Mizoram Board
Class XI
Physics
Sample Paper-2 Solution

1.
(i) $[ML^2T^{-2}]$
(ii) Dimensionless

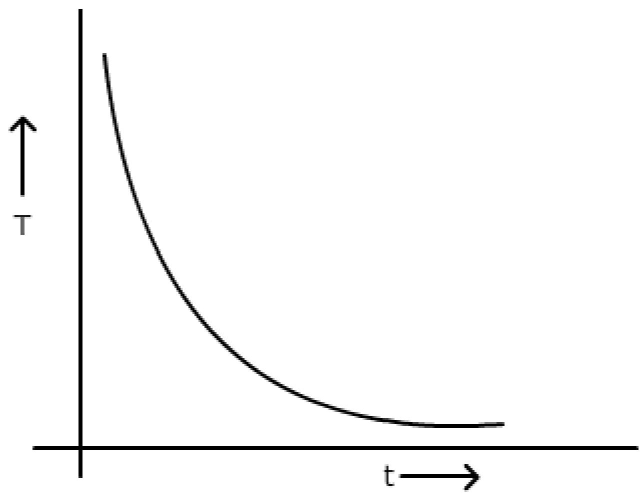
2. Reaction is the force applied by the block on the Earth.

3. Two advantages of 'I' shape of iron beams are
(i) minimizes sagging
(ii) minimizes buckling

4. Wire B.

5. Natural Convection: Trade winds/Land and sea breeze
Forced Convection: Human circulatory system

6.



7. Invar is used because of a very small coefficient of linear expansion.

8. The frequency of free oscillations of a vibrating system.

9. Absolute error is the magnitude of difference between the value of individual measurement and the true value of the quantity.

$\Delta t = t_2 - t_1$
$= (50 \pm 0.5) - (20 \pm 0.5)$
$= 30°C \pm 1°C$

10.
(i) Velocity is negative as the slope of x-t graph is negative.
(ii) Acceleration is negative. The increasing slope indicates speeding up, and hence the sign of acceleration and velocity are same.

11.

$$T = \frac{2u\sin\theta}{g}$$

$$\Rightarrow u\sin\theta = \frac{gT}{2}$$

Max. Height $H = \frac{u^2\sin^2\theta}{2g}$

$$= \frac{(u\sin\theta)^2}{2g}$$

$$= \frac{\left(\frac{gT}{2}\right)^2}{2g}$$

$$= \frac{gT^2}{8}$$

12.
(i) A horse cannot pull a cart and run forward in space because no reaction from any surface underneath is available which can make the horse move forward.
(ii) Due to inertia of motion, the upper part of the body continues to move along the tangent to the circular path of the bus and hence passengers are thrown outward when the bus takes a sudden turn.

13. Concurrent forces are the forces whose lines of action intersect at a common point.
Conditions:
1. $\sum\vec{F} = 0$
2. $\sum\vec{\tau} = 0$

14. Because the gravitational force between the satellite and the earth provides the necessary centripetal force required to keep it in its orbit.
No, because New Delhi is not on the equatorial plane.

15.
(a) All have same average K.E. as K_{av} depends only on temperature.
(b) C, B and A as $v_{rms}\ \alpha \frac{1}{\sqrt{m}}$

OR

(i) $P = \frac{1}{3}\frac{mn}{V} v_{rms}^2$

$\frac{P_i}{P_f} = \frac{1}{2}$

(ii) $P = \frac{2}{3}E$

$\Rightarrow E = \frac{3}{2}P = 3\times10^5\ J/m^3$

16.

$\frac{v_1}{v_0} = \sqrt{\frac{T}{T_0}} = \sqrt{\frac{273+t}{273+0}}$

where v_1, v_0 are the velocities of sound at T and T_0 respectively.

Therefore, $\frac{v_1}{v_0} = \left(1 + \frac{t}{273}\right)^{1/2} = 1 + \frac{1}{2} \times \frac{t}{273}$,
neglecting the higher powers,

Therefore, $v_1 = v_0\left(1 + \frac{t}{546}\right) = V_0 + V_0\left(\frac{t}{546}\right)$

Therefore, $v_1 - v_0 = \frac{v_0 t}{546} = \frac{332 \times 1}{546} = 0.608 = 61$ cm/s.

Thus, the velocity of sound increases by 61 cm/s for every 1^oC (or 1K) rise in the temperature.

17. $x(t) = \int \upsilon\, dt = \int(-12t + 12)dt$

$= -12\frac{t^2}{2} + 12t + c$

$= -6t^2 + 12t + c$

Since, at t = 0, x(0) = 5, therefore, c = 5
Therefore, $x(t) = -6t^2 + 12t + 5$ m

Also, $a = \frac{dv}{dt}$

$= -12\ m/s^2$

18.

$\vec{F}_1 = 2\hat{j}\ N$

$\vec{F}_2 = 2\cos 60^0\,\hat{i} - 2\sin 60^0\,\hat{j}$

$= \hat{i} - \sqrt{3}\hat{j}\ N$

$\vec{F}_3 = -1\sin 60^0\,\hat{i} + 1\cos 60^0\,\hat{j}$

$= -\frac{\sqrt{3}}{2}\hat{i} + \frac{1}{2}\hat{j}\ N$

$$\vec{F}_1 + \vec{F}_2 - \vec{F}_3 = 2\hat{j} + (\hat{i} - \sqrt{3}\hat{j}) - \left(-\frac{\sqrt{3}}{2}\hat{i} + \frac{1}{2}\hat{j}\right)$$

$$= \left(1 + \frac{\sqrt{3}}{2}\right)\hat{i} + \left(\frac{3}{2} - \sqrt{3}\right)\hat{j}\ N$$

19.

(i) Conservative: spring force, gravitational force
Non-conservative: Human push, viscous drag

(ii) $F = -\frac{dU}{dr}$

20. 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.

Or

(a) $\vec{F} = 7\hat{i} + 3\hat{j} - 5\hat{k},\ \vec{r} = \hat{i} - \hat{j} + \hat{k}$

$$\vec{\tau} = \vec{r} \times \vec{F}$$

$$= \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & -1 & 1 \\ 7 & 3 & -5 \end{vmatrix}$$

$$= (5-3)\hat{i} + (5+7)\hat{j} + (3+7)\hat{k}$$

$$\vec{\tau} = 2\hat{i} + 12\hat{j} + 10\hat{k}$$

(b) Curl the fingers of right hand along the direction of rotation, the out stretched thumb points along the direction of angular velocity.

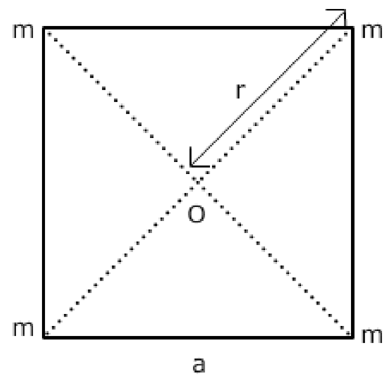
21. If we define perpendicular axes *X*, *Y*, and *Z* (which meet at origin *O*) so that the body lies in the *XY* plane, and the *Z* axis is perpendicular to the plane of the body and
(i) I_X be the moment of inertia of the body about the *X* axis;
(ii) I_Y be the moment of inertia of the body about the *Y* axis; and
(iii) I_Z be the moment of inertia of the body about the *Z* axis.
The perpendicular axis theorem states that

$$I_Z = I_X + I_Y$$

$I = MR^2$
$= 2 \times (.50)^2 = 0.5 \text{ kg m}^2$

$I' = MR^2 + MR^2$
$= 2MR^2 = 2 \times 0.5$
$= 1 \text{kg m}^2$

22.



$$U(r) = -\frac{Gm_1m_2}{r_{12}}$$

Therefore,

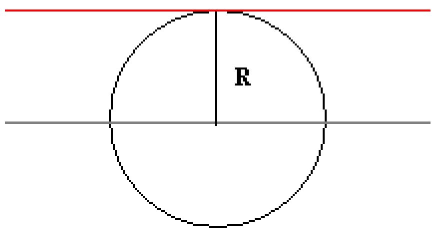
$$\text{Total } U = -4\frac{Gm^2}{a} - 2\frac{Gm^2}{a\sqrt{2}}$$
$$= -\frac{2Gm^2}{a}\left(2 + \frac{1}{\sqrt{2}}\right)$$
$$= -5.41\frac{Gm^2}{a}$$

$$\text{Potential } V(r) = -\frac{Gm_1}{r_1}$$

$$\text{Total } V = -4\frac{Gm}{\left(\frac{a\sqrt{2}}{2}\right)} = -4\sqrt{2}\frac{Gm}{a}$$

23. The moment of inertia of a rigid body about an axis defined by the formula $I = \sum m_i r_i^2$ where r_i is the perpendicular distance of the i^{th} point of the body from the axis.

The moment of inertial about a tangent to the ring in the plane of the ring is the moment of inertia about a diameter parallel to the tangent + Mh^2 where h is the distance between the two parallel axes.



I = $MR^2/2 + MR^2 = 3/2\ MR^2$

24. It is a reversible engine in which all input heat originates from a hot reservoir at temperature T_H and all heat rejected goes into a cold reservoir at T_C, It consists of two isothermal processes and two adiabatic processes.
The efficiency of a Carnot engine is

$$\eta = 1 - \frac{T_C}{T_H}$$

25.
Let S_n and S_{n-1} be the distance covered in n and (n – 1) seconds respectively.

$$S_n = x(n) - x(0)$$

$$= v(0)n + \frac{1}{2}an^2 \qquad (\because x(t) - x(0) = v(0)t + \frac{1}{2}at^2)$$

and $S_{n-1} = x(n-1) - x(0)$

$$= v(0)(n-1) + \frac{1}{2}a(n-1)^2$$

But $S = S_n - S_{n-1}$

$$= \left[v(0)n + \frac{1}{2}an^2\right] - \left[v(0)(n-1) + \frac{1}{2}a(n-1)^2\right]$$

$$= v(0)n + \frac{1}{2}an^2 - v(0)n + v(0) - \frac{1}{2}an^2 - \frac{a}{2} + an$$

$$= v(0) - \frac{a}{2} + an$$

or $S = v(0) + \frac{a}{2}(2n-1)$

26.
(a) Ravi shares his knowledge with his friends and has concern towards his friends.

(b)
(i) All the planets move around in elliptical orbits with the sun at its focus.
(ii) The line joining the sun and the planet sweeps out equal areas in equal intervals of time.
(iii) The square of the time period of revolution of the planet is directly proportional to the cube of the semi-major axis of the elliptical orbit $T^2 \propto a^3$.

27.

From the forces acting on the vehicle on a banked curve,

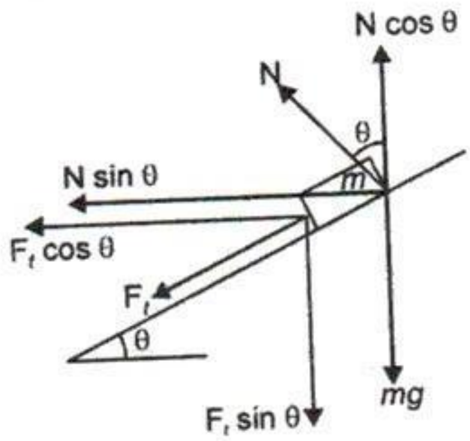
$$N\cos\theta - F_c\sin\theta = mg$$

$$N\sin\theta + F_c\cos\theta = \frac{mv^2}{r} \quad (F_c = \mu N)$$

Dividing the equation, we have,

$$\frac{v^2}{rg} = \frac{N\sin\theta + \mu N\cos\theta}{N\cos\theta - \mu N\sin\theta}$$

$$v^2 = rg\left[\frac{\tan\theta + \mu}{1 - \mu\tan\theta}\right]$$ [dividing each term of right side by N cos θ]



$$v = \sqrt{rg\left(\frac{\mu + \tan\theta}{1 - \mu\tan\theta}\right)}$$

If $\mu = 0$ i.e., banked road is perfectly smooth. Then from above

$$v_o = (rg\tan\theta)^{1/2}$$

$$v_o^2 = rg\tan\theta$$

Or $$\tan\theta = \frac{v_o^2}{rg}$$

$$\theta = \tan^{-1}\frac{v_o^2}{rg}$$

Or

(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.

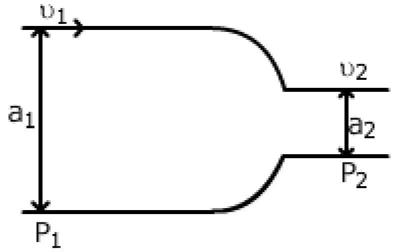
(ii) The oscillations in which the amplitude decreases progressively with the time are called damped oscillation.

(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.

28. Laminar flow occurs when a fluid flows in parallel layers, with no disruption between the layers.



$$P_1 + \frac{1}{2}\rho v^2{}_1 = P_2 + \frac{1}{2}\rho v^2{}_2 \text{ and } a_1 v_1 = a_2 v_2$$

Therefore, $P_2 = P_1 + \frac{1}{2}\rho\left(v_1^2 - v_2^2\right)$

$$= P_1 + \frac{1}{2}\rho\left[v_1^2 - \left(\frac{a_1}{a_2}\right)^2 v_1^2\right]$$

$$= P_1 + \frac{1}{2}\rho v_1^2\left[1 - \left(\frac{a_1}{a_2}\right)^2\right]$$

$$= 4\times10^4 + \frac{1}{2}\times10^3\times4\left[1 - \frac{4\times10^{-4}}{1\times10^{-4}}\right]$$

$$= 4\times10^4 - 0.6\times10^4$$

$$= 3.4\times10^4\ P_a$$

Or

(i) A, because for producing the same strain, more stress is required in case of the material A.
(ii) A, because it has a greater plastic range.
(iii) B, because it has a lesser plastic range.
(iv) A is stronger as it can bear greater stress before the wire of this material will break.

29.
(i) –z direction

(ii) $f = \frac{w}{2\pi}$

$$= \frac{500}{2\pi} = \frac{250}{\pi}\ \text{Hz}$$

(iii) $\lambda = \frac{2\pi}{R}$

$$= \frac{2\pi}{0.025} = 80\pi\ \text{m}$$

(iv) $v = \frac{\omega}{R}$

$$= \frac{500}{0.025} = 2\times10^4\ \text{m/s}$$

(v) $v_{p\max} = \omega A$

$$= 0.25 \times 10^{-3} \times 500 = 0.125\ \text{cm/s}$$

Or

(a) Definition: The Doppler effect is the change in frequency and wavelength of a wave for an observer moving relative to the source of the waves.

(i) For the listener standing outside the circle, the whistle moves towards him as well as away from him. Therefore, the frequency will appear to increase as well as decrease.

(ii) For the listener at the centre, the distance between him and the whistle remains constant. So, there will be no change in frequency.

(b) Beat frequency = 5 Hz
Application of beats is in tuning of musical instruments.