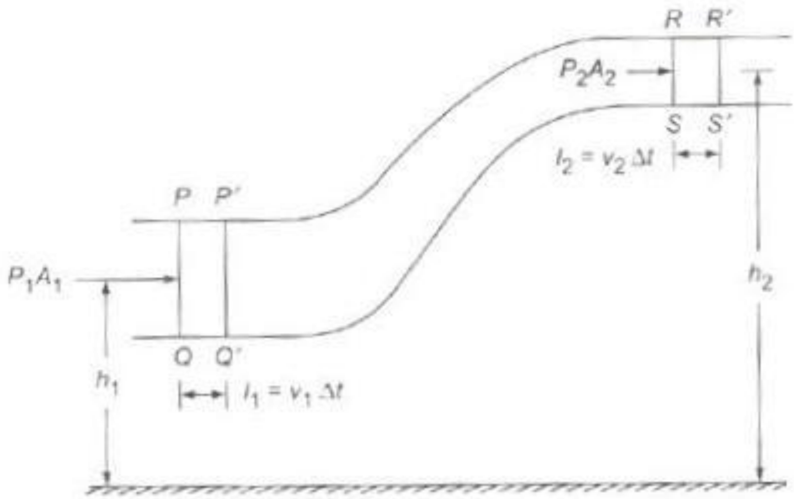
$$= \frac{1}{4T} M\omega^2 A^2 \left[t - \frac{\sin 2\omega t}{2\omega} \right]_0^T$$

$$= \frac{1}{4T} M\omega^2 A^2 (T)$$

$$= \frac{M\omega^2 A^2}{4} \qquad \ldots (ii)$$

It can be inferred from equations (*i*) and (*ii*) that the average kinetic energy for a given time period is equal to the average potential energy for the same time period.

28.



Consider a liquid flowing through a non- uniform tube PR. Suppose the velocity of the liquid changes from v_1 at P to v_2 at R.

Take the mass of the liquid element under consideration as m, then, m = area of cross-section Ã— length Ã— density

$= A_1 v_1 \Delta t \rho$

$= A_2 v_2 \Delta t \rho$

Where ρ is density of the liquid.

Using the equation of continuity, we can write

$A_1 v_1 = A_2 v_2$

(i) The gain in kinetic energy is

$$= \frac{1}{2} m v_2^2 - \frac{1}{2} m v_1^2$$

$$= \frac{1}{2} m (v_2^2 - v_1^2)$$

$$= \frac{1}{2} A_1 v_1 \Delta t \rho (v_2^2 - v_1^2) \qquad \text{........(i)}$$

(ii) The gain in potential energy

$$= mgh_2 - mgh_1$$

$$= mg(h_2 - h_1)$$

$$= A_1 v_1 \Delta t \rho g (h_2 - h_1) \qquad \text{.........(ii)}$$

(iii) Net work done on the liquid

$= \text{Work done on the liquid} - \text{work done by the liquid}$

$= P_1A_1v_1\,\Delta t - P_2A_2v_2\,\Delta t$

$= (P_1 - P_2)A_1v_1\,\Delta t$

$(\because A_1v_1 = A_2v_2)$

Applying the principle of conservation of energy,

Net work done on the liquid = Gain in K.E + Gain in P.E

$\therefore (P_1 - P_2)A_1v_1\Delta t$

$= \frac{1}{2}A_1v_1\,\Delta t\,\rho(v_2^2 - v_1^2) + A_1v_1\,\Delta t\,\rho g(h_2 - h_1)$

or $(P_1 - P_2) = \frac{1}{2}(v_2^2 - v_1^2) + \rho g\,(h_2 - h_1)$

or $P_1 + h_1\rho g + \frac{1}{2}\rho v_1^2 = P_2 + h_2\rho g + \frac{1}{2}\rho v_2^2$

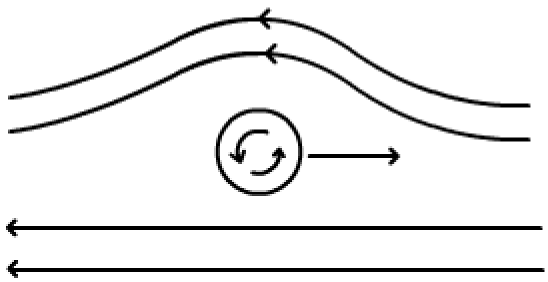
or $P + h\rho g + \frac{1}{2}\rho v^2 = \text{constant}$ ....(iii)

Divinding (iii) by ρg we have,

$\frac{P}{\rho g} + h + \frac{1}{2}\frac{v^2}{g} = \text{constant}$

This equation is called Bernoulli's equation.

OR



Magnus effect: If a moving ball is given a spin, the air layers at the top acquire higher velocity than those at the bottom. So, as per Bernoulli's theorem, pressure below the ball becomes greater than that at the top. Due to net upward force, the ball follows a curved path.

Viscosity is a measure of the resistance of a fluid which is being deformed by either shear stress or extensional stress.

Dimension: $[ML^{-1}T^{-1}]$

SI unit: Poiseulli/decapoise

Depends on: 1. Temperature
2. Nature of liquid

29.

(i) They are the free oscillation of a system purely because of certain specific restoring forces (say gravity of a simple pendulum or the mass attached to the spring). The frequency of such a system is called its natural frequency (n_o) and the corresponding time period as the natural time period of the oscillating system. Since there are no frictional or viscous forces present, the amplitude of oscillations remains constant. These oscillations are also called undamped vibrations.

(ii) The oscillations in which the amplitude decreases progressively with the time are called damped oscillation.

(iii) When we feed energy back to the oscillations at the same rate at which it is dissipated, then the amplitude of such oscillations would remain constant with time. These oscillations are called maintained or sustained oscillations.

(iv) When an external periodic agent of frequency (n) is applied to an oscillator of natural frequency (n_o), the external agent is called the driver and the oscillating body is called the driven. The driven oscillator ultimately settles down to the frequency of the driver. Such oscillations that are forced upon the oscillator by the external periodic agent are known as the forced oscillations.

(v) When the frequency of the driver (n) approaches the frequency of the driven (n_o), then the amplitude of the forced oscillation (and hence power drawn) becomes quite large. The driver and the driven are said to be in resonance. The phenomenon of setting a body into vibration with its natural its natural frequency by another body vibrating with the same frequency is called resonance.

OR

Let a body of man m be dropped in a straight hole in the Earth of them M and radius R.

The body will be attracted towards the centre of the Earth with a force given by,

$$F = \frac{GMm}{R^2}$$

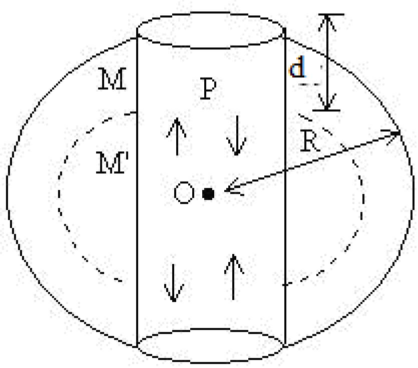
But $F = mg$

$$\therefore \qquad mg = \frac{GMm}{R^2} \quad \text{or} \quad g = \frac{GM}{R^2}$$

$$= \frac{G\,\frac{4}{3}\pi R^3 \rho}{R^2}$$

Or $\quad g = \dfrac{4\pi GR\rho}{3} \qquad (i)$

Where ρ is mean density of the Earth.



When the body is dropped into the straight hole and it falls through the depth d, the value of acceleration due to gravity at the point P is given by,

$$g' = \frac{GM'}{(R-d)^2}$$

Where M' is the mass of the sphere of radius $(R-d)$

$$\therefore \qquad g' = \frac{4\pi G(R-d)\rho}{3}$$

Thus, $g'/g = \dfrac{(R-d)}{R^2}$

or $\quad g' = \dfrac{g'}{R^2}(R-d)$ or $g' \propto (R-d)$

i.e., acceleration (in magnitude) of the body is proportional to the displacement from the centre of the earth O. Thus, the motion is SHM.

Time period,

$$T = 2\pi\sqrt{\frac{\text{Displacement}}{\text{Acceleration}}}$$

$$= 2\pi\sqrt{\frac{(R-d)}{\left[\frac{R-d}{R}\right]g}} = 2\pi\sqrt{\frac{R}{g}}$$