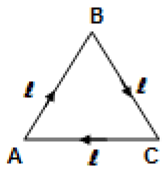
EXERCISE # 02

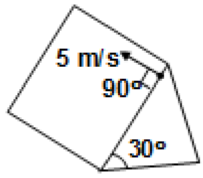
SECTION : (A) - Single Correct Options

152. A particle moves over the sides of an equilateral triangle of side ℓ with constant speed v as shown in figure. The magnitude of average acceleration as it moves from A to C is



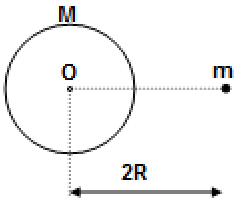
(A) $\frac{v^2}{\ell}$ (B) $\frac{\sqrt{3}}{2}\frac{v^2}{\ell}$ (C) $\frac{\sqrt{3}v^2}{\ell}$ (D) $\frac{v^2}{2\ell}$

153. A particle is given velocity 5 m/s on a fixed large inclined surface as shown in the figure. The radius of curvature of the path of the particle after 1 sec from the start is about($g = 10\ m/s^2$)



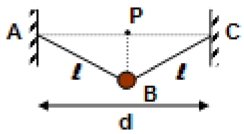
(A) 7 m (B) 14 m (C) 21 m (D) 28 m

154. A particle of mass m is at a distance 2R from the centre of a thin shell of mass M and having radius R as shown in figure. The gravitational field at the centre of shell is



(A) zero (B) $\frac{GM}{R^2}$ (C) $\frac{G(M+m)}{4R^2}$ (D) $\frac{Gm}{4R^2}$

155. A bob of mass m is in equilibrium with the help of two inextensible string connected to fixed support. The bob is slightly displaced perpendicular to the plane of figure and released. The time period of oscillation of bob is



(A) $2\pi\sqrt{\frac{\ell}{g}}$ (B) $2\pi\sqrt{\frac{d}{g}}$ (C) $2\pi\sqrt{\frac{\ell+d}{g}}$ (D) $2\pi\sqrt{\frac{(\sqrt{4\ell^2-d^2})}{2g}}$

156. Ratio of lateral contraction strain to longitudinal elongation strain for a stretched copper wire, (assuming volume remains constant)

(A) 2 (B) 1/2 (C) 1 (D) 1/4

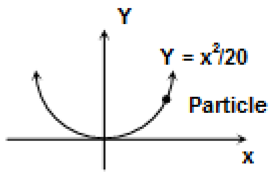
157. A small meteorite of mass m travelling toward centre of earth strikes earth at equator. Earth is uniform sphere of mass M radius R. Length of day is T seconds before meteorite strikes when meteorite strikes length of day would be increased by

(A) $\frac{m}{M}T$ sec (B) $\frac{5m}{2M}T$ sec (C) $\frac{2mT}{5M}$ sec (D) $\frac{M}{5mT}$ sec

158. A cube is floating in water having edge a with $\frac{a}{3}$ length dipped inside. A liquid of relative density ρ if filled till the block is completely submerged. The force of buoyancy acting on cube in second case in comparison to first case will

(A) remain same (B) increase (C) decrease (D) can't tell

159. The coefficient of static friction between the parabola surface and the particle is 0.8. If the equation of parabolic surface is $y = \frac{x^2}{20}$, then find the maximum x-coordinate the particle can have so that the particle does not slide down.

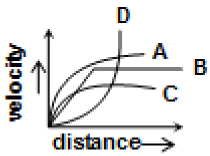


(A) 8 m (B) $4\sqrt{10}$ m (C) 12 m (D) 160 m

160. A body is dropped from a height h. The magnitude of angular momentum of the body, about a fixed point in space, during the fall of the body may

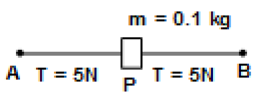
(A) Increase continuously (B) remains constant
(C) Decrease continuously (D) Any of (A) or (B) may be true.

161. A small spherical ball is dropped in a viscous liquid. The graph of velocity verses distance is given by



(A) curve A (B) curve B (C) curve C (D) curve D

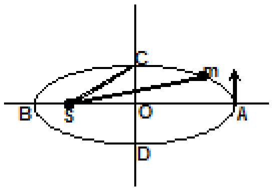
162. A particle of mass 0.1 kg is attached to a light wire which is stretched tightly between two fixed points A and B with tension 5N in each.



The whole system is kept on a horizontal frictionless surface. If AP = BP = $(1/\pi^2)$m and a very small transverse displacement is given to m so that it executes SHM. The frequency of oscillation is

(A) 5 Hz (B) 10 Hz (C) 20 Hz (D) None

163. A hypothetical planet having mass m is moving on an elliptical path around sun [mass of sun $(M) \gg m$], which is situated at one of the focus as shown in the figure. The speed of planet, when it is at C, is [SC = r and AB = 2r]

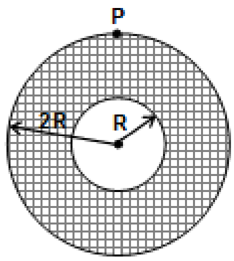


(A) $\sqrt{\frac{GM}{r}}$ (B) $\sqrt{\frac{3GM}{r}}$ (C) $2\sqrt{\frac{GM}{r}}$ (D) none of the above

164. Two satellites S_1 and S_2 revolve around a planet in coplanar circular orbits in the same sense. Their orbital radii are 10^4 km and 4×10^4 km respectively. The time period for S_1 is 1 hr. The absolute angular speed of S_2 as observed by an astronaut in S_1, when S_2 is closest to S_1, is

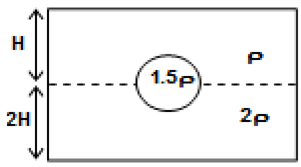
(A) $\frac{\pi}{3}$ rad/hr (B) $\frac{7\pi}{4}$ rad/hr (C) $\frac{9\pi}{4}$ rad/hr (D) π rad/hr

165. From a uniform circular disc of radius 2R a concentric disc of radius R is removed. The mass of the remaining portion is M. The disc is suspended through a small pin hole at point P as shown in the figure. Its time period of small oscillation will be



(A) $\pi\sqrt{\frac{13R}{g}}$ (B) $\pi\sqrt{\frac{5R}{g}}$ (C) $2\pi\sqrt{\frac{R}{g}}$ (D) $\pi\sqrt{\frac{7R}{g}}$

166. A cylindrical vessel with base area 'A' has two liquids with densities ρ and 2ρ. A solid sphere of density 1.5ρ is in equilibrium at the interface of liquid with half its volume immersed in one liquid as shown in the figure. If the sphere has volume V and heights of liquids are H and 2H, the force exerted on the bottom of the vessel is



(A) $\frac{(3V+10HA)\rho g}{2}$ (B) $5\rho gHA$ (C) $\frac{3}{2}V\rho g$ (D) data insufficient

167. A body weighed with a spring balance in a train at rest shows a weight W_0. When the train begins to move with a velocity v around the equator from west to east and if the angular velocity of earth is ω, then the weight recorded in the spring balance is approximately

(A) $W_0\left(1+\frac{2v\omega}{g}\right)$ (B) $W_0\left(1-\frac{2v\omega}{g}\right)$ (C) $W_0\left(1-\frac{v\omega}{g}\right)$ (D) $W_0\left(1+\frac{v\omega}{g}\right)$

168. A vessel of uniform cross-sectional area A is filled with liquid. At a depth h below the free surface of the liquid is a hole of cross sectional area a. The velocity with which the liquid comes out of the hole is

(A) $\sqrt{\frac{2ghA}{A-a}}$ (B) $\sqrt{2gh}$ (C) $\sqrt{\frac{2gh}{A^2+a^2}}$ (D) $A\sqrt{\frac{2gh}{A^2-a^2}}$

169. Drops of liquid of density σ are floating half immersed in an immissible liquid of density ρ. The surface tension of liquid is T then the radius of the drops are

(A) $\sqrt{\frac{3T}{g(2\sigma+\rho)}}$ (B) $\sqrt{\frac{3T}{g(2\sigma-\rho)}}$ (C) $\sqrt{\frac{3T}{g(\sigma-2\rho)}}$ (D) $\sqrt{\frac{3T}{2g(\sigma-\rho)}}$

170. A solid sphere, made from a material of specific gravity 27, has a concentric spherical cavity and just sinks in water. Then, the ratio of radius of the cavity to that of outer radius of the sphere must be

(A) $\frac{(13)^{1/3}}{3}$ (B) $\frac{(26)^{1/3}}{3}$ (C) $\frac{(28)^{1/3}}{3}$ (D) $\frac{(9)^{1/3}}{3}$

171. Two immiscible liquids of densities ρ_1 and ρ_2 ($>\rho_1$) are mixed in equal quantities and filled into a tank upto height h. The tank has a small hole drilled at the bottom of the right hand wall. The velocity of efflux is

(A) $\sqrt{\left(1+\frac{\rho_2}{\rho_1}\right)gh}$ (B) $\sqrt{\left(1+\frac{\rho_1}{\rho_2}\right)gh}$ (C) $\sqrt{\rho_1 gh}$ (D) $\sqrt{\rho_2 gh}$

172. A scalene triangular lamina of uniform mass density and negligible thickness has one of its vertices at the origin. The position vectors of its other two vertices are $\vec{a}$ and $\vec{b}$. The location of its centre of mass will be

(A) $\frac{\vec{a}+\vec{b}}{2}$ (B) $\frac{\vec{a}+\vec{b}}{3}$ (C) $\frac{2(\vec{a}+\vec{b})}{3}$ (D) $\frac{3(\vec{a}+\vec{b})}{4}$

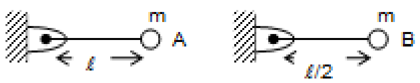
173. A particle moves with a constant speed u along the curve y = sin x. The magnitude of its acceleration at the point corresponding to x = $\pi/2$ is

(A) $\frac{u^2}{2}$ (B) $\frac{u^2}{\sqrt{2}}$ (C) u^2 (D) $\sqrt{2}\,u^2$

174. A circular disc of mass m and radius R is rotating on a rough surface having a coefficient of friction with an initial angular velocity ω. Assuming a uniform normal reaction on the entire contact surface, the time after which the disc comes to rest is

(A) $\frac{\omega R}{\mu g}$ (B) $\frac{3\omega R}{4\mu g}$ (C) $\frac{1}{2}\frac{\omega R}{\mu g}$ (D) $\frac{\sqrt{3}}{2}\frac{\omega R}{\mu g}$

175. Consider the two bobs as shown in the figure. The bobs are pivoted to the hinges through massless rods. If t_A be the time taken by the bob A to reach the lowest position and t_B be the time taken by the bob B to reach the lowest position. (Both bobs are released from rest from a horizontal position) then the ratio t_A/t_B is



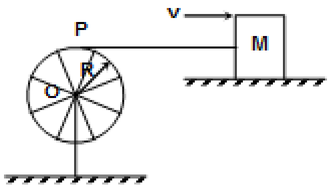
(A) $\sqrt{3}$ (B) $\sqrt{5}$ (C) $\sqrt{2}$ (D) $\frac{1}{\sqrt{2}}$

176. A uniform solid cube of mass M has edge length a. The moment of inertia of the cube about its face diagonal will be

(A) $\frac{\sqrt{3}}{2}Ma^2$ (B) $\frac{1}{2}Ma^2$ (C) $\frac{5}{12}Ma^2$ (D) $\frac{7}{12}Ma^2$

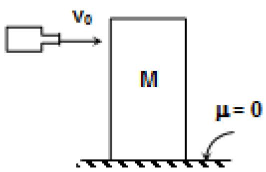
SECTION : (B) - More Than One Correct Options

177. A circular ring of mass M is hinged (by spokes of negligible mass and radius R) at the centre O on a firm vertical pillar and it can rotate freely about O. An inextensible, massless string has one end connected to the circumference of the ring at point P. Other end of the string is connected to a block of mass M at its centre of mass as shown. Initially the string is slack. The block is given sharp impulse such that it moves with speed v on a frictionless surface away from the ring. The string gets an impulse J.



(A) The impulse received by the string is Mv/2.
(B) Angular speed of rotation of ring is v/2R
(C) Loss of energy in the process is $\frac{1}{4}Mv^2$
(D) Work done by the impulse on the block is $-\frac{3}{8}Mv^2$

178. A block of mass M is kept stationary on a frictionless floor. A jet of water starts colliding horizontally at time t = 0 on the block with speed v_0. The area of C.S. of jet is a and the density of liquid is ρ. After colliding with the block, water always falls on the ground parallel to the vertical surface of the block. Assume the speed of the block is v at any time t. The acceleration of the block at that instant is



(A) $\frac{\rho}{M}(v_0 - v)av_0$ (B) $\frac{\rho a v_0}{M}(v_0 + v)$ (C) $\frac{\rho a v_0^2}{M}e^{-\frac{\rho a v_0 t}{M}}$ (D) $\frac{\rho a v_0^2}{M}t$

179. A brass ring of density ρ_r and mass m_r is tied with a piece of cork of mass m_C and density ρ_C. This arrangement floats completely immersed in an liquid of density ρ_ℓ.

(A) mass of liquid displaced is $\frac{1}{2}\left(\frac{m_r}{\rho_r} + \frac{m_C}{\rho_C}\right)\rho_C$

(B) Ratio of mass of cork and that of ring is $\left(\frac{1+\rho_\ell/\rho_C}{1+\rho_\ell/\rho_r}\right)$

(C) mass of liquid displaced is given by $\left(\frac{m_r}{\rho_r} + \frac{m_C}{\rho_C}\right)\rho_1$

(D) radio of mass of cork and that of ring is $\frac{(1-\rho_\ell/\rho_r)}{(\rho_\ell/\rho_C - 1)}$

180. Surface tension of water in a pool is s = 7.2×10^{-2} Nm^{-1}. An insect or mass m = 10^{-6} kg rests on the free surface of water. Spherical base of its each of 6 legs has radius r = 1×10^{-5} m. Each leg shares equal weight of the insect.

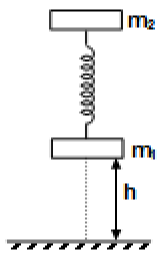
(A) Vertical component of force acting on each leg when q be the angle of contact is $2\pi rs \cos\theta$.

(B) Angle of contact, $\cos\theta = \frac{mg}{12\pi rs}$

(C) Q = 57°

(D) Q = 0.54°

181. The shown system is relaxed when at a height h form the ground. Coefficient of restitution between m_1 and ground is nil.



(A) When released the change in length of spring is given by $(m_1 + m_2)g/k$

(B) When released the change in length of spring is given by m_1g/k

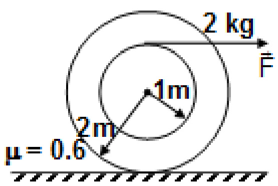
(C) maximum value of h so that system has a tendency to set rebound when released is $\frac{m_2g}{k}\left(\frac{m_1+m_2}{m_2}\right)$

(D) minimum value of h so that system has a tendency to get rebound when released is given by $\frac{m_1g}{k}\left(\frac{2m_2+m_1}{2m_2}\right)$

182. A mass m kg is subjected to a constant force F kgf which cause it move in t sec to a distance x m. The velocity acquired is v m/sec. then the distance covered x is given by

(A) $\frac{v^2m}{2Fg}$ (B) $\frac{2}{3}\frac{v^2m}{Fg}$ (C) $\frac{2}{3}\frac{Fgt^2}{m}$ (D) $\frac{1}{2}\frac{Fgt^2}{m}$

183. An annular disc of radii 2 m and 1 m, having mass 2 kg is kept on rough surface as shown in the figure and pulled by horizontal force FN. Choose the correct statement(s)



(A) Friction force acting on the body is forward direction.

(B) Friction force acting on the body is backward direction.

(C) If F = 150 N body will roll without slipping

(D) If F = 150 N body will roll with slipping

184. Suppose that the position vector function for a particle is given as

$\vec{r}(t) = x(t)\hat{i} + y(t)\hat{j}$, where x(t) = t + 1 and y(t) = $\frac{t^2}{8} + 1$

choose correct statement(s)

(A) Average speed of the particle during the time interval t = 2.0 sec to 4.0 sec is 1.25 m/s

(B) Average speed of the particle during the time interval t = 2.0 sec to 4.0 sec is 2.50 m/s

(C) Speed of the particle at t = 2.0 sec is $\frac{\sqrt{5}}{2}$ m/s

(D) Speed of the particle at t = 2.0 sec is $\sqrt{5}$ m/s

185. A heavy particle is projected from a point at the foot of a fixed plane, inclined at an angle 45° to the horizontal, in the vertical plane containing the line of greatest slope through the point.

If ϕ (> 45°) is the inclination to the horizontal of the initial direction of projection then

(A) Particle will strike the plane horizontally if tan ϕ = 2

(B) Particle will strike the plane at right angle if tan ϕ = 3.

(C) Particle will strike the plane at right angle if tan ϕ = 2

(D) Particle will strike the plane horizontally if tan ϕ = 4

186. In a one dimensional collision between two particles, their relative velocity is $\vec{v}_1$, before the collision and $\vec{v}_2$ after the collision.

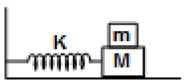
(A) $\vec{v}_1 = \vec{v}_2$, if the collision is elastic

(B) $\vec{v}_1 = -\vec{v}_2$, if the collision is elastic

(C) $\vec{v}_1 = -k\vec{v}_2$ in all cases, where $k \geq 1$

(D) $|\vec{v}_2| = |\vec{v}_1|$ in all cases

187. The friction coefficient between the two blocks shown in the figure is μ and the horizontal plane is smooth. The system is slightly displaced horizontally and released. Which of the following statements is/are true?



(A) The time period of small oscillation is $2\pi\sqrt{\frac{M+m}{K}}$

(B) The magnitude of the frictional force between the blocks, when the displacement from the mean position is x, is $\frac{mk|x|}{M+m}$

(C) If the upper block does not slip relative to the lower block then the value of maximum amplitude is $\frac{\mu(M+m)g}{K}$

(D) If the upper block does not slip relative to the lower block then the value of maximum amplitude is $\frac{\mu m(M+m)g}{MK}$

188. A body totally immersed in water by a height h. The density of the body is d and the density of water is d_0 while the volume of the body is V and d > d_0. Which of the following statements will be true?

(A) the net work done on raising the body is Vdgh.

(B) the increase in the potential energy of the body is vgh $(d - d_0)$

(C) the potential energy of water must increase by raising the body

(D) the work done on the body by gravitational force is equal and opposite to the work done by the hydrostatic forces

189. Which of the following statements are true?

(A) when two quantities are subtracted, the absolute error in the final result is the difference of the absolute errors in the individual quantities taken in same order.

(B) when two quantities are multiplied, the fractional error or the relative error in the result is the sum of the relative errors of the two quantities.

(C) when two quantities are divided, the fractional error or the relative error in the result is the difference of the relative errors of the two quantities.

(D) When two quantities are multiplied, the percentage uncertainty of the final result is equal to the square of the sum of the squares of the percentage uncertainties of the original number.

190. A satellite revolves around a planet in circular orbit of radius R (much larger than the radius of the planet) with a time period of revolution T. If the satellite is stopped and then released in its orbit (Assume that the satellite experiences gravitational force due to the planet only).

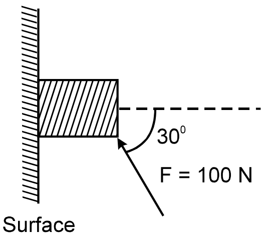
(A) It will fall into the planet

(B) The time of fall of the satellite is nearly $\frac{T}{\sqrt{8}}$

(C) The time of fall of the satellite into the planet is nearly $\frac{\sqrt{2}T}{8}$

(D) It cannot fall into the planet so time of fall of the satellite is meaningless

191. A force of 100 N is applied on a stationary block of mass 3kg as shown in figure. If the coefficient of friction between the surface and the block is 0.25 then :



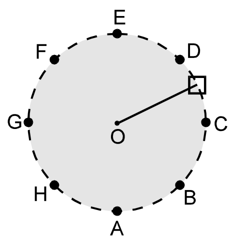
(A) The frictional force acting on the block is 20N downwards

(B) The normal reaction on the block is $50\sqrt{3}$.

(C) The friction force (kinetic) acting on the block is $\frac{25\sqrt{3}}{2}$N

(D) If coefficient of friction is changed to 0.35 then the friction force acting on the block is again 20 N downwards.

192. A machine in an amusement park, consist of a cage at the end of one arm hinged at O. The cage revolves along a vertical circle of radius r (ABCDEFGH) about its hinge O at constant linear speed $v = \sqrt{gr}$. The cage is so attached that the man of weight 'w' standing on a weighing machine inside the cage is always vertical then



(A) the reading of his weight on the machine is same at all positions

(B) the weight reading at A is greater than the weight reading at E by 2 w

(C) the weight reading at G = w

(D) the ratio of the weight reading at E to that at A = 0

(E) the ratio of the weight reading at A to that at C = 2.

193. In a tug of war, the team that exerts a larger tangential force on the ground wins. Consider the period in which a team is dragging the opposite team by applying a larger tangential force on the ground. Which of the following works are negative?

(A) work by the losing team on the winning team

(B) work by the ground on the winning team

(C) work by the ground on the losing team

(D) total external work on the two teams.

194. Which of the following is **incorrect** ?

(A) Total mechanical energy is always conserved.

(B) Work done by kinetic friction is always negative.

(C) Every conservative force is a constant force.

(D) Work done by all forces on a rigid body is the change in its kinetic energy.

195. A rigid body is in pure rotation.

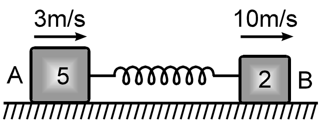
(A) You can find two points in the body in a plane perpendicular to the axis of rotation having same velocity.

(B) You can find two points in the body in a plane perpendicular to the axis of rotation having same acceleration.

(C) Speed of all the particles lying on the curved surface of a cylinder whose axis coincides with the axis of rotation is same.

(D) Angular speed of the body is same as seen from any point in the body.

196. Two blocks A (5kg) and B(2kg) attached to the ends of a spring constant 1120N/m are placed on a smooth horizontal plane with the spring undeformed. Simultaneously velocities of 3m/s and 10m/s along the line of the spring in the same direction are imparted to A and B then



(A) when the extension of the spring is maximum the velocities of A and B are zero.

(B) the maximum extension of the spring is 25cm.

(C) the first maximum compression occurs $3\pi/56$ seconds after start.

(D) maximum extension and maximum compression occur alternately.

197. A mass of 0.2kg is attached to the lower end of a massless spring of force-constant 200 N/m, the upper end of which is fixed to a rigid support. Which of the following statements is/are true?

(A) In equilibrium, the spring will be stretched by 1cm.

(B) If the mass is raised till the spring is unstretched state and then released, it will go down by 2cm before moving upwards.

(C) The frequency of oscillation will be nearly 5 Hz.

(D) If the system is taken to the moon, the frequency of oscillation will be the same as on the earth.

198. A particle is executing SHM between points $-X_m$ and X_m, as shown in figure-I. The velocity V(t) of the particle is partially graphed and shown in figure-II. Two points A and B corresponding to time t_1 and time t_2 respectively are marked on the V(t) curve.

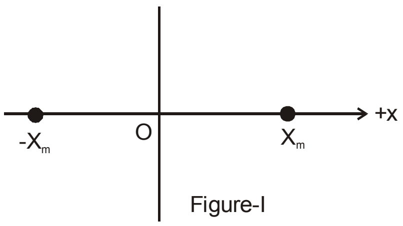


Figure-I

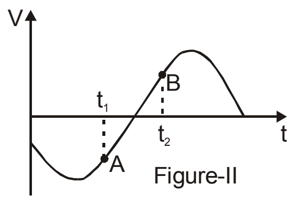


Figure-II

(A) At time t_1 , it is going towards X_m.

(B) At time t_1, its speed is decreasing.

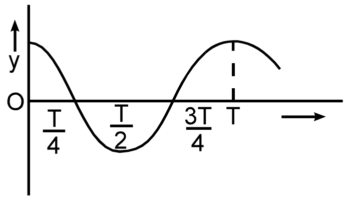
(C) At time t_2, its position lies in between $-X_m$ and O.

(D) The phase difference $\Delta\phi$ between points A and B must be expressed as $90° < \Delta\phi < 180°$.

199. A particle moves on the X-axis according to the equation $x = x_0 \sin^2 \omega t$. The motion is simple harmonic

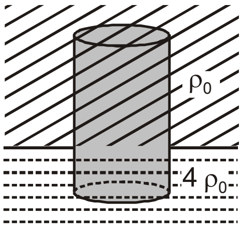
(A) with amplitude x_0 (B) with amplitude $x_0/2$ (C) with time period $\frac{2\pi}{\omega}$ (D) with time period $\frac{\pi}{\omega}$

200. The displacement time graph of a particle executing S.H.M. is shown. Which of the following statements is/are true ?



(A) the velocity is maximum at t = T/2
(B) the acceleration is maximum at t = T
(C) the force is zero at t = 3T/4
(D) the potential energy equals the total oscillation energy at t = T/2

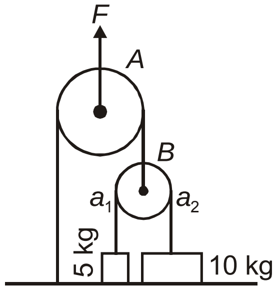
201. A uniform solid cylinder of length l submerged partially in two immiscible liquids is in equilibrium as shown. If one-third length of the cylinder is submerged in liquid of density $4\rho_0$



(A) Density of the cylinder is $2\rho_0$
(B) Pressure difference between top and bottom of the cylinder is $2\rho_0 gl$
(C) For slight vertical displacement from the position shown, angular frequency of oscillation is $\sqrt{\frac{3g}{2l}}$
(D) For slight vertical displacement from the position shown, angular frequency of oscillation is $\sqrt{\frac{5g}{2l}}$

202. Consider a thin spherical shell of mass m and radius r. A particle of mass m is located at a distance $\frac{r}{2}$ from its centre. Choose the correct alternative(s).
(A) Gravitational force by the particle on the shell is zero
(B) Gravitational interaction energy of the particle and shell is $\frac{-Gm^2}{r}$
(C) Gravitational potential energy of the system is $\frac{-Gm^2}{2r}$
(D) Work done by external agent if the particle is moved to the shell centre may be zero or positive

203. The acceleration of block of masses 5 kg and 10 kg are a_1 and a_2 respectively, choose the correct alternative



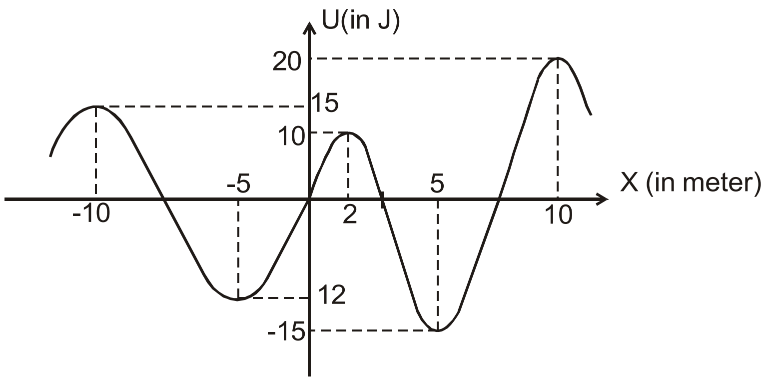
(A) Both a_1 and a_2 are zero if F = 100 N

(B) a_1 = 5 m/s^2 and a_2 = 0 if F = 300 N

(C) a_1 = 15 m/s^2 and a_2 = 2.5 m/s^2 if F = 500 N

(D) Accelerations of blocks independent of F

204. In the figure the variation of potential energy of a particle of mass m = 2kg is represented w.r.t. its x-coordinate. The particle moves under the effect of this conservative force along the x-axis. Which of the following statements about the particle is true :



(A) If it is released at the origin it will move in negative x-axis.

(B) If it is released at x = 2 + Δ where $\Delta \to 0$ then its maximum speed will be 5 m/s and it will perform oscillatory motion

(C) If initially x = – 10 and $\vec{u} = \sqrt{6}\,\hat{i}$ then it will cross x = 10

(D) x = – 5 and x = + 5 are unstable equilibrium positions of the particle

205. A ball is dropped from a height h. At the same time another ball is thrown vertically up along the same line with a velocity u:

(A) they will strike in air if, u > $\sqrt{\frac{gh}{2}}$

(B) the maximum time elapse in between the collision will be $\sqrt{\frac{2h}{g}}$

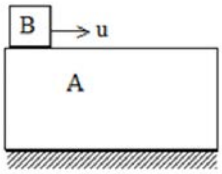
(C) they will strike in air if u < $\sqrt{\frac{gh}{2}}$

(D) if both the particles are travelling along parallel line they may meet twice

206. A tank is filled up to a height h with a liquid and is placed on a platform of height h from the ground. To get maximum range x_m, a small hole is punched at a distance y from the free surface of the liquid. Then

(A) $x_m = 2h$ (B) $x_m = 1.5h$ (C) y = h (d) y = 0.75 h

207. A long block A is at rest on a smooth horizontal surface. A small block B, whose mass is half of mass of A, is placed on A at one end and projected along the surface of A with some velocity u. The coefficient of friction between the blocks is μ.



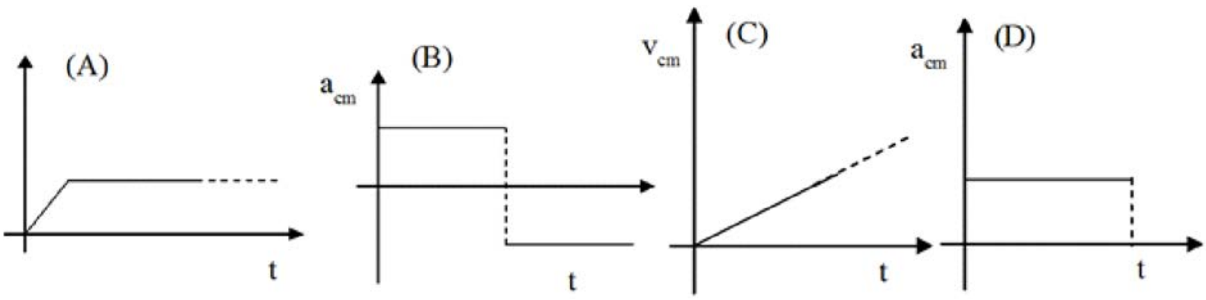
(A) The blocks will reach a final common velocity $\frac{u}{3}$.

(B) The work done against friction is two thirds of the intitial kinetic energy B.

(C) Before the blocks reach a common velocity the acceleration of A relative to B is $\frac{2}{3}\mu g$.

(D) Before the blocks reach a common velocity the acceleration of A relative to B is $\frac{3}{2}\mu g$.

208. A uniform disc of radius r is rotated clockwise with angular speed ω and kept vertically on rough surface. If v_{cm}, a_{cm} are velocity and acceleration of centre of mass, then which of the following graphs holds true?



SECTION : (C) -Passage Type Questions

PASSAGE 01

The concept of a black hole is one of the most interesting products of modern gravitational theory, yet the basic idea can be understood on the basis of Newtonian principles.

Using the theory of gravitation, we know that escape velocity from the surface of a star is given as

$$v = \sqrt{\frac{2GM}{R}} = \sqrt{\frac{8\pi G\rho R}{3}} \quad \text{(expression for escape velocity)}$$

If we find the escape velocity from surface of the sun, it comes out to be about 6.18×10^5 m/s. This value is roughly $\frac{1}{500}$ times the velocity of light. Now consider various stars with same average density ρ as that of the sun and different radii R. The equation of escape velocity suggests that for a given value of density ρ, the escape speed v is directly proportional to R. In 1783, Rev. John Mitchell, an amateur astronomer, noted that if a body with same average density as sun had about 500 times the radius of the sun, the magnitude of its escape velocity would be greater than the speed of light c. With his statement " All light emitted from such a body would be made to return towards it", Mitchell became the first person to suggest the existence of what we now call a " black hole".

The expression for escape speed also suggests that a body of mass M will act as a black hole if its radius is less than or equal to a certain critical radius.

How can we determine this critical radius? You might think that you can find the answer by simply setting v = c in the expression for escape velocity. As a matter of fact, this does give the correct result but only because of two compensating errors. Kinetic energy of light is not ½ mc^2 and the gravitational potential energy near a black hole is not –GMm/r. An 1916, Karl Schwarzschild used Einstein's general theory of relativity (in part a generalization and extension of Newtonian gravitation theory) to derive an expression for the critical radius R_s, now called the Shwarzschild radius, which is given as $R_S = \frac{2GM}{c^2}$. The surface of the sphere with radius R_s surrounding a black hole is called the event horizon. Since light cannot escape from within that sphere, we can't see the events occurring inside.

If light cannot escape from a black hole, how can we know such things exist? The answer is that any gas or dust near the black hole tends to be pulled into an accretion disc that swirls around and in to the black hole, rather like a whirlpool. While there are some black holes with masses of the order of a few times the solar mass, there is also an evidence for super massive black holes.

One example is thought to lie at the centre of the milky was Galaxy, some 26000 light years away from earth in the direction of constellation Sagittarius. High resolution images of Galactic centre reveal stars moving at speeds greater than 1500 km/s about an unseen object that lies at the position of a source of radio waves called SgrA*. By analysing these motions astronomers can infer the period t and semi-major axis of each star's orbit. The mass m_x of the unseen object can now be calculated using Kepler's third law $T = \frac{2\pi a^{3/2}}{\sqrt{2Gm_x}}$. At points far away from a black hole, its gravitational effects are same as those of any normal body with same mass.

209. An object of mass m is located at a distance r form the centre of a black hole with Schwarzschild radius R_s. The attractive force exerted by the black hole on the body is

(A) $\frac{mc^2R_s}{r^2}$ (B) $\frac{2mc^2Rs}{r^2}$ (C) $\frac{\sqrt{2}mc^2R_s}{r^2}$ (D) $\frac{mc^2R_s}{2r^2}$

210. Astronomers have observed a small massive object at the centre of our Milky way galaxy. A ring of material orbits this massive object; the ring has a diameter of about 15 light years and an orbital speed of 200 km/s. What is the mass of the massive object at the centre of milky way? Given G = 6.67×10^{-11} $Nm^2 kg^{-2}$ and 1 light year = 9.5×10^{15} m

(A) Approximately 8.1×10^{37} kg (B) approximately 4.3×10^{37} kg

(C) Approximately 6×10^{37} kg (D) approximately 3×10^{37} kg

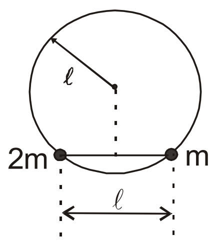
211. Many astronomers believe that the massive object at the centre of the Milky way galaxy (same as the one in previous question) is a black hole. If so, what must the Schwarzschild radius of this black hole be?

(A) 6.4×10^{10} m approx (B) 3.2×10^{10} m approx

(C) 9.6×10^{10} m approx (D) 3.2×10^{9} m approx

PASSAGE 02

Two beads of mass 2m and m, connected by a rod of length ℓ and of negligible mass are free to move in a smooth vertical circular wire frame of radius ℓ as shown. Initially the system is held in horizontal position (Refer figure)



212. The velocity that should be given to mass 2m (when rod is in horizontal position) in counter-clockwise direction so that the rod just becomes vertical is :

(A) $\sqrt{\frac{5g\ell}{3}}$ (B) $\sqrt{\left(\frac{3\sqrt{3}-1}{3}\right)g\ell}$ (C) $\sqrt{\frac{3}{2}g\ell}$ (D) None of these

213. If the rod is replaced by a massless string of length ℓ and the system is released when the string is horizontal then :

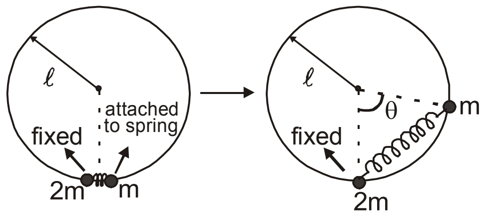
(A) Mass 2m will arrive earlier at the bottom.

(B) Mass m will arrive earlier at the bottom.

(C) Both the masses will arrive together but with different speeds.

(D) Both the masses will arrive together with same speeds.

214. The string is now replaced by a spring of spring constant k and natural length ℓ. Mass 2m is fixed at the bottom of the frame. The mass m which has the other end ofthe spring attached to it is brought near the mass 2m and released as shown in figure. The maximum angle θ that the spring will substend at the centre will be : (Take k = 10 N/m, ℓ = 1 m, m = 1 kg and ℓ = r)



(A) 60° (B) 30° (C) 90° (D) None of these

PASSAGE 03

The velocity of a particle is varying with time according to the relation $v = v_0 \sin \omega t$ m/s
Where, v_0 ω are constants.

Considering the motion from time t = 0 till $t = \frac{\pi}{\omega}$, answer the following:

215. The acceleration of the particle follows a

(A) sinusoidal curve (B) straight line (C) semi-circular path (D) none of the above

216. The total distance travelled by the particle during this time is:

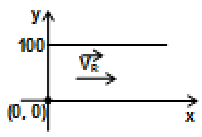
(A) $\frac{2v_0\pi}{\omega}$ (B) $\frac{2v_0}{\omega}$ (C) $\frac{v_0}{\omega}$ (D) $\frac{v_0}{2\omega}$

217. The acceleration of the particle at $t = \frac{\pi}{2\omega}$ is

(A) $v_0\omega$ (B) 0 (C) $2v_0\omega$ (D) $\pi v_0\omega$

PASSAGE 4

A river is flowing with a speed of 10 m/s along the x-axis as shown. The river is 100 m wide. A man in a boat starts from one bank of the river at the point (0, 0), (origin) and crosses the river with speed 20 m/s. One river bank is along the x-axis and the other is parallel to the x-axis along y = 100



218. For the boat to reach the point (0, 100) directly, the man should row the boat with a velocity:

(A) $10(\hat{i} + \sqrt{3}\hat{j})$ (B) $10(-\hat{i} + \sqrt{3}\,\hat{j})$ (C) $10(-\sqrt{3}\,\hat{i} + \hat{j})$ (D) $10(\sqrt{3}\,\hat{i} + \hat{j})$

219. If the man rows the boat in such a way that the direction of velocity of boat is always perpendicular to the river velocity, then the man lands at the point:

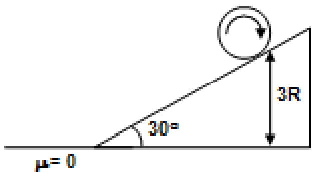
(A) (50, 50) (B) (100, 100) (C) (50, 100) (D) (5, 100)

220. The minimum time required to cross the river is

(A) 5 sec (B) 10 sec (C) $5\sqrt{3}$ sec (D) none of these

PASSAGE 05

A cylinder of mass m and radius R is rotated about its axis with angular velocity ω_0 (as shown in the figure) and lowered on a rough inclined plane at an angle 30° with horizontal and $\mu = \frac{1}{\sqrt{3}}$. The point of initial contact of cylinder and incline is at a height of 3 R from horizontal



221. Find the time when cylinder comes at rest.

(A) $\frac{R\omega_0}{g}$ (B) $\frac{2R\omega_0}{g}$ (C) $\frac{R\omega_0}{2g}$ (D) none of these

222. Find the time t when cylinder reach the bottom of the incline.

(A) $\frac{2R\omega_0}{g}+6\sqrt{\frac{R}{g}}$ (B) $\frac{2R\omega_0}{g}+3\sqrt{\frac{R}{g}}$ (C) $\frac{R\omega_0}{g}+6\sqrt{\frac{R}{g}}$ (D) $\frac{R\omega_0}{2g}+6\sqrt{\frac{R}{g}}$

223. Find the work done by friction during t = 0 to t = t sec.

(A) $\frac{mR^2\omega^2}{2}$ (B) $\frac{mR^2\omega^2}{4}$ (C) $mR^2\omega^2$ (D) $\frac{mR^2\omega^2}{3}$

PASSAGE 06

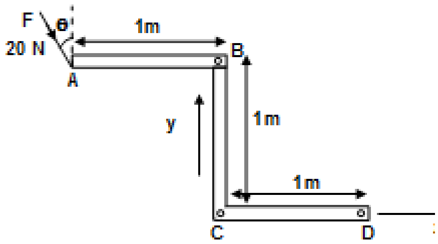
Torque of a force $\vec{F}$ about a point O is defined as $\vec{\tau} = \vec{r}_0 \times \vec{F}$, where $\vec{r}_0$ is the position vector of the point of application of force with respect to point O. The torque of force $\vec{F}$ about an axis having unit vector $\hat{p}$ passing through O will be the component of torque $\vec{\tau}_0$ along the axis.

$$\vec{\tau}_{Axis} = (\vec{\tau}\cdot\hat{p})\hat{p}$$

Hence $\vec{\tau}$ about an axis is zero if the axis is parallel to the force and torque about a point is zero if the line of action of force, when produced intersect the axis or passes through the point O. It can also be concluded that magnitude of torque about an axis is equal to the product of the magnitude of force and the length of the common perpendicular on the line of action of force as well as the axis

If A z-frame of rod of uniform mass density is kept in the x-y –plane as shown in the figure. Force F also lies in the x-y plane.

224. Choose the correct statement ($\vec{\tau}_B, \vec{\tau}_C, \vec{\tau}_D$ are torque about point B, C and D respectively)



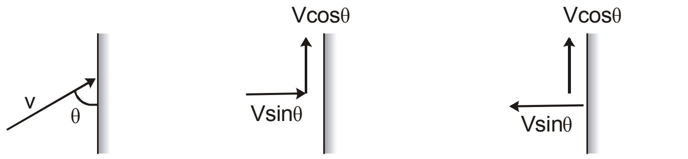
(A) $\vec{\tau}_B = \vec{\tau}_C$ (B) $\vec{\tau}_B = \vec{\tau}_D$ (C) $\vec{\tau}_C = \vec{\tau}_D$ (D) none of these

225. If $\theta = 0$, the magnitude of torque of force about centre of mass of system is
(A) 20 Nm (B) 40 Nm (C) 10 Nm (D) zero

226. If $\theta = 90°$, the magnitude of torque of force about an axis passing through centre of mass of system and parallel to the x-axis is
(A) 20 Nm (B) 40 Nm (C) 10 Nm (D) zero

PASSAGE 07

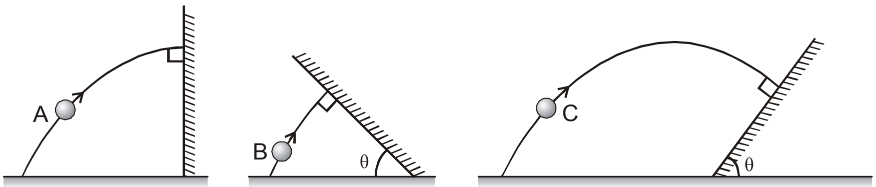
We know how by neglecting the air resistance, the problems of projectile motion can be easily solved and analysed. Now we consider the case of the collision of a ball with a wall. In this case the problem of collision can be simplified by considering the case of elastic collision only. When a ball collides with a wall we can divide its velocity into two components, one perpendicular to the wall and other parallel to the wall. If the collision is elastic then the perpendicular component of velocity of the ball gets reversed with the same magnitude.



Velocity just before collision | Components of velocity just before collision | Components of velocity just after collision

The other parallel component of velocity will remain constant if wall is given smooth.

Now let us take a problem. Three balls 'A' and 'B' & 'C' are projected from ground with same speed at same angle with the horizontal. The balls A,B and C collide with the wall during their flight in air and all three collide perpendicularly with the wall as shown in figure.



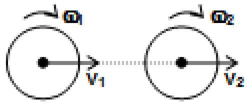
227. If the time taken by the ball A to fall back on ground is 4 seconds and that by ball B is 2 seconds. Then the time taken by the ball C to reach the inclined plane after projection will be :
(A) 6 sec. (B) 4 sec. (C) 3 sec. (D) 5 sec.

228. The maximum height attained by ball B from ground is :
(A) 20 m (B) 5 m (C) 15 m (D) None of these

229. The vertical component of velocity of balls with which they are projected :
(A) 20 m/s (B) 10 m/s (C) $10\sqrt{3}$ m/s (D) Undeterminable

PASSAGE 08

Two disks of equal mass are kept in a horizontal plane on a smooth horizontal surface. The linear and angular speeds of disk 1 and disk 2 are v_1, w_1 and v_2, w_2 respectively as shown ($v_1 > v_2$). All surfaces are smooth and coefficient of restitution between disk 1 and 2 is 1



230. Let v_1' and v_2' be the final linear speeds after collision of the disks 1 and 2 respectively. Then,
(A) $v_1 = v_1'$ (B) $v_2 = v_2'$ (C) $v_1 v_1' = v_2 v_2'$ (D) $v_1 v_2' = v_2 v_1'$

231. Let ω_1' and ω_2' be the final angular speeds after collision of the disks 1 & 2 respectively, then
(A) $\omega_1 = \omega_2'$ (B) $\omega_2 = \omega_1'$ (C) $\omega_1 \omega_1' = \omega_2 \omega_2'$ (D) $\omega_1 \omega_2' = \omega_2 \omega_1'$

232. The angular momentum of the second disk is conserved about

(A) only the center of the disk

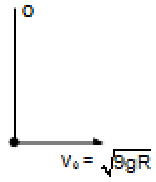
(B) no point on the disk

(C) only the center and point of contact of disks during collision

(D) none of the above

PASSAGE 09

A ball is projected with horizontal velocity $\upsilon_0 = \sqrt{9gR}$ at the bottom most point attached with inextensible string of length R & fixed at O as shown. Give the answer of following questions

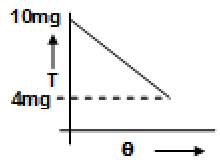


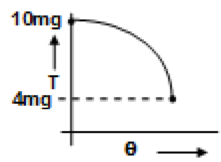
233. Tension in the string in horizontal position

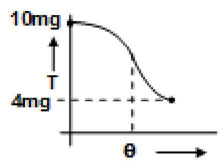
(A) 10 mg (B) 7 mg (C) mg (D) 8 mg

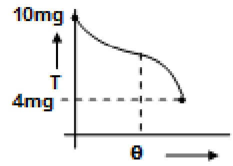
234. Graph between tension vs angle θ rotated from shown position is best represented by

(for $\theta \in [0, \pi]$)

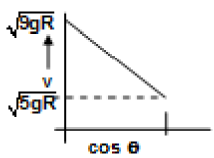
(A)


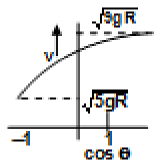
(B)


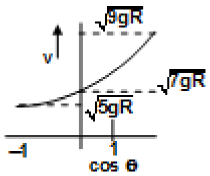
(C)


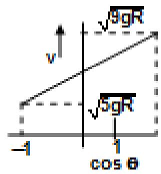
(D)


235. Graph between v vs cos θ is best represented by for θ ε [0, π]

(A)


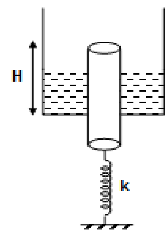
(B)


(C)


(D)


PASSAGE 10

A smooth vertical cylindrical rod just fits the hole at the bottom of the container as shown in the figure. The volume of the rod submerged is V. Mass of the rod is such that $\rho Vg = mg \Rightarrow m = \rho V$, where ρ is the density of the liquid. Let K be the spring constant of the spring. Now answer the following questions:



236. The initial compression of the spring is

(A) $\frac{\rho Vg}{k}$ (B) 0 (C) $\frac{2\rho Vg}{k}$ (D) $\frac{\rho Vg}{2k}$

237. Let T be the time period of small oscillation of the rod, then

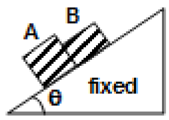
(A) $T > 2\pi\sqrt{\frac{m}{k}}$ (B) $T < 2\pi\sqrt{\frac{m}{k}}$ (C) $T = 2\pi\sqrt{\frac{m}{k}}$ (D) $T = \infty$

238. Net force applied by the liquid on the rod is

(A) mg (B) ρvg (C) 0 (D) $2\rho vg$

PASSAGE 11

In arrangement shown in figure mass of block A is m_1 and mass of block B is m_2 friction coefficient between m_1 & wedge is μ_1 and m_2 and wedge is μ_2. Answer the following questions.



239. If $m_1 = m_2 = m$ (say) and $\mu_1 > \mu_2 > \tan$ then select the correct statement

(A) contact force between the two blocks is $m\frac{(\mu_1 - \mu_2)}{2}g\tan\theta$

(B) contact force between the two blocks is $m\frac{(\mu_1 + \mu_2)}{2}g\tan\theta$

(C) contact force between the two blocks is $\left(\frac{\mu_1 - \mu_2}{2}\right)mg\sin\theta$

(D) contact force is zero

240. If $\mu_1 < \tan\theta$ and $\mu_2 > \tan\theta$ then select correct statement

(A) acceleration of both block is same and non zero

(B) acceleration of both block is zero

(C) acceleration of block A is ($g\sin\theta - \mu g\cos\theta$ and acceleration of block of B is ($g\sin - \mu_2 g\cos\theta$).

(D) acceleration of block A is ($g\sin\theta - \mu_1 g\cos\theta$) and acceleration of block B is zero.

SECTION : (D) - Matrix Match

241.

Column I		Column II
(a) $\int \tau dt$ about an axis	(P)	$\frac{L}{2m}$
(b) Aerial velocity	(Q)	Maximum with $\perp r$ force
(c) Torque	(R)	Pseudo force
(D) Centrifugal force	(S)	Change is angular momentum

242. In vertical circular motion, suppose v is the velocity of bob at bottommost point, then match the following:

Table-1		Table-2
(a) If $v = 2\sqrt{gR}$	(p)	Bob will complete the circle
(b) If $v = 3\sqrt{gR}$	(q)	Bob will oscillate
(C) If $v = 4\sqrt{gR}$	(r)	String will slack
(d) If $v = \sqrt{gR}$	(s)	String will break

243. In the following problem v_0 = orbital speed and v_{esc} = escape velocity

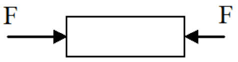
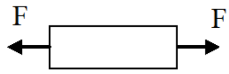
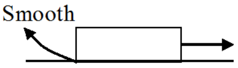
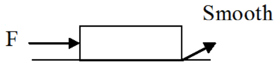
Match the following :

Table -1	**Table -2**
(a) When $v < v_0$	(P) The path of satellite is hyperbolic
(b) When $v = v_{esc} = \sqrt{2}(v_0)$	(Q) The satellite may strike the earth
(c) When $v > v_{esc}$	(R) The orbit of satellite is elliptical
(d) $v_{esc} > v > v_0$	(s) The path of satellite is parabolic

244. **Match the following:**

Table -1	**Table-2**
(a) Surface tension	(P) N/m^2
(b) coefficient of viscosity velocity	(Q) J/m^3
(c) Modulus of elasticity	(R) N/M
(d) Pressure	(S) J/m^2

245. In column I, a uniform bar of uniform cross-section area under the application of forces is shown in the figure and in column II, some effects/phenomena are given. Match the entries of Column I with the entries of Column II.

Column I	**Column II**
(a) 	(p) Uniform stresses developed in the rod
(b) 	(q) Non-uniform stresses developed in the rod
(c) 	(r) Compressive stresses developed
(d) 	(s) Tensile stesses developed

246.

Column I		*Column II*	
A.	A body moving on a circular path	(P)	less than that at the point of projection
B.	In a projectile motion, radius of curvature at the point of projection	(Q)	friction lies between zero to limiting friction
C.	In a projectile motion, radius of curvature at the top of its motion	(R)	greater than that at the top of its motion
D.	A car moves on flat horizontal circular road with increasing speed	(S)	there must have radial acceleration

247. Four bodies each of mass m are moving on earth with equal speed u.

1st one on equator along west to east, 2nd one on equator along east to west,

3rd one on north pole along 0° longitude, 4th one on south pole along 180° longitude,

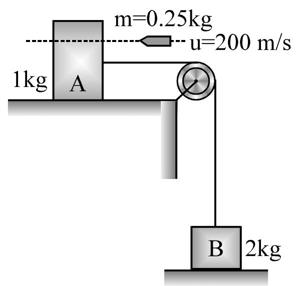
(Assume : Earth is sphere, ω = angular velocity of earth, R = radius of earth)

Column I		*Column II*	
(A)	Normal reaction on 1st body due to earth	(P)	mg
(B)	Normal reaction on 2nd body due to earth	(Q)	$mg + \frac{m(u+\omega R)^2}{R}$
(C)	Normal reaction on 3rd body due to earth	(R)	$mg - \frac{m(\omega R - u)^2}{R}$
(D)	Normal reaction on 4th body due to earth	(S)	$mg - \frac{m(\omega R + u)^2}{R}$

248. For the following statements, except gravity and contact force between the contact surfaces, no other force is acting on the body.

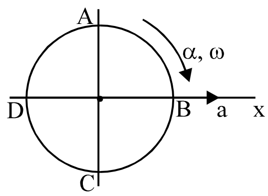
	Column A		Column B
(A)	When a sphere is in pure–rolling on a fixed horizontal surface.	(P)	Upward direction
(B)	When a cylinder is in pure rolling on a fixed inclined plane in upward direction then friction force acts in	(Q)	$v_{cm} > R\omega$
(C)	When a cylinder is in pure rolling down a fixed incline plane, friction force acts in	(R)	$v_{cm} < R\omega$
(D)	When a sphere of radius R is rolling with slipping on a fixed horizontal surface, the relation between v_{cm} and ω is	(S)	No frictional force acts.

249. A block A of mass M_A = 1 kg is kept on a smooth horizontal surface and attached by a light thread to another block B of mass M_B = 2 kg. Block B is resting on ground and thread and pulley are massless and frictionless. A bullet of mass m = 0.25 kg moving horizontally with velocity of u = 200 m/s penetrates through the block A and comes out with a velocity of 100 m/s.



	Column I	Column II (Values are in their respective SI units)
(a)	velocity of 2 kg block just after bullet comes out	(p) 50/3
(b)	max. disp. of 1 kg block in left direction	(q) 25
(c)	impulse by string on block B	(r) 25/3
(d)	Impulse by particle on block A	(s) 5.2

250. A disc of radius R is rolling with angular velocity ω, angular acceleration α and linear acceleration 'a', along x-direction. There are 4 points A, B, C and D on the disc as shown.



	Column I		Column II
(a)	Acceleration of point A	(p)	$\sqrt{(a+\omega^2 R)^2+(\alpha R)^2}$
(b)	Acceleration of point B	(q)	$\sqrt{(a+\alpha R)^2+(\omega^2 R)^2}$
(c)	Acceleration of point C	(r)	$\sqrt{(a-\alpha R)^2+(\omega^2 R)^2}$
(d)	Acceleration of point D	(s)	$\sqrt{(a-\omega^2 R)^2+(\alpha R)^2}$

251. A satellite is projected horizontally near the surface of a planet with a speed V. The value of acceleration of a freely falling body near this planet is found to be 4.9 m/s². Radius of the planet is 3200 km. For various values of V, the path of satellite can be predicted. Match the velocity of satellite with its respective path.

(Take $\sqrt{2} = 1.4$)

	Column I		***Column II***
(a)	V = 5 km/s	(P)	Hyperbola
(b)	V = 4 km/s	(Q)	Circular
(c)	V = 5.6 km/s	(R)	Ellipse
(d)	V = 6.6 km/s	(S)	Parabola

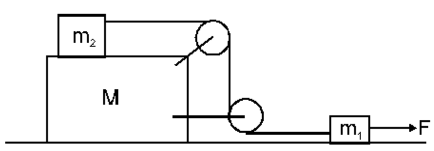
252. A particle is moving under the action of a variable force which is always pointing towards a fixed point.

	Column A		**Column B**
(a)	The particle may be in	(p)	Conserved
(b)	Total mechanical energy	(q)	May be conserved
(c)	Total angular momentum about the fixed point	(r)	Circular motion
(d)	Total kinetic energy	(s)	Rectilinear motion.

253.

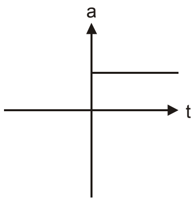
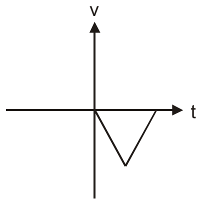
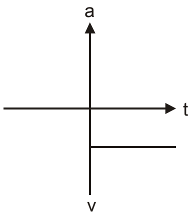
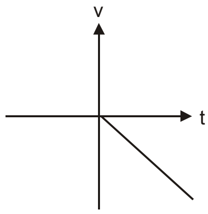
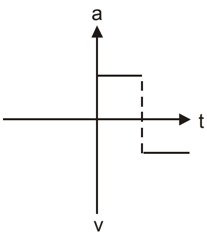
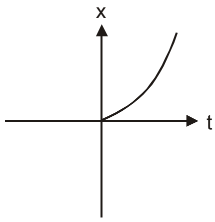
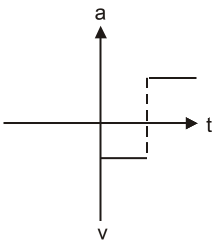
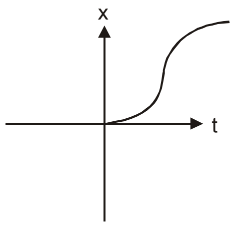
	Column A		**Column B**
(a)	When two particles are executing SHM on parallel lines in such a way that each time particles crosses each other in opposite direction at a displacement A/2, where A is the amplitude of SHM, then the phase difference between the particles is	(p)	$\frac{\pi}{2}$
(b)	A particle starts SHM from the extreme position, the initial phase of the particle is	(q)	Transverse waves
(c)	The phenomenon of beats can take place for	(r)	$\frac{2\pi}{3}$
(d)	The waves created in metal can be	(s)	Longitudinal waves

254. Three blocks of masses m_1, m_2 and M are arranged as shown in figure. All the surfaces are frictionless and string is inextensible. Pulleys are light. A constant force F is applied on block of mass m_1. All the pulley and string are light. Part of the string connecting both pulleys is vertical and part of the strings connecting pulleys with masses m_1 and m_2 are horizontal.



(A) Acceleration of mass m_1	(p) $\frac{F}{m_1}$
(B) Acceleration of mass m_2	(q) $\frac{F}{m_1 + m_2}$
(C) Acceleration of mass M	(r) zero
(D) Tension in the string	(s) $\frac{m_2F}{m_1 + m_2}$

255. In each of the situations assume that particle was initially at rest at origin and there after it moved rectilinearly. Some of the graph in left column represent the same motion as represented by graphs in right column match these graphs.

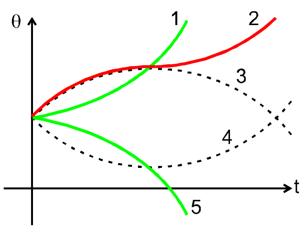
Column 1	**Column 2**
(A) 	(p) 
(B) 	(q) 
(C) 	(r) 
(D) 	(s) 

256. For a particle moving in x-y plane initial velocity of particle is $\vec{u} = u_1\hat{i} + u_2\hat{j}$ and acceleration of particle is always $\vec{a} = a_1\hat{i} + a_2\hat{j}$ where u_1, u_2, a_1, a_2 are constants. Some parameters of motion is given in column-I, match the corresponding path given in column-II.

Column I	**Column II**
(A) If $u_1 \neq 0$, $u_2 = 0$, $a_1 \neq 0$, $a_2 \neq 0$	(p) path of particle must be parabolic
(B) If $u_1 = 0$, $u_2 \neq 0$, $a_1 \neq 0$, $a_2 \neq 0$	(q) path of particle must be straight line
(C) If $u_1 = 0$, $u_2 = 0$, $a_1 \neq 0$, $a_2 \neq 0$	(r) path of particle may be parabolic
(D) If $u_1 \neq 0$, $u_2 \neq 0$, $a_1 \neq 0$, $a_2 \neq 0$	(s) path of particle may be straight line

257. A particle is moving in circular motion around an axis. The motion of the particle in four different situations is described in the table. In the graph shown. Five curves are plotted and marked, and vertical axis gives angular position θ of the particle. Correctly match the curves with the situations to which they belong.

Situation	I	II	III	IV
Initial θ (rad)	+10	+10	+10	+10
Intial angular Velocity ω (rad/s)	+5	– 5	– 5	+ 5
Constant angular acceleration on α (rad/s^2)	+ 2	– 2	+ 2	– 2



Situation	**Curve**
(A) I	(P) 1
(B) II	(Q) 2
(C) III	(R) 3
(D) IV	(S) 4
	(T) 5

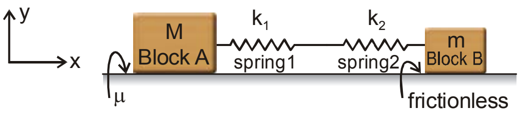
258. Motion of particle is described in column-I. In column-II, some statements about work done by forces on the particle from ground frame is given. Match the particle's motion given in column-I with corresponding possible work done on the particle in certain time interval given in column-II.

Column-I	Column-II
(A) A particle is moving in horizontal circle	(p) Total work done by all the forces may be positive
(B) A particle is moving in vertical circle with uniform speed	(q) Total work done by all the forces may be negative
(C) A particle is moving in air (projectile motion without any air resistance) under gravity	(r) Total work done by all the forces must be zero
(D) A particle is attached to roof of moving train on inclined surface.	(s) Total work done by gravity may be positive.

259. In the diagram shown in figure, all pulleys are smooth and massless and strings are light. Match the blocks in column-I with their motion in column-II.

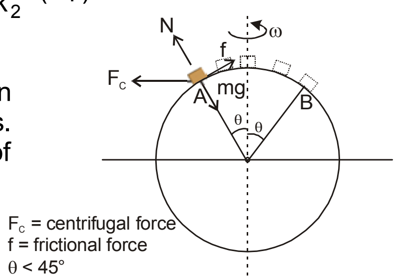
Column I	Column II
(A) 1 kg block	(p) will remain stationary
(B) 2 kg block	(q) will move down
(C) 3 kg block	(r) will move up
(D) 4 kg block	(s) has acceleration 5 m/s^2

260. Two blocks A and B of masses m and M are placed on a horizontal surface, both being interconnected with a horizontal series combination of two massless springs 1 and 2, of force constants k_1 and k_2 respectively as shown. Friction coefficient between block A and the surface is m and the springs are initially non-deformed. Now the block B is displaced slowly to the right by a distance x, and it is observed that block A does not slip on the surface. Block B is kept in equilibrium by applying an external force at that position. Match the required information in the left column with the options given in the right column.



Left column	Right column
(A) Friction force on block A by the surface	(p) $k_1 x (-\hat{i})$
(B) Force by spring 1 on block A	(q) $\mu Mg (-\hat{i})$
(C) Force exerted by spring 2 on spring 1.	(r) $\frac{k_1k_2x}{k_1+k_2}(\hat{i})$
(D) External force on block B.	(s) $\frac{k_1k_2x}{k_1+k_2}(-\hat{i})$

261. The block is placed at different position of earth from A to B as shown. Then the following parameters for different positions from A to B will vary as follows. Consider the effect of rotation of earth about its own axis. Neglect the effect of rotation of earth around the sun and assume earth as a perfect sphere.



Column I	Column II
(A) Gravity force	(p) first increases and then decreases
(B) Normal force	(q) first decreases and then increases
(C) Centrifugal force	(r) remains constant
(D) Frictional force	(s) will not act

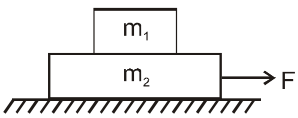
262. Two identical uniform solid spheres of mass m each approach each other with constant velocities such that net momentum of system of both spheres is zero. The speed of each sphere before collision is u. Both the spheres then collide. The condition of collision is given for each situation of column-I. In each situation of column-II information regarding speed of sphere(s) is given after the collision is over. Match the condition of collision in column-I with statements in column-II.

Column-I	**Column-II**
(A) Collision is perfectly elastic and head on	(p) speed of both spheres after collision is u
(B) Collision is perfectly elastic and oblique	(q) velocity of both spheres after collision is different
(C) Coefficient of restitution is $e = \frac{1}{2}$ and collision is head on	(r) speed of both spheres after collision is same but less than u.
(D) Coefficient of restitution is $e = \frac{1}{2}$ and collision is oblique	(s) speed of one sphere may be more than u.

263.

Column I	**Colulmn II**
(A) A constant force acting along the line of SHM affects	(p) the time period
(B) A constant torque acting along the arc of angular SHM affects	(q) the frequency
(C) A particle falling and sticking on the block (spring + mass system) executing SHM on a smooth horizontal plane when the later cross the mean position affects.	(r) the mean position
(D) A particle executing SHM on a smooth horizontal plane when kept on a uniformly accelerated car it changes	(s) the amplitude

264. A small block of mass m_1 lies over a long plank of mass m_2. The plank in turn lies over a smooth horizontal surface. The coefficient of friction between m_1 and m_2 is m. A horizontal force F is applied to the plank as shown in figure. Column-I gives four situation corresponding to the system given above. In each situation given in column-I, both bodies are initially at rest and subsequently the plank is pulled by the horizontal force F. Take length of plank to be large enough so that block does not fall from it. Match the statements in column-I with results in column-II.



Column-I	**Column-II**
(A) If there is no relative motion between the block and plank, the work done by force of friction acting on block in some time interval is	(p) positive
(B) If there is no relative motion between the block and plank, the work done by force of friction acting on plank is some time interval	(q) negative
(C) If there is relative motion between the block and plank, then work done by friction force acting on block plus work done by friction acting on plank is	(r) zero
(D) If there is no relative motion between the block and plank, then work done by friction force acting on block plus work done by friction acting on plank is	(s) is equal to negative of loss in mechanical energy of two block plus plank system.

265. Match the following

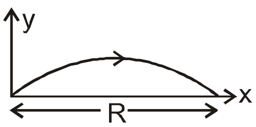
Column I	**Column II**
(a) Instantaneous speed	(P) is a vector quantity
(b) Instantaneous velocity	(Q) Its magnitude can decrease with time
(c) Average velocity	(R) Will remain constant for a particle moving uniformly in a circle
(d) Average speed	(S) Does not depend on the initial and final position only but depends on the motion in between

266. Consider motion of a particle in one dimension. Initially particle is at origin and has velocity towards positive x - direction. x, v, a and t denote displacement, velocity, acceleration and time respectively. Column II gives subsequent motion of the particle under the conditions in column I. Match the condition in Column I with the resultant motion in Column II

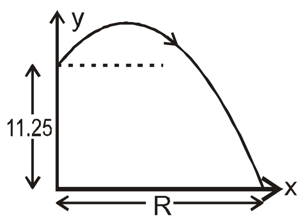
Column I		**Column II**
(A)	$a = -3v$	(p) Particle never stops
(B)	$v = 6 - 3t$	(q) Particle stops at least once
(C)	$x = 3 - 3\cos 2t$	(r) Particle travels finite distance before coming to rest first time.
(D)	$x = 3t + 6t^2$	(s) Particle comes back to origin at least once.

267. In the column-I, the path of a projectile (initial velocity 10 m/s and angle of projection with horizontal 60° in all cases) is shown in different cases. Rangle 'R' is to be matched in each case from column-II. Take $g = 10\ m/s^2$. Arrow on the trajectory indicates the direction of motion of projectile.

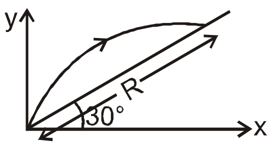
Column-I | **Column-II**

(A) 

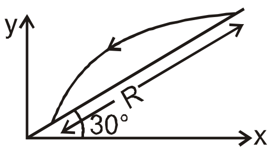
(p) $R = \frac{15\sqrt{3}}{2}$ m

(B) 

(q) $R = \frac{40}{3}$ m

(C) 

(r) $R = 5\sqrt{3}$ m

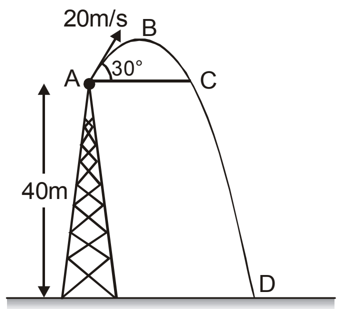
(D) 

(s) $R = \frac{20}{3}$ m

268. A particle is projected horizontally at time t = 0 from a given height above the ground level. Then match the physical quantities given in Column - I with the corresponding results given in Column - II. Consider all quantities in Column I from t = 0 and before the particle reaches the ground.

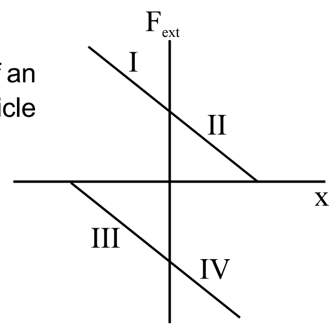
Column - I	Column - II
(A) Magnitude of acceleration	(p) remains constant
(B) Magnitude of average velocity from t = 0 to any time t	(q) decreases with time t
(C) Angle between acceleration and velocity vector	(r) increases with time t
(D) Distance of particle from its initial position.	(s) depends on initial velocity.

269. A projectile is fired from top of a 40 m high tower with velocity 20 m/s at an angle of 30° with the horizontal (see figure). $g = 10\ m/s^2$.



(a) Ratio of time taken from A to D with time taken from A to C is equal to	(P) 1
(b) Ratio of vertical distance travelled from A to D with the maximum height from ground is less than.	(Q) 2
(c) Ratio of final speed at D with the initial speed at A is less than	(R) 3
(d) Ratio of horizontal displacement from A to D with height of tower is greater than	(S) 4

270. A block is executing SHM on a rough horizontal surface under the action of an external variable force. The force is plotted against the position x of the particle from the mean position.

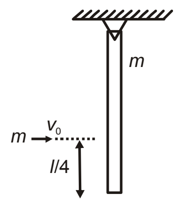


	Column I	Column II	
(A)	x positive , v positive	(P)	I
(B)	x positive , v negative	(Q)	II
(C)	x negative , v positive	(R)	III
(D)	x negative , v negative	(S)	IV

SECTION : (E) - Integer Type

271. The gravitational field in a region is given by $\vec{E} = (3\hat{i} + 2\hat{j})$ N/kg. Calculate the work done (in joule) by gravitational field when a particle (of mass 1 kg) is moved from $A\left(0, \frac{5}{2}\right)$ to $B(1, 1)$ along the line $2y + 3x = 5$

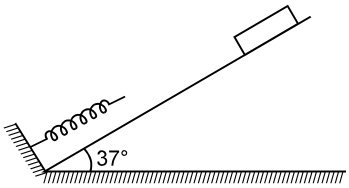
272. A rod of mass m = 1 kg and length l = 36 cm is hinged on a horizontal table as shown in figure. A ball of same mass, m = 1 kg is given a velocity v_0 = 4.3 m/s on the table to hit the rod at a distance $\frac{l}{4}$ from the lowest position of the rod. The ball after collision sticks to the rod. Angular speed, just after collision is $2n$ (rad/s). Find n.



273. A box weighing 2000 N is to be slowly slid through 20 m on a straight track having friction coefficient 0.2 with the box. A person is pulling the box with a chain at an angle θ with the horizontal. Find the work when the person has chosen a value of θ which ensures him the minimum magnitude of the force.

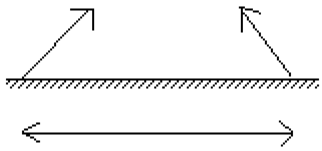
274. The US athlete Florence Griffith-Joyner won the 100 m sprint gold medal at Seol Olympic 1988 setting a new Olympic record of 10.54 s. Assume that she achieved her maximum speed in a very short time and then ran the race with that speed till she crossed the line. Take her mass to be 50 kg. Assume that the track, the wind etc. offered an average resistance of one tenth of her weight. What power Griffith-Joyner had to exert to maintain uniform speed ?

275. Figure shows a spring fixed at the bottom end of a rough incline of inclination 37°. A small block of mass 2 kg starts slipping down the incline from a point 4.8 m away from the spring. The block compresses the spring by 20 cm, stops momentarily and then rebounds through a distance of 1 m up the incline. Find the spring constant of the spring. Take $g = 10\ m/s^2$.

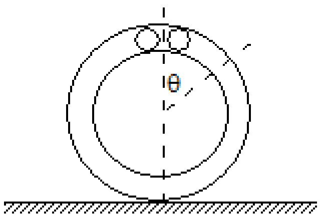


276. The limbs of a manometer consists of uniform capillary tubes of radii 1.44×10^{-3} m and 7.2×10^{-4} m. Find out the correct pressure difference (in N/m^2) if the level of the liquid (density $10^3\ kg/m^3$, surface tension 72×10^{-3} N/m) in the narrower tube stands 0.2 m above that in the broader tube

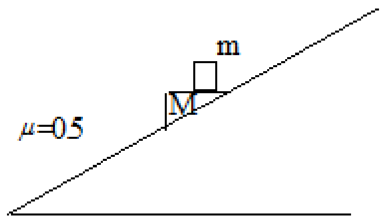
277. Two balls having masses 'M' each are launched at an angle of 45^0 above horizontal with a velocity of 10 m/s shown in the figure. For the elastic collision between the balls; find the value of X (initial separation between the balls). Take their velocity to be horizontal when they collide in air. Can the two balls collide for more than once ?



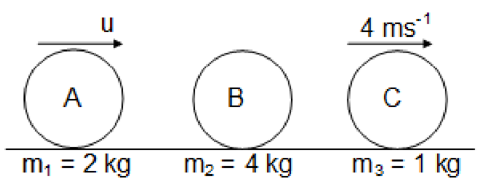
278. A circular tube of mass M is placed vertically on a horizntal surface as shown in the figure. Two small spheres, each of mass m and size such that they, just fit in the tube are released from the top, as shown n the figure. If θ gives the angle between the radius vector of either ball with the verticle, obtain the value of the ratio m/M for which the tube brakes its contact with ground when $\theta = 60^0$ (Ignore any friction)



279. A block of mass m is kept on the horizontal top surface of wedge of mass M which is kept on an incline plane of inclination θ ($\sin\theta = 3/5$) as shown in the figure. Coefficient of friction between the wedge and incline is 0.5. The minimum coefficient of friction between m and M so that m does not slip on M when the system is released from rest is X/Y. The value of Y-X is:

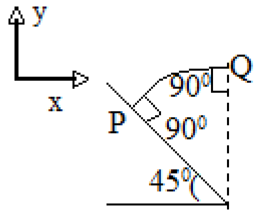


280. Three balls A, B, C are kept on a smooth surface. Balls A and C start moving with a constant velocity u & 4 ms^{-1} respectively as shown in the figure. If the collision between A and B is elastic then find out the value of u so that B can also collide with ball C after some time.



281. Two identical particles A and B of mass m are released from the positions shown in the figure. They collide elastically on horizontal portion MN. The ratio of the heights attained by the balls A and B after the collision is X/Y. Find the value of |X-Y|(Assume all the surfaces to be smooth)

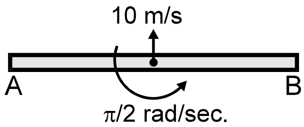
282. A ball is projected normally from point P (Which is on an inclined plane) with speed u= $10\sqrt{2}$ m/s. It strikes the vertical wall normally. If all the collisions are perfectly elastic, then find the time period (in seconds) of periodic motion.



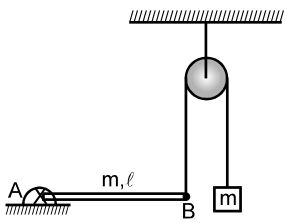
283. The potential energy of a particle is determined by the expression $U = \alpha (x^2 + y^2)$, where α is a positive constant. The particle begins to move from a point with the coordinates (2, 2) (m), only under the action of potential field force. Then its kinetic energy T at the instant when the particle is at a point with the coordinates (1, 1) (m) is n α .Find the value of n.

284. A uniform disc of radius R = 2 is given velocity 5m/s over a rough surface. After some time its kinetic energy becomes zero. Then find the initial angular velocity (in rad/sec).

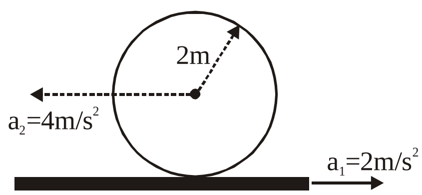
285. A uniform rod AB of length 4m and mass 12 kg is thrown such that just after the projection the centre of mass of the rod moves vertically upwards with a velocity 10 m/s and at the same time it is rotating with an angular velocity $\frac{\pi}{2}$ rad/sec about a horizontal axis passing through its mid point. Just after the rod is thrown it is horizontal and is as shown in the figure. Find the acceleration (in m/sec^2) of the point A in m/s^2 when the centre of mass is at the highest point. (Take g = 10m/s^2 and π^2 = 10)



286. Uniform rod AB is hinged at the end A in a horizontal position as shown in the figure. The other end is connected to a block through a massless string as shown. The pulley is smooth and massless. Masses of the block and the rod are same and are equal to 'm'. Then acceleration of the block just after release from this position is xg/8.Find the value of x.

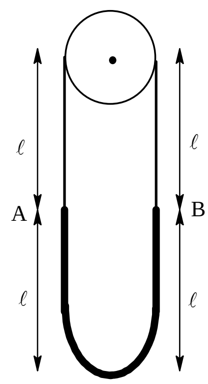


287. In the figure, a sphere of radius 2 metre rolls on a plank. The accelerations of the sphere and the plank are indicated. The value of α is

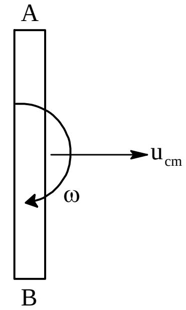


288. Two uniform ropes having linear mass densities m and 4m, length 2ℓ. Each are joined to form a closed loop. The loop is hanging over a fixed frictionless small pulley with the lighter rope above as shown in the figure (In the figure equilibhrium position is shown). Now if the point B (joint) is slightly displaced in downward direction and released. It is found that, the loop perform angular SHM with the period of the oscillation

$N \times 10$ sec. Find the value of N (take $\ell = \frac{150}{\pi^2}$ metre)



289. A uniform rod AB of length l travelling with linear velocity u_{cm} and rotating with angular velocity ω about its centre of mass such that $u_{cm} = \omega l/2$. The distance covered by the end B w.r.t ground when the rod completes one full rotation is xl. Find the value of x.

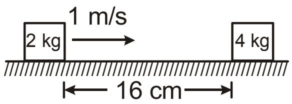


290. The position vector of a particle is given as $\vec{r} = (t^2 - 4t + 6)\hat{i} + (t^2)\hat{j}$. The time after which the velocity vector and acceleration vector becomes perpendicular to each other is equal to:

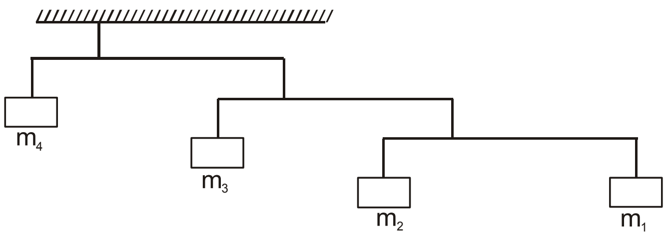
291. A juggler throws balls into air. He throws one whenever the previous one is at its highest point. He throws two balls per second. Find the height to which each ball goes (in centimeter). ($g = 10\ m/s^2$)

292. A smooth right circular cone of semi vertical $\angle\alpha = \tan^{-1}(5/12)$ is at rest on a horizontal plane. A rubber ring of mass 2.5 kg which requires a force of 15 N for an extension of 10 cm is placed on the cone. Find the increase in the radius of the ring (in cm) when it is in equilibrium. ($\pi^2 = 10$)

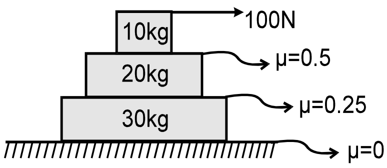
293. The friction coefficient between the horizontal surface and each of the blocks shown in figure is 0.20. The collision between the blocks is perfectly elastic. Find the separation between the two blocks (in cm) when they come to rest. Take $g = 10\ m/s^2$.



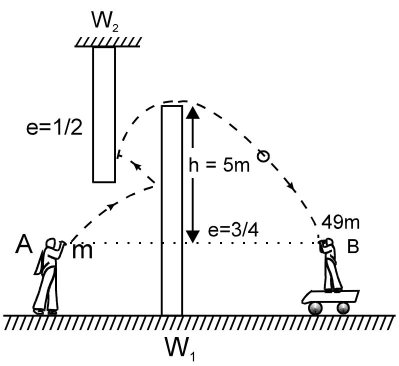
294. Figure shows an arrangement of masses hanging from a ceiling. In equilibrium, each rod is horizontal, has negligible mass and extends three times as far to the right of the wire supporting it as to the left. If mass m_4 is 48 kg then mass m_1 is equal to



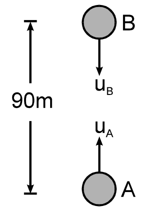
295. Three blocks are kept as shown in the figure. Acceleration (in SI units) of 20 kg block with respect to ground is:



296. Sachin Tendulkar (A) projects a ball of mass ' m ' towards Virendra Sehwag (B) of mass 48 m as shown in figure. The ball collides with the two vertical walls and when it just passes the wall W_1, its velocity is horizontal. Sehwag is standing on a cart of mass ' m ', catches the ball at the same level at which the ball is projected. After the catch, cart starts moving with a velocity 0.3 m/s horizontally towards right. Find X/Y if velocity of projection is $X\hat{i}+Y\hat{j}$. Walls are smooth and there is no friction between cart and ground. Sehwag remains fixed with respect to the cart. Coefficient of restitution of ball with the walls and the required height is shown in the figure.



297. Two particles A and B of masses 1 kg and 2 kg respectively are projected in the same vertical line as shown in figure with speeds u_A = 200 m/s and u_B = 85 m/s respectively. Initially they were 90 m apart. Find the maximum height (in metres) attained by the centre of mass of the system of particles A and B, from the initial position of centre of mass of the system. Assume that none of these particles collides with the ground in that duration Take g = 10 m/s^2.



298. An ideal spring of spring constant K= 4000 N/m and unstretched length ℓ_0 = 0.5 m is placed on a smooth table. One end of the spring is fixed at the centre of the table and other end is attached to a small block of mass m = 20 kg. The block is moving in a circle with constant speed 10 m/s. Find the tension (in kN) in the spring.

299. An insect starts from rest from point (3, 4) and moves with an acceleration $2\sqrt{2}$ m/s^2 in x-y plane along a line, equally inclined to both the axis. After 3 sec insect turns towards right in perpendicular direction without wasting any time and keeping speed same at the moment of turning. For the further motion acceleration is $2\sqrt{2}$ m/sec^2 in the direction of motion. The position of insect after 5 seconds from the starting is $\mathbf{X}\,\hat{i} - \mathbf{Y}\,\hat{j}$. The value of |X-Y| is:

300. A solid sphere moving with linear velocity 2 m/s and angular velocity 8 rad/s is rolling without slipping on a rough horizontal surface to collide eleastically with identical sphere at rest of mass 1 kg and radius R. There is no friction between them. Find the ratio of linear sphere of first sphere after it again starts rolling without slipping to the net angular impulse imparted to the second sphere by the external forces.

AnswerKey

Qs.	Ans.	Qs.	Ans.	Qs.	Ans.
152	B	201	ACD	251	A-(R),B-(Q),C-(S),D-(P)
153	B	202	ABD	252	A-(R,S),B-(Q),C-(P),D-(Q)
154	D	203	ABC	253	A-(r),B-(p),C-(s),D-(qs)
155	D	204	ABC	254	A-(q),B-(q),C-(r),D-(s)
156	B	205	AB	255	A-(r),B-(q),C-(s),D-(p)
157	B	206	AC	256	A-(p),B-(p),C-(q),D-(rs)
158	A	207	ABD	257	A-(P),B-(T),C-(S),D-(R)
		208	AD	258	A-(p,q),B-(r,s),C-(p,q,s),D-(p,q,s)
159	A	209	D	259	A-(r),B-(p),C-(q),D-(qs)
160	B	210	B	260	A-(S),B-(R),C-(R),D-(R)
161	A	211	A	261	A-(r),B-(p),C-(q),D-(q)
162	A	212	B	262	A-(p,q),B-(p,q),C-(q,r),D-(q,r)
163	A	213	D	263	A-(r,s),B-(r,s),C-(p,q,s),D-(r,s)
164	A	214	A	264	A-(p),B-(q),C-(q,s),D-(r)
165	A	215	A	265	A-(Q,R,S),B-(P,Q,S),C-(P,Q),D-
166	B	216	B	266	A-(p),B-(q,r,s),C-(q,r,s),D-(p)
167	B	217	B	267	A-(r),B-(p),C-(s),D-(q)
168	D	218	B	268	A-(p),B-(r,s),C-(q,s),D-(r,s)
169	B	219	C	269	A-(Q),B-(Q,R,S),C-(Q,R,S),D-(P)
170	B	220	A	270	A-(Q),B-(S),C-(P),D-(R)
171	A	221	A	271	0
172	B	222	C	272	5
173	C	223	B	273	7690J
174	B	224	D	274	465W
175	C	225	A	275	1000N/m
176	C	226	C	276	1860
177	ABCD	227	C	277	50
178	AC	228	C	278	2
179	CD	229	A	279	9(X-2,Y-11)
180	ABC	230	C	280	6
181	BD	231	D	281	9
182	AD	232	D	282	2
183	BC	233	A	283	6
184	BC	234	C	284	5
185	AB	235	B	285	5
186	BC	236	A	286	3
187	ABC	237	C	287	3
188	B	238	C	288	1
189	B	239	D	289	4
190	AC	240	D	290	1
191	ABD	241	A-(S),B-(P),C-(Q),D-(R)	291	125
192	BCDE	242	A-(r),B-(p),C-(p),D-(q)	292	1
		243	A-(R,A),B-(S),C-(P),D-(R)	293	5
193	CD	244	A-(R,S),B-(R,S),C-(P,Q),D-(P,Q)	294	1
194	ABC	245	A-(P,R),B-(PS),C-(QS),D-(QR)	295	1
195	CD	246	A-(S),B-(R),C-(P),D-(Q,S)	296	4
196	BCD	247	A-(S),B-(R),C-(P),D-(P)	297	5
197	ABCD	248	A-(S),B-(P),C-(P),D-(QR)	298	2
198	BC	249	A-(R),B-(S),C-(P),D-(Q)	299	25
199	BD	250	A-(Q),B-(S),C-(R),D-(P)	300	4
200	BCD				