# Meghalaya Board
# Class XI
# Physics
# Sample Paper 2 – Solution

## GROUP-A

1. (iii) They arise due to random and unpredictable fluctuations in experimental conditions (temperature, supply etc) and personal errors by the observer taking readings.
2. (iv) When a body is in uniform circular motion, its speed remains constant but its velocity, angular acceleration, angular velocity changes due to change in its direction.
3. (i)Parallax is the name given to the change in position of an object with respect to the background when the object is seen from two different positions.The distance between two such positions is called the basis.
4. (iii) The angular momentum of the body remains same.The body flies away tangentially, keeping angular momentum conserved as no external torque acts on the particle.
5. (i)Modulus of elasticity is inversely proportional to strain for a given stress. If steel and rubber are under the same stress, the strain in steel is less than rubber. Hence steel is more elastic than rubber.
6. (ii) Bernoulli's theorem states that for the streamline flow of an ideal liquid, the total energy (the sum of the pressure energy, potential energy and kinetic energy) per unit mass remains constant at every cross-section throughout the flow.
7. (ii)When temperature of a substance increases, the molecules start moving vigorously in all directions, thus expanding and increasing the volume.
8. (iii)Momentum can be zero on an average for the molecules of an ideal gas in equilibrium, since the molecules travel in random directions.

## GROUP-B

**9.**

$$1 \text{ par sec} = 3.08 \times 10^{16} \text{ m}$$

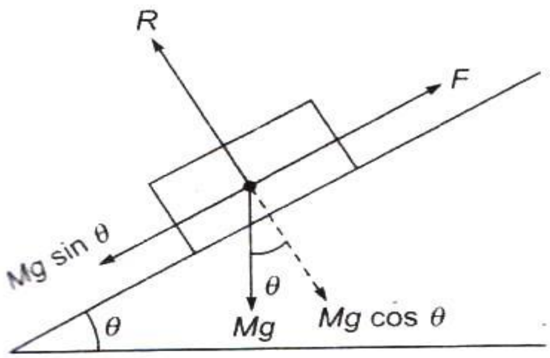
$$1 \text{ ly} = 9.46 \times 10^{15} \text{ m}$$

$$\therefore \quad \frac{1 \text{ par sec}}{1 \text{ ly}} = \frac{3.08 \times 10^{16} \text{ m}}{9.46 \times 10^{15} \text{ m}} = 3.26$$

Or $\quad 1 \text{ par sec} = 3.26 \text{ ly}$

**10.** While swimming, a person pushes the water backwards, and as a result he himself is pushed forward by the reaction force exerted by the water on him.

**11.** The angle of repose is defined as the angle of the inclined plane at which a body placed on it, just begins to slide.
In the figure




**12.** Mass, m = 75 kg;

$$\text{Total height} = \left(\frac{10\times 20}{100}\right)\text{m} = 2\text{m}$$

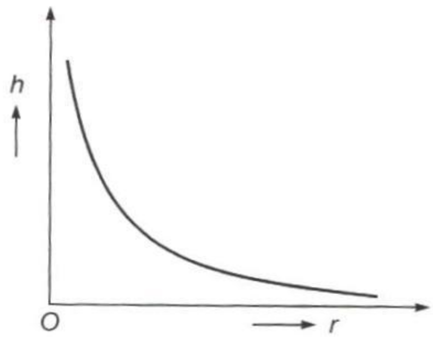
$$t = 5\,\text{s}$$

$$\therefore \text{Power} = \frac{\text{Work}}{\text{Time}} = \frac{75\times 10\times 2}{5}$$

$$= 300\text{W}$$

**13.** No. The correct unit of torque is newton-metre, and not joule. This is done to create a difference between the scalar nature of work and the vector nature of torque.

**14.** The graph of h vs r is




**15.** $\alpha : \beta : \gamma :: 1:2:3$

**16.** Wave motion

**GROUP-C**

**17.**

(i) $M^{3/2} L^{-1/2} T^{-2}$

(ii) $M^{1/2} L^{-3/2} T^{0}$

**18.** An ideal or a perfect gas possesses the following two characteristics:

(i) The size of the molecules of the gas is zero, i.e. each molecule is only a point mass with no dimensions.

(ii) There is no force of attraction between the molecules.

**Or**

$T = 2\pi\sqrt{\frac{l}{g}}$ where l is effective length.

Initially as the level of water drops, the effective length of the pendulum increases and this increases the time period. When the hollow sphere is completely empty, the effective length decreases due to rise in centre of gravity and the time period reduces to its original time period.

**19.**

$\vec{A} = \hat{i} + 2\hat{j} + 3\hat{k}$

$\vec{B} = 2\hat{i} - \hat{j}$

$\vec{A}$ is perpendicular to $\vec{B}$, if $\vec{A}.\vec{B} = 0$

$\therefore (\hat{i}+2\hat{j}+3\hat{k}).(2\hat{i}-\hat{j}) = 2-2 = 0$

Thus $\vec{A}$ is perpendicular to $\vec{B}$.

**20.**

$R = \frac{u^2 \sin 2\theta}{g}, R_{max} = \frac{u^2}{g} [At\ \theta = 45°]$

$H = \frac{u^2 \sin^2\theta}{g} = \frac{u^2 (\sin 45°)^2}{2g} = \frac{u^2}{4g}$

$\frac{R_{max}}{H} = 4$

**21.** Work done is defined as the product of component of force along the direction of motion and displacement.

$\vec{F} = (-\hat{i}+2\hat{j}+3\hat{k})$

The body moves 4m along z – axis only.

$\therefore \vec{S} = (0\hat{i}+0\hat{j}+4\hat{k})m$

Work done, $W = \vec{F}.\vec{S}$

$= (-\hat{i}+2\hat{j}+3\hat{k}).(0\hat{i}+0\hat{j}+4\hat{k})$

$= 12(\hat{k}\hat{k})Nm$

$= 12\,J$ $\qquad (\because \hat{k}.\hat{k} = 1)$

**22.**

$$v = \frac{\omega}{k}$$

$$= \frac{2\pi/0.05}{2\pi/50}$$

$$= 1000cm/s = 10m/s$$

**23.**

Let m be the mass of the stone.

$a_s (= g) = F/m$

and $a_e = F/M$

where M is the mass of the earth

$$\therefore \frac{a_e}{a_s}\frac{F/m}{F/M} = \frac{m}{M}$$

Or $a_e = \frac{m}{M} \times g = \frac{6 \times 9.8}{6 \times 10^{24}}$

$= 9.8 \times 10^{-24} m s^{-2}$

**24.**

(a) $PV^{\gamma}$ = constant, where $\gamma = C_P/C_V$

(b)

(i) $TV^{\gamma-1}$ = constant

(ii) $P^{\frac{1-\gamma}{\gamma}}T$ = constant

or $P^{1-\gamma}T^{\gamma}$ = constant

## GROUP-D

**25.**

$\vec{V_B}$ = Velocity of boat in still water when wind is not blowing

$\vec{V_W}$ = Velocity of wind

$\vec{V_R}$ = Velocity of river with respect to ground

(a) $\vec{V_B} + \vec{V_W}\ \vec{V_R} = 20\ km/h = (20\sin 53°)\hat{i} + (20\cos 53°)\hat{j}$

$\vec{V_B} + \vec{V_W} = 4 km/h$ due east

$= 4\hat{i} + 0\hat{j}$

$\vec{V_B} + \vec{V_R} = 8\ km/h$ due south $= 0\hat{i} - 8\hat{j}$

$(\vec{V_B} + \vec{V_W}) + (\vec{V_B} + \vec{V_R}) = (\vec{V_B} + \vec{V_W} + \vec{V_R}) + \vec{V_B} = 4\hat{i} - 8\hat{j}$

$(20\sin 53°)\hat{i} + (20\cos 53°)\hat{j} + \vec{V_B} = 4\hat{i} - 8\hat{j}$

$\vec{V_B} = (-11.97)\hat{i} - (20.03)\hat{j}$

i.e $\vec{V_B} = \sqrt{(11.97)^2 + (20.03)^2}$

$= 23.32 km/h$

Direction is given as

$\tan\theta = \frac{-20.03}{-11.97}$

$\theta = \tan^{-1}(1.67) = 59°$ south of west

(b) $\vec{V_W} = \vec{V_B} + \vec{V_W} - \vec{V_B}$

$= \left[4\hat{i} + 0\hat{j}\right] - \left[(-11.97)\hat{i} - (20.03)\hat{j}\right] = (15.97)\hat{i} + (20.03)\hat{j}$

$\vec{V_W} = \sqrt{(15.97)^2 + (20.03)^2}$

$= 25.61\ km/h$

Its direction is given as

$\tan B = \tan^{-1}\left(\frac{20.03}{15.97}\right) = \tan^{-1}(1.25) = 51.34$ north of east

**26.**

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

**27.** The weight recorded = Reaction on weighing machine

(a) When the lift moves upwards with a uniform velocity,

$Ma = R - Mg; a = 0$ for uniform velocity

$\therefore R = Mg = 60 \times 9.8$

$= 588\,N$

$\therefore$ the reading shown by the machine

$= \frac{588}{9.8} = 60\,kgf$

(b) When the lift is moving upwards with a uniform acceleration of $2\,ms^{-2}$, we have,

$Ma = R - Mg$

$R = M(g + a)$

$= 60(9.8 + 2)$

$= 60 \times 11.8\,N$

$= 708\,N$

The reading shown by the machine

$= \frac{708}{9.8} = 72.24\,kgf$

(c) When the lift moves downward with a uniform acceleration of $2ms^{-2}$, we have

$Ma = Mg - R$

$R = M(g - a)$

$= 60(9.8 - 2)$

$= 468N$

The reading shown by the machine is

$\frac{468}{9.8} = 47.8kgf$

(d) When the lift falls freely, $a = g$

$Ma = Mg - R$

$R = M(g - a)$

$= M(g - g)$

$R = 0$

The reading shown by the machine is zero i.e. the body appears to be weightless.

**28.** Kinetic energy of electron,

$E_e = 10 \text{ keV} = 10^4 \times 1eV$

$= 10^4 \times 1.6 \times 10^{-19}$ J

$= 1.6 \times 10^{-15}$ J

Kinetic energy of proton,

$E_p = 100 \text{ keV} = 10^5 \times 1eV$

$= 10^5 \times 1.6 \times 10^{-19}$ J

$= 1.6 \times 10^{-14}$ J

$E_e = \frac{1}{2} m_e V_e^2$

$E_p = \frac{1}{2} m_p V_p^2$

Where the symbols have their usual meanings.

$\therefore \quad V_e = \sqrt{\frac{2E_e}{m_e}}$

$= \sqrt{\frac{2 \times 1.6 \times 10^{-15}}{9.11 \times 10^{-31}}}$

$= 5.93 \times 10^7 \text{ ms}^{-1}$

and $\quad V_p = \sqrt{\frac{2E_p}{m_p}}$

$= \sqrt{\frac{2 \times 1.6 \times 10^{-14}}{1.67 \times 10^{-27}}}$

$= 4.38 \times 10^6 \text{ ms}^{-1}$

The required ratio $\frac{V_e}{V_p} = \frac{5.93 \times 10^7}{4.38 \times 10^6} = 13.5$

**Or**

$$(P_1 - P_2)Av\Delta t = Av\rho\Delta tg(h_2 - h_1) + \frac{1}{2}Av\Delta t\rho(v_2{}^2 - v_1{}^2)$$

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

$$\text{(i.e.)} \quad P_1 + \rho gh_1 + \frac{\rho}{2}v_1{}^2 = P_2 + \rho hg_2 + \frac{\rho}{2}v_2{}^2$$

$$\Rightarrow \frac{P_1}{\rho} + gh_1 + \frac{1}{2}v_1{}^2 = \frac{P_2}{\rho} + gh_2 + \frac{1}{2}v_2{}^2$$

$$\therefore \frac{P}{\rho} + gh + \frac{1}{2}v^2 = \text{constant}$$

**29.**

(i) No. The linear speed of the comet changes when it orbits the sun in a highly elliptical orbit, because the linear speed $v=R^{\omega}$

(ii) No.
(iii) Yes, as the comet moves under the effect of a pure radial force.
(iv) No, when the comet is closer to the sun its kinetic energy increases because of the increase in its speed.
(v) No, as the distance keeps on varying from the sun, its potential energy also keeps on varying.
(vi) The total energy of the comet always remains constant.

**30.**

(i) Let L be the original length of a wire of cross- section A and Young's modulus Y.

Let the extension in the wire be l.

$$\therefore \quad Y = \frac{FL}{Al}$$

$$\text{or} \quad F = \frac{YAl}{L}$$

Let dl be the further extension in the wire. Then small work done dW in the extension gets stored in the wire and raises its energy.

dW = F dl

$= \frac{YAl}{L} dl,$

or $\int_0^W dW = \frac{YA}{L}\int_0^l l\,dl$

or $W = \frac{YA}{L} \times \frac{l^2}{2}$

$= \frac{1}{2} \times \frac{YAl}{L} \times l$

or $W = \frac{1}{2} \times \text{Stretching force} \times \text{Extension}$

(ii) $\frac{\text{Work done}}{\text{volume}} = \frac{1}{2}\frac{Fl}{AL}$

$= \frac{1}{2} \times \frac{F}{A} \times \frac{l}{L}$

$= \frac{1}{2} \times \text{Stress} \times \text{Strain}$

**31.** It is a device used for converting heat energy into mechanical energy.

(i) External combustion engine: where fuel is burnt in a separate unit, outside the working portion of the engine, e.g. steam engine.

(ii) Internal combustion engine: where fuel is burnt within the working portion of the engine, e.g petrol engine and diesel engine

**32.**

(i)Hydrogen

As 2 g of hydrogen contains N molecules, 1kg of hydrogen contains

$\frac{N}{2} \times 1000 = 500N$ molecules, where $N = 6.023 \times 10^{23}$

In case of $N_2$, 28 g of nitrogen contains N molecules.

Therefore, 1 kg of nitrogen contains

$\frac{N}{28} \times 1000 = 36\ N$ molecules

(ii) Hydrogen

As $P = \frac{1}{3}\frac{M}{V}c^2$, $P \propto C^2$

Since M and V are the same in both the cases, $C_{H_2} > C_{N_2}$, therefore, the pressure exerted by hydrogen is more than that by nitrogen.

(iii) $\frac{C_{H_2}}{C_{N_2}} = \sqrt{\frac{\rho_{N_2}}{\rho_{H_2}}} = \sqrt{\frac{14}{1}} = 3.74$

$\therefore\ C_{H_2} = 3.74 C_{N_2}$

**33.**

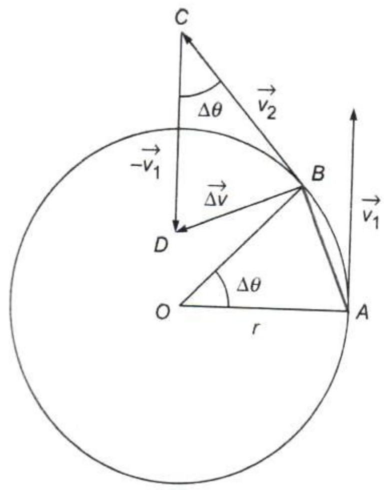
(i) Amplitude, $A = 5\times10^{-3} m$

$ii) k = 80\ ;\ k = \frac{2\pi}{\lambda}$ find $\lambda = \frac{\pi}{40} m$

$iii) \omega = 3\ ;\ \omega = 2\pi f$ find $f = \frac{3}{2\pi} Hz$

**GROUP-E**

**34.** Centripetal force is that force which is required to move a body in circular path with uniform speed. This force acts on the body along the radius and towards the centre.




Consider a body of mass m moving along a circular path of radius r. A and B denote the position of the body at times t and (t + Δt) and the angular displacement is Δθ in time Δt.

The velocities at A and B are represented by $\vec{v_1}$ and $\vec{v_2}$ respectively.

As the speed is uniform,

$|\vec{v_1}| = |\vec{v_2}| = v$

Change in velocity in going from A to B $= \vec{\Delta v} = \vec{v_2} - \vec{v_1}$

where $\vec{CD} = -\vec{v_1}$

From ΔBCD, $\vec{BD} = \vec{BC} + \vec{CD}$

or $\vec{\Delta v} = \vec{v_2} - \vec{v_1}$

Thus, when the body moves from A to B the change in velocity is represented by $\vec{BD}$

From similar ΔAOB and ΔBCD, $\frac{BD}{AB} = \frac{BC}{OA}$

or $|\vec{\Delta v}| = \frac{AB \times BC}{OA} = \frac{r\Delta\theta \times v}{r}$ $\left[\because \Delta\theta = \frac{\overset{\frown}{AB}}{r} \simeq \frac{AB}{r} \text{ and } |\vec{BC}| = BC = |\vec{v_2}| = v\right]$

or $\Delta v = v\,\Delta\theta$

Dividing by $\Delta t$ on both sides we get,

$$\frac{\Delta v}{\Delta t} = v\frac{\Delta \theta}{\Delta t}$$

or $\lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} = v\left[\lim_{\Delta t \to 0} \frac{\Delta \theta}{\Delta t}\right]$

or $\frac{dv}{dt} = v\omega$

Or $a_c = v\omega$

where $a_c$ is called the centripetal acceleration.

But, $v = r\omega$

$\therefore a_c = r\omega^2 = \frac{v^2}{r}$

If F is the magnitude of the centripetal force,

$F = ma_c = \frac{mv^2}{r} = mr\omega^2$

Since $\vec{F} = m\vec{a_c} = m\left[\lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t}\right]$

The direction of the centipetal force is same as $\Delta \vec{v}$, when $\Delta t \to 0$.

When $\Delta t \to 0, \Delta\theta \to 0$ and $B \to A$

In such a case, $\Delta \vec{v}$ points along $\overline{BO}$, i.e. the radius of the circle.

Hence, $\vec{F}$ points along the radius and towards the centre of the circle.

**Or**

A body thrown up in space and allowed to fall under the effect of gravity alone is called a projectile.

The expressions for maximum height and time of flight are:

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

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

Given that speed of the ball, $u$ = 40 m/s
Maximum height, H = 25 m
In projectile motion, the maximum height reached by a body projected at an angle $\theta$, is given by the relation:

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

$$25 = \frac{(40)^2 \sin^2 \theta}{2 \times 9.8}$$

$\sin^2 \theta = 0.30625$

$\sin \theta = 0.5534$

$\therefore \quad \theta = \sin^{-1}(0.5534) = 33.60°$

Horizontal range, R

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

$$= \frac{(40)^2 \times \sin 2 \times 33.60}{9.8}$$

$$= \frac{1600 \times \sin 67.2}{9.8}$$

$$= \frac{1600 \times 0.922}{9.8} = 150.53 \text{ m}$$

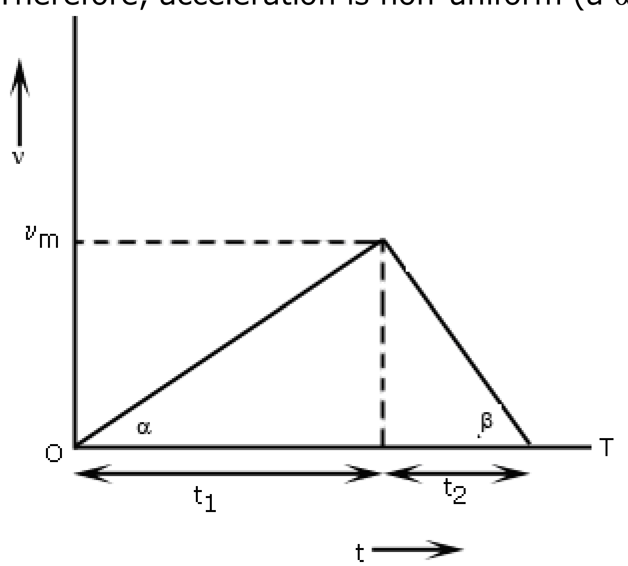
**35.** $x \propto t^3$

$\Rightarrow x = kt^3$

$\Rightarrow v = \frac{dx}{dt} = 3kt^2$

$\Rightarrow a = \frac{dv}{dt} = 6kt$

Therefore, acceleration is non-uniform ($a \propto t$)



Slope of $v-t$ graph = acceleration

Therefore, $\alpha = \frac{v_m}{t_1}, \beta = \frac{v_m}{t_2}$

$$\frac{1}{\alpha} = \frac{t_1}{v_m}, \frac{1}{\beta} = \frac{t_2}{v_m}$$

$$\frac{1}{\alpha} + \frac{1}{\beta} = \frac{t_1 + t_2}{v_m} = \frac{\alpha + \beta}{\alpha\beta}$$

$$v_m = \frac{(t_1 + t_2)\alpha\beta}{\alpha + \beta} = \frac{\alpha\beta T}{\alpha + \beta}$$

**Or**

For the stationary observer: 400 Hz; 0.875 m; 350 m/s
For the running observer: Not exactly identical

**For the stationary observer:**
Frequency of the sound produced by the whistle, v = 400 Hz
Speed of sound = 340 m/s
Velocity of the wind, $v$ = 10 m/s

As there is no relative motion between the source and the observer, the frequency of the sound heard by the observer will be the same as that produced by the source, i.e., 400 Hz.
The wind is blowing toward the observer. Hence, the effective speed of the sound increases by 10 units, i.e.,

Effective speed of the sound, $v_e$ = 340 + 10 = 350 m/s
The wavelength ($\lambda$) of the sound heard by the observer is given by the relation:

$$\lambda = \frac{v_e}{v} - = \frac{350}{400} = 0.875 \text{ m}$$

**For the running observer:**
Velocity of the observer, $v_o$ = 10 m/s
The observer is moving toward the source. As a result of the relative motions of the source and the observer, there is a change in frequency ( $v'$ ).

This is given by the relation:

$$\nu' = \left(\frac{v + v_0}{v}\right)\nu$$

$$= \left(\frac{340 + 10}{340}\right) \times 400 = 411.76 \text{ Hz}$$

Since the air is still, the effective speed of sound = 340 + 0 = 340 m/s

The source is at rest. Hence, the wavelength of the sound will not change, i.e., remains 0.875 m.
Hence, the given two situations are not exactly identical.

**36.** Let $K_1$ and $K_2$ be the spring constant of the two springs. Then,

$$T_1 = 2\pi\sqrt{\frac{m}{K_1}}$$

and $T_2 = 2\pi\sqrt{\frac{m}{K_2}}$

$$\therefore K_1 = \frac{4\pi^2 m}{T_1^2} \text{ and } K_2 = \frac{4\pi^2 m}{T_2^2}$$

When the springs are in series,

$$T = 2\pi\sqrt{\frac{m}{\frac{(K_1K_2)}{(K_1+K_2)}}}$$

$$= 2\pi\sqrt{\frac{m(K_1+K_2)}{(K_1K_2)}}$$

$$K_1 + K_2 = 4\pi^2 m\left[\frac{1}{T_1^2} + \frac{1}{T_2^2}\right]$$

$$= 4\pi^2 m\left(\frac{T_1^2 + T_2^2}{T_1^2\ T_2^2}\right)$$

and $K_1K_2 = \frac{16\pi^4 m^2}{T_1^2\ T_2^2}$

$$\therefore \frac{(K_1+K_2)}{K_1K_2} = 4\pi^2 m\left(\frac{T_1^2 + T_2^2}{T_1^2\ T_2^2}\right) \times \frac{T_1^2\ T_2^2}{16\pi^4 m^2}$$

$$= \frac{T_1^2 + T_2^2}{4\pi^2 m^2}$$

$$T = 2\pi\sqrt{m\left(\frac{T_1^2 + T_2^2}{4\pi^2 m}\right)}$$

$$= \sqrt{T_1^2 + T_2^2}$$

Similarly, when connected in parallel

$$T = 2\pi\sqrt{\frac{m}{K_1 + K_2}} = \frac{T_1 T_2}{\sqrt{T_1^2 + T_2^2}}$$

**Or**

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

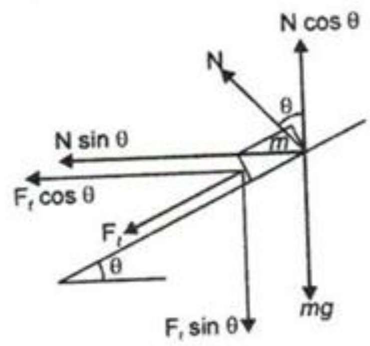
$$N\cos\theta - F_c\sin\theta = mg$$

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

Dividing the equation, we have,

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

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




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

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

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