PHYSICS

BOOKS - FULL MARKS PHYSICS (TAMIL ENGLISH)

MOTION OF SYSTEM OF PARTICLES AND RIGID BODIES

In Text Solved Examples

1. Two point masses 3 kg and 5 kg are at 4 m and 8 m from the origin on X-axis. Locate the position of center of mass of the two point masses (from the origin and (1) from 3 kg mass.

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2. From a uniform disc of radius R, a small disc of radius $\frac{R}{2}$ is cut and removed as shown in

the diagram. Find the center of mass of the remaining portion of the disc.

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3. The positiion vectors of two point masses 10 kg and 5 kg are $\left(3\hat{i}+2\hat{j}+4\hat{k}\right)m$ and $\left(3\hat{i}+6\hat{j}+5\hat{k}\right)m$ respectively. Locate the position of center of mass.

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4. The center of mass is located at position i EX.5.4. Locate the center of mass of a uniform rod of mass M and length

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5. A man of mass 50 kg is standing at one end of a boat of mass 300 kg floating on still water. He walks towards the other end of the boat with a constant velocity of $2ms^{-1}$ with respect to a stationary observer on land. What will be the velocity of the boat, (a) with respect

to the stationary observer on land? (b) with respect to the man walking in the boat?

[Given: There is friction between the man and the boat and no friction between the boat and water.]

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6. A projectile of mass 5 kg, in its course of motion explodes on its own into two fragments. One fragment of mass 3 kg falls at

three fourth of the range R of the projectile. Where will the other fragment fall? .

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7. If the force applied is perpendicular to the handle of the spanner as shown in the diagram, find the (i) torque exerted by the force about the center of the nut, (ii) direction of torque and (iii) type of rotation caused by the torque about the nut.

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8. A force of $\left(2\hat{i}+3\hat{j}+5\hat{k}\right)N$ is is applied at a point whose position vector is $\left(7\hat{i}+4\hat{j}-2\hat{k}\right)m$. Find the torque of force about the origin.

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9. A crane has an arm length of 20 m inclined at 30° with the vertical. It carries a container of mass of 2 ton suspended from the top end

of the arm. Find the torque produced by the gravitational force on the container about the point where the arm is fixed to the crane. [Given: 1 ton = 1000 kg, neglect the weight of the arm. $g - 10ms^{-2}$]

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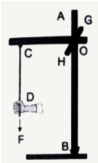
10. Three mutually perpendicular beams AB, OC, GH are fixed to form a structure which is fixed to the ground firmly as shown in the Figure. One string is tied to the point and its

free end D is pulled with a force F. Find the magnitude and direction of the torque produced by the force

(i) about the points D, C, O and B

(ii) about the axis CD, OC, AB and GH.



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11. A particle of mass (m) is moving with constant velocity (v). Show that its angular

momentum about any point renains constant throughout the motion.

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12. Arun and Babu carry a wooden log of mass 28 kg and length 10 m which has almost uniform thickness. They hold it at 1 m and 2 m from the ends respectively. Who will bear more weight of the log? $[g = 10ms^{-2}]$

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13. A cyclist while negotiating a circular path with speed $20ms^{-1}$ is found to bend an angle by 30° with vertical. What is the radius of the circular path? (given,$g = 10ms^{-2}$).

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14. Find the moment of inertia of a uniform rod about an axis which is perpendicular to the rod and touches any one end of the rod.

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15. Find the radius of gyration of a disc of mass M and radius R rotating about an axis passing through the center of mass and perpendicular to the plane of the disc.

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16. Find the rotational kinetic energy of a ring of mass 9 kg and radius 3 m rotating with 240 rpm about an axis passing through its centre and perependicualr to its plane.

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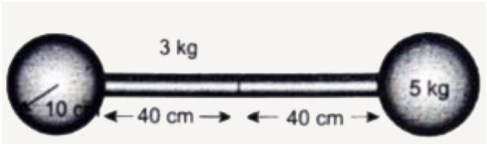
17. Find the moment of incrtia about the metric center of the given structure made up of one thin rod connecting two similar solid spheres as shown in Figure.



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18. A disc of mass 500 g and radius 10 cm can freely rotate about a fixed axis as shown in figure. Light and inextensible string is wound several turns around it and 100 g body is suspended at its free end. Find the acceleration of this mass. [Given: The string makes the disc to rotate and does not slip over it. $g - 10ms^{-2}]$

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19. A jester in a circus is standing with his arms extended on a turntable rotating with angular velocity c. He brings his arms closer to his body so that his moment of inertia is reduced to one third of the original value. Find his new angular velocity [Given: There is no external torque on the turn table in the given situation.]

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20. Find the rotational kinetic energy of a ring of mass 9 kg and radius 3 m rotating with 240 rpm about an axis passing through its centre and perependicualr to its plane.

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21. A rolling wheel has velocity of its center of mass as 5 ms. If its radius is 1.5 m and angular velocity is $3\mathrm{rad\,s^{-1}}$, then check whether it is in pure rolling or not.

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22. If a sphere is rolling, the ratio of translational energy to total kinetic energy is given by:

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23. Four round objects namely a ring, a disc, a hollow sphere and a solid sphere with same radius R and made of same material start to

roll down an inclined plane at the same time. The object that will reach the bottom third is

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24. Three particles each of mass m are placed at the three corners of an equilateral triangle of side a. The work done on the system to increase the sides of the triangle to 2a is:

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25. An electron of mass 9×10^{-31} kg revolves around a nucleus in a circular orbit of radius 0.53Å. What is the angular momentum of the electron? (Velocity of electron is, $v = 2.2 \times 10^{6} ms^{-1}$).

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26. A solid sphere of mass 20 kg and radius 0.25 m rotates about an axis passing through

the center. What is the angular momentum if the angular velocity is 5 rad/s .

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27. A solid cylinder when dropped from a height of 2 m acquires a velocity while reaching the ground. If the same cylinder is rolled down from the top of an inclined plane to reach the ground with same velocity, what must be the height of the inclined plane? Also compute the velocity

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28. A small particle of mass on is projected with an initial velocity v at an angle 8 with x axis in X-Y plane as shown in Figure. Find the angular momentum of the particle.

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29. From a complete ring of mass M and radius R, a sector angle is removed. What is the moment of inertia of the incomplete ring

about axis passing through the center of the ring and perpendicular to the plane of the ring?

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30. A mussless right angled triangle is spended with its right angle comer. A mass of 100kg is suspended from another comer ll which subtiends an angle 53°. Find the mass that should be suspended from other comer so that (hypolemic) remains horizontal.

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31. Energy of 1000 J is spent in increasing the speed of a flywheel from 30 rpm to 720ppm, find the moment of inertia of the wheel

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32. Consider two cylinders with same radius and same mass. Let one of the cylinders be solid and another one be hollow. When subjected to some torque, which one among

them gets more angular acceleration than the other?

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33. A thin horizontal circular dise is rotating about a vertical axis passing through its center. An insect goes from A to point B along its diameter as shown in Figure. Discuss how the angular speed of the circular disc changes?

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34. (I) Relation between rotational kinetic energy and Angular momentum is $\frac{L^2}{2I}$

(II) Rotational work done is $F\theta$

Which one is correct ?

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35. Consider a thin uniform circular ring rolling down in an inclined plane without slipping. Compute the linear acceleration

along the inclined plane if the angle of inclination is 45'

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Textual Questions Solved Multiple Choice Questions

1. The centre of mass of a system of particles does not depend upon

A. position of particles

B. relative distance between particles

C. masses of particles

D. force acting on particle

Answer: D

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2. A couple produces _____ motion.

A. pure rotation

B. pure translatio

C. rotation and translation

D.

Answer: A

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3. A particle is moving with a contant velocity along a line parallel to positive X-axis. The magnitude of its angular momentum with respect of the origin is

A. zero

B. increasing with

C. decreasing with x

D. remaining constant

Answer: D

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4. A rope is wound round a hollow cylinder of mass 3 kg and radius 40 cm. What is the angular acceleration of the cylinder if the rope is pulled with a force of 30 N.

A. $0.25 \text{rad} s^{-1}$

B. $25 \text{rad} s^{-1}$

C. $5 m s^{-2}$

D. $25 m s^{-1}$

Answer: B

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5. A closed cylindrical container is partially filled with water. As the container rotates in a

horizontal plane about a perpendicular bisector, its moment of inertia.

A. increases

B. decreases

C. remains constant

D. depends on direction of rotation

Answer: A

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6. A rigid body rotates with an angular momentum L. If its kinetic energy is halved, the angular momentum becomes,

A. L

B. $L/2$

C. 2L

D. $L\sqrt{2}$

Answer: D

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7. A particle undergoes uniform circular motion. The angular momentum of the particle remain conserved about:

A. the center point of the circle

B. the point on the circumference of the circle

C. any point inside the circle

D. any point outside the circle

Answer: A

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8. When a mass is rotating in a plane about a fixed point, its angular momentum is directed along

A. a line perpendicular to the plane of rotation

B. the line making an angle of 45° to the plane of rotation

C. the radius

D. angent to the path

Answer: A

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9. Two discs of same moment of inertia rotating about their regular axis passing through centre and perpendicular to the plane of disc with angular velocities ω_1 and ω_2. They are brought in to contanct face to face

coinciding the axis of rotation. The expression for loss of energy during this process is

A. $\frac{1}{4}I(\omega_1 - \omega_2)^2$

B. $I(\omega_1 - \omega_2)^2$

C. $\frac{1}{8}I(\omega_1 - \omega_2)^2$

D. $\frac{1}{2}I(\omega_1 - \omega_2)^2$

Answer: A

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10. A disc of moment of inertia la is rotating in a horizontal plane about its symmetry axis with constant angular speed co. Another discinitially at rest of moment of inertia I, is dropped coaxially on to the rotating disc. Then, both the discs rotate with same constant angular speed The loss of kinetic energy due to friction in this process is,

A. $\frac{1}{2}\frac{I_b^2}{(I_a+I_b)}\omega^2$

B. $\frac{I_b^2}{(I_a+I_b)}\omega^2$

C. $\frac{(I_b-I_a)^2}{(I_a+I_b)}\omega^2$

D. $\frac{1}{2}\frac{I_b I_b}{2(I_a + I_b)}\omega^2$

Answer: A

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11. The ratio of the acceleration for a solid sphere (mass m and radius R) rolling down an incline of angle θ without slipping and slipping down the incline without rolling is,

A. $5:7$

B. $2:3$

C. $2:5$

D. $7:5$

Answer: A

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12. From a disc of radius R a mass M, a circular hole of diameter R, whose rim passes through the centre is cut. What is the moment of

inertia of the remaining part of the disc about a perpendicular axis passing through it

A. $15MR^2/32$

B. $13MR^2/32$

C. $11MR^2/32$

D. $9MR^2/32$

Answer: B

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13. The speed of a solid sphere after rolling down from rest without sliding on an inclined plane of vertical height h is

A. $\sqrt{\frac{4}{3}gh}$

B. $\sqrt{\frac{10}{7}gh}$

C. $\sqrt{2gh}$

D. $\sqrt{\frac{1}{2}gh}$

Answer: A

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14. The speed of the centre of a wheel rolling on a horizontal horizontal surface is v_0. A point on the rim in level with the centre will be moving at a speed of speed of:

A. zero

B. v_a

C. $\sqrt{v_o}$

D. $2v_0$

Answer: C

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15. A drum of radius R and mass M, rolls down without slipping along an inclined plane of angle θ. The frictional force:

A. dissipates kinetic energy as heat

B. decreases the rotational motion

C. decreases the rotational and translational motion

D. converts translational energy into rotational energy

Answer: D

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Textual Questions Solved Short Answer Questios

1. Define the center of mass of a body.

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2. Find out the center of mass for the given geometrical structures.

(a) Equilateral triangle

(b) Cylinder

(c) Square

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3. Define torque and mention its unit.

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4. What are the conditions in which force can not produce torque ?

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5. Give any two examples of torque in day-to-day life.

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6. What is the relation between torque and angular momentum?

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7. What is equilibrium ? (or) Define mechanical equilibrium of a rigid body.

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8. How do you distinguish between stable and unstable equilibrium?

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9. Define couple.

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10. State the principle of moments .

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11. Define centre of gravity.

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12. Mention any two physical significance of moment of inertia.

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13. What is the radius of gyration?

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14. State conservation of angular momentum.

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15. What are the rotational equivalents for the physical quantities (i) mass and (ii) force?

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16. What is the condition for pure rolling ?

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17. What is the difference between sliding and slipping ?

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Textual Questions Solved Long Answer Questios

1. Explain the types of equilibrium with suitable examples

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2. Explain the method to find the centre of gravity of irregularly shaped lamina.

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3. Explain why a cyclist bends while negotiating a curve road?

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4. Derive the expresssion for moment of inertia of a rod about its centre and perpendicular to the rod.

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5. Derive the expression for moment of inertia of a uniform ring about an axis passing thorugh the centre and perpendicular to the plane.

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6. Derive the expression for moment of inerita of a uniform disc about an axis passing through the centre and perpendicular to the plane.

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7. Discuss conservation of angular momentum with example.

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8. State and prove parallel axis theorem

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9. State and prove perpendicular axis theorem.

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10. Discuss the effect of rolling on inclined plane and derive the expression for the acceleration.

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Textual Questions Solved Conceptual Questions

1. When a tree is cut, the cut is made on the side facing the direction in which the tree is required to fall. Why?

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2. Why does a porter bend forward while carrying a sack of rice on his back ?

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3. Why is it much easier to balance a meter scale on your finger tip than balancing on a match stick ?

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4. Two identical water bottles one empty and the other filled with water are allowed to roll down an inclined plane. Which one of them reaches the bottom first ? Explain your answer.

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5. Write the relation between angular momentum and rotational kinetic energy. For two objects of same angular momentum, compare the moment of inertia using the graph.

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6. Three identical solid spheres move doen through three inclined planes A,B and C all same dimensions. A is without friction B is

undergoing pure rolling and C is rolling with slipping. Compare the kinetic energies E_A, E_B and E_C at the bottom.

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7. Which of the following statement is false?

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Textual Questions Solved Numerical Problems

1. A uniform disc of mass 100 g has a diameter of 10 cm. Calculate the total energy of the disc when rolling along a horizontal table with a velocity of 20 cm s^{-1}. (take the surface of table as reference).

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2. A particle of mass 5 units is moving with a uniform speed of $v = 3\sqrt{2}$ units in the XOY

plane along the line $y = x + 4$. Find the magnitude of angular momentum.

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3. A fly wheel rotates with a uniform angular acceleration. If its angular velocity increases form 20π rad/s to 40π rad/s in 10 seconds. Find the number of rotations in that period.

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4. A uniform rod of mass m and lengh I makes a constant angle θ with an axis of rotation which passes through one end of therod. Find the moment of inertia about this axis.

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5. Two particles P and Q of mass 1 kg and 3 kg respectively start moving towards each other form rest under mutual attraction. What is the velocity of their center of mass ?

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6. Find the moment of inertia of a hydrogen molecule about an axis passing through its center of mass and perpendicular to the interatomic axis. Given : mass of hydrogen atom 1.7×10^{-27} kg and inter atomic distance is equal to 4×10^{-10} m.

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7. The 747 being plane is landing at a speed of $70ms^{-1}$. Before touching the ground, the wheels are not rotating. How long a skid mark do the wing wheels leave (assume their mass is 100 kg which is distributed uniformly, radius is 0.7 m, and the coefficient of friction with the ground is 0.5)?

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Additional Questions Solved I Multiple Choice Question

1. The changes produced by the deforming forces in a rigid body are

A. very large

B. infinity

C. negligibly small

D. small

Answer: C

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2. When a rigid body moves all particles that constitute the body follows

A. same path

B. different path

C. either same or different path

D. circular path

Answer: B

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3. For bodies of regular shape and uniform mass distribution, the center of mass is at

A. the corners

B. inside the objects

C. the point where the diagonals meet

D. the geometric center

Answer: D

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4. For square and rectangular objects center of mass lies at

A. the point where the diagonals meet

B. at the corners

C. on the center surface

D. any point

Answer: A

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5. Center of mass may lie

A. within the body

B. outside the body

C. both (a) and (b)

D. only at the centre

Answer: C

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6. The dimension of point mass is

A. positive

B. negative

C. zero

D. infinity

Answer: C

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7. The motion of centre of mass of a system of two particles is unaffected by their internal forces

A. irrespective of the actual directions of the internal forces

B. only if they are along the line joining the particles

C. only if acts perpendicular to each othe

D. only if acting opposite

Answer: A

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8. A circular plate of diameter 10 cm is kept in contact with a square plate of side 10 cm. The density of the material and the thickness are same everywhere. The center of mass of the system will be

A. inside the circular plate

B. inside the square plate

C. At the point of contact

D. outside the system

Answer: B

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9. The centre of mass of a system of particles does not depend upon

A. masses of particles

B. position of the particles

C. distribution of masses

D. forces acting on the particles

Answer: D

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10. The Centre of mass of a solid cone along the line from the centre of the base to the vertex is at

A. $\frac{1}{2}$ th of its height

B. $\frac{1}{3}$ rd of its height

C. $\frac{1}{4}$ th of its height

D. $\frac{1}{5}$ th of its height

Answer: D

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11. All the particles of a body are situated at a distance of X from origin. The distance of the center of mass from the origin is

A. $\geq r$

B. $\leq r$

C. $= r$

D. $> r$

Answer: B

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12. A free falling body breaks into three parts of unequal masses. The center of mass of the

three parts taken together shifts horizontally towards

A. heavier piece

B. lighter piece

C. does not shift horizontally

D. depends on vertical velocity

Answer: C

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13. The distance between the centres of carbon and oxygen atoms in the gas molecule is 1.13Å. The centre of mass of the molecule relative to oxygen atom is

A. 0.602Å

B. 0.527Å

C. 1.13Å

D. 0.565Å

Answer: B

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14. The unit of position vector of center of mass is

A. kg

B. kgm^2

C. m

D. m^2

Answer: C

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15. The sum of moments of masses of all the particles in a system about the center of mass is

A. minimum

B. maximum

C. zero

D. infinity

Answer: C

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16. The motion of center of mass depends on

A. external forces acting on it

B. internal forces acting within it

C. both (a) and (b)

D. neither

Answer: A

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17. Two particles P and Q move towards with each other from rest with the velocities of 1 and $20ms^{-1}$ under the mutual force of attraction. The velocity of centre of mass is

A. $20ms^{-1}$

B. $20ms^{-1}$

C. $30ms^{-1}$

D. zero

Answer: D

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18. The reduced mass of the system of two particles of masses 2 m and 4 m will be

A. 2

B. $\frac{2}{3}m$

C. $\frac{3}{2}m$

D. $\frac{4}{3}m$

Answer: D

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19. The motion of the center of mass of a system consists of many particles describes its

A. rotational motion

B. vibratory motion

C. oscillatory motion

D. translator motion

Answer: C

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20. The positon of center of mass can be written in the vector form as

A. $\sum m_i \vec{r}_i$

B. $\sum m_i \vec{r}_i^2$

C. $\frac{\sum m_i \vec{r}_i}{M}$

D. $\frac{\sum m_i \vec{r}_i^2}{M}$

Answer: C

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21. The positions of two masses, x1 and x2. The position of center of mass is

A. $\frac{m_1 m_2}{m_1 x_1 + m_2 x_2}$

B. $m_1 x_1 + m_2 x_2$

C. $\frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$

D. $\frac{m(x_1 + x_2)}{m_1 + m_2}$

Answer: C

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22. In a two particle system, one particle lies at origin another one lies at a distance of X. Then the position of center of mass of these particles is

A. $\frac{m_2 X_2}{m_1 + m_2}$

B. $\frac{X}{2}$

C. $\frac{mX}{m_1 + m_2}$

D. $\frac{m_1 + m_2}{mX}$

Answer: B

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23. State the principle of moments .

A. $m_1X_2 = m_2X_1$

B. $\frac{m_1}{m_2} = \frac{X_2}{X_1}$

C. $\frac{m_1}{m_2} = \frac{X_1}{X_2}$

D. $\frac{m_1X_1}{m_2X_2} = 0$

Answer: B

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24. Infinitesimal quantity means

A. collective particles

B. extremely small

C. nothing

D. Extremely larger

Answer: B

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25. In the absence of external forces the center of mass will be in a state of

A. rest

B. uniform motion

C. may be at rest or in uniform motion

D. vibration

Answer: C

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26. The activity of the force to produce rotational motion in a body is called as

A. angular momentum

B. torque

C. spinning

D. drive force

Answer: B

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27. The moment of the external applied force about a point or axis of rotation is known as

A. angular momentum

B. torque

C. spinning

D. drive force

Answer: B

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28. Torque is given as

A. $\vec{r} . \vec{F}$

B. $\vec{r} \times \vec{F}$

C. $\vec{F} \times \vec{r}$

D. $rF \cos \theta$

Answer: B

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29. The magnitude of torque is

A. $rF\sin\theta$

B. $rF\cos\theta$

C. $rF\tan\theta$

D. rF

Answer: A

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30. The direction of torque acts

A. along $\overrightarrow{F}$

B. along $\vec{r}$ &$\vec{F}$

C. Perpendicular to $\vec{r}$

D. Perpendicular to both $\vec{r}$ and $\vec{F}$

Answer: D

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31. The unit of torque is

A. Js

B. Nm^{-2}

C. Nm

D. Js^{-1}

Answer: C

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32. The direction of torque is found using

A. left hand rule

B. right hand rule

C. palm rule

D. serew rule

Answer: B

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33. If the direction of torque is out of the paper then the rotation produced by the torque is

A. clockwise

B. anti-clockwise

C. Straight line

D. random direction

Answer: A

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34. If the direction of the torque is inward the paper then the rotation is

A. clockwise

B. anti-clockwise

C. Straight line

D. random direction

Answer: A

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35. If $\vec{r}$ and $\vec{F}$ are parallel or anti-parallel, then the torque is

A. zero

B. minimum

C. maximum

D. infinity

Answer: A

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36. the maximum possible value of torque is

A. zero

B. infinity

C. $\overrightarrow{r} + \overrightarrow{F}$

D. rF

Answer: D

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37. The relation between torque and angular acceleration is

A. $\vec{\tau} = \frac{I}{\vec{\propto}}$

B. $\vec{\propto} = \frac{\vec{\tau}}{I}$

C. $\vec{\propto} = I\vec{\tau}$

D. $\vec{\tau} = \frac{\overrightarrow{\propto}}{I}$

Answer: B

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38. Angular momentum is ..... Vector.

A. $\vec{p} \times \vec{r}$

B. $\vec{r} \times \vec{p}$

C. $\frac{\vec{r}}{\vec{p}}$

D. $\vec{r} \cdot \vec{p}$

Answer: B

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39. The magnitude of angular momentum is given by

A. rp

B. $rp\sin\theta$

C. $rp\cos\theta$

D. $rp\tan\theta$

Answer: A

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40. Angular momentum is associated with

A. rotational motion

B. linear motion

C. both (a) and (b)

D. circular motion only

Answer: C

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41. Angular momentum acts perpendicular to

A. $\overrightarrow{r}$

B. $\overrightarrow{p}$

C. both $\overrightarrow{r}$ and $\overrightarrow{p}$

D. plane of the paper

Answer: C

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42. Angular momentum is given by

A. $\frac{I}{\omega}$

B. $\tau\omega$

C. $I\omega$

D. $\frac{\omega I}{2}$

Answer: C

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43. The rate of change of angular momentum is

A. Torque

B. angular velocity

C. centripetal force

D. centrifugal force

Answer: A

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44. The force acting on a body it is a rest

A. is gravitational force

B. Normal force

C. Both gravitational as well as normal force

D. No force is acting'

Answer: C

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45. The net force acting on a body when it is at rest is

A. gravtitational force

B. Normal force

C. Sum of gravitational and normal force

D. zero

Answer: D

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46. If the net torque acting on the body is zero, then the body is in

A. translational equilibrium

B. rotational equilibrium

C. both (a) and (b)

D. none

Answer: A

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47. If the net torque acting on the body is zero, then the body is in

A. translational equilibrium

B. rotational equilibrium

C. mechanical equilibrium

D. none

Answer: B

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48. When the net force and net torque acts on the body is zero then the body is in

A. translational equilibrium

B. rotational equilibrium

C. mechanical equilibrium

D. none

Answer: D

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49. When the net force and net torque acts on the body is zero then the body is in

A. satic equilibrium

B. Dynamic equilibrium

C. both (a) and (b)

D. translational equilibrium

Answer: C

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50. When two equal and opposite forces acting on the body at two different points, it may give

A. net force

B. torque

C. stable equilibrium

D. none

Answer: B

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51. The torque in rotational motion is analogous to _____in translational motion.

A. linear momentum

B. mass

C. couple

D. force

Answer: D

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52. Which of the following example does not constitute a couple?

A. steering a car

B. turning a pen cap

C. ball rolls on the floor

D. closing the door

Answer: C

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53. If the linear momentum and angular momentum are zero, then the object is said to be in

A. stable equilibrium

B. unstable equilibrium

C. neutral equilibrium

D. all the above

Answer: D

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54. When the body is disturbed, the potential energy remains same, then the body is in

A. stable equilibrium

B. unstable equilibrium

C. neutral equilibrium

D. all the above

Answer: C

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55. The point where the entire weight of the body acts is called as

A. center of mass

B. center of gravity

C. both (a) and (b)

D. pivot

Answer: B

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56. The forces acting on a cyclist negotiating a circular level road is/are

A. gravitational forc

B. centrifugal force

C. frictional force

D. all the above

Answer: B

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57. While negotiating a circular level road a cyclist has to bend by an angle from vertical to stay in an equilibrium is

A. $\tan\theta = \frac{rg}{r^2}$

B. $\theta = \tan^{-1}\left(\frac{v^2}{rg}\right)$

C. $\theta = \sin\left(\frac{rg}{r^2}\right)$

D. zero

Answer: B

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58. Moment of inertia for point mass is

A. m^2r

B. rw^2

C. mr^2

D. zero

Answer: C

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59. Moment of inertia for bulk object

A. rm^2

B. rw^2

C. $m_i r_i^2$

D. $\sum m_i r_i^2$

Answer: D

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60. For rotational motion, moment of inertia is a measure of

A. translational inertia

B. mass

C. rotational inertia

D. invariable quantity

Answer: C

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61. Unit of moment of inertia

A. kgm

B. mkg^{-2}

C. kgm^2

D. kgm^{-1}

Answer: C

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62. The dimensional formula for moment of inertia.....

A. $\left[ML^{-2}\right]$

B. $\left[M^2L^{-1}\right]$

C. $\left[M^{-2}\right]$

D. $\left[ML^2\right]$

Answer: D

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63. Moment of inertia of a body is a

A. variable quantity

B. invariable quantity

C. constant quantity

D. measure of torque

Answer: A

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64. Moment of inertia of a thin uniform rod about an axis passing through the center of mass and perpendicular to the length is

A. $\frac{1}{3}Ml^2$

B. $\frac{1}{12}ml^2$

C. $\frac{1}{2}M\left(l^2+b^2\right)$

D. Ml^2

Answer: B

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65. The moment of inertia of a Thin rod about and axis passing through the centre and perpendicular to the length is _____.

A. $\frac{1}{3}Ml^2$

B. $\frac{1}{12}ml^2$

C. $\frac{1}{2}M\left(l^2+b^2\right)$

D. Ml^2

Answer: A

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66. Moment of inertia of a thin uniform rectangular sheet about an axis passing through the center of mass and perpendicular to the plane of the sheet is

A. $\frac{1}{3}Ml^2$

B. $\frac{1}{12}ml^2$

C. $\frac{1}{2}M\left(l^2+b^2\right)$

D. Ml^2

Answer: C

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67. Moment of inertia of a thin uniform ring about an axis passing through the center of gravity and perpendicular to the plane is

A. MR^2

B. $2MR^2$

C. $\frac{1}{2}MR^2$

D. $\frac{3}{2}MR^2$

Answer: A

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68. Moment of inertia of a thin uniform disc about an axis passing through the center lying on the plane (along diameter is)

A. MR^2

B. $2MR^2$

C. $\frac{1}{2}MR^2$

D. $\frac{3}{2}MR^2$

Answer: C

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69. Derive the expression for moment of inerita of a uniform disc about an axis passing through the centre and perpendicular to the plane.

A. MR^2

B. $2MR^2$

C. $\frac{1}{2}MR^2$

D. $\frac{2}{3}MR^2$

Answer: C

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70. Moment of inertia of a thin uniform disc about an axis passing through the center lying on the plane (along diameter is)

A. MR^2

B. $\frac{1}{2}MR^2$

C. $\frac{3}{2}MR^2$

D. $\frac{1}{4}MR^2$

Answer: D

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71. Moment of inertia of a thin uniform hollow cylinder about an axis of the cylinder is

A. MR^2

B. $\frac{1}{2}MR^2$

C. $\frac{3}{2}MR^2$

D. $\frac{1}{4}MR^2$

Answer: A

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72. Moment of inertia of a uniform hollow cylinder about an axis passing perpendicular to the length and passing through the center is

A. MR^2

B. $M\left(\frac{R^2}{2}+\frac{l^2}{12}\right)$

C. $\frac{1}{2}MR^2$

D. $M\left(\frac{R^2}{4}+\frac{l^2}{12}\right)$

Answer: B

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73. Moment of inertia of a uniform solid cylinder about an axis passing through the center and along the axis of the cylinder is

A. MR^2

B. $M\left(\frac{R^2}{2}+\frac{l^2}{12}\right)$

C. $\frac{1}{2}MR^2$

D. $M\left(\frac{R^2}{4}+\frac{l^2}{12}\right)$

Answer: C

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74. Moment of inertia of a uniform solid cylinder about as axis passing perpendicular to the length and passing through the center is

A. MR^2

B. $M\left(\frac{R^2}{2}+\frac{l^2}{12}\right)$

C. $\frac{1}{2}MR^2$

D. $M\left(\frac{R^2}{4}+\frac{l^2}{12}\right)$

Answer: D

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75. Moment of inertia of a thin hollow sphere about an axis passing through the center along its diameter is

A. $\frac{2}{3}MR^2$

B. $\frac{5}{3}MR^2$

C. $\frac{7}{5}MR^2$

D. $\frac{2}{5}MR^2$

Answer: A

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76. Moment of inertia of a thin hollow sphere about an axis passing through the edge along its tangent is

A. $\frac{2}{3}MR^2$

B. $\frac{5}{3}MR^2$

C. $\frac{7}{5}MR^2$

D. $\frac{2}{3}MR^2$

Answer: B

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77. Moment of inertia of a uniform solid sphere about an axis passing through the center along its diameter is

A. $\frac{2}{3}MR^2$

B. $\frac{5}{3}MR^2$

C. $\frac{7}{5}MR^2$

D. $\frac{2}{5}MR^2$

Answer: D

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78. Moment of inertia of a uniform solid sphere about an axis passing through the edge along its tangents is

A. $\frac{2}{3}MR^2$

B. $\frac{5}{3}MR^2$

C. $\frac{7}{5}MR^2$

D. $\frac{2}{3}MR^2$

Answer: C

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79. The ratio of K^2/R^2 of a thin uniform ring about an axis passing through the center and perpendicular to the plane is

A. 1

B. 2

C. $\frac{1}{2}$

D. $\frac{3}{2}$

Answer: A

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80. The ratio of K^2 / R^2 of a thin uniform ring about an axis passing through the center and perpendicular to the plane is

A. 1

B. 2

C. $\frac{1}{2}$

D. $\frac{3}{2}$

Answer: C

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81. When no extemal torque acts on the body, the net angular momentum of a rotating body

A. increases

B. decreases

C. increases or decreases

D. remains constant

Answer: D

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82. Moment of inertia of a body is proportional to

A. ω

B. $\frac{1}{\omega}$

C. ω^2

D. $\frac{1}{\omega^2}$

Answer: B

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83. When the hands are brought closer to the body, the angular velocity of the ice dancer

A. decreases

B. inreases

C. constant

D. may decreases or increases

Answer: B

Watch Video Solution

84. When the hands are stretched out from the body, the moment of inertia of the ice dancer

A. decreases

B. inreases

C. constant

D. may decreases or increases

Answer: B

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85. The work done by the torque is

A. F.ds

B. $F.\ d\theta$

C. $\tau d\theta$

D. $r.\ d\theta$

Answer: C

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86. Rotational Kinetic energy of a body is

A. $\frac{1}{2}mr^2$

B. $\frac{1}{2}I\omega^2$

C. $\frac{1}{2}Iv^2$

D. $\frac{1}{2}m\omega^2$

Answer: B

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87. Rotational kinetic energy is given by

A. $\frac{1}{2}mr^2$

B. $\frac{1}{2}Iv^2$

C. $\frac{L^2}{2I}$

D. $\frac{2I}{L^2}$

Answer: C

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88. If E is a rotational kinetic energy then angular momentum is

A. $\sqrt{2IE}$

B. $\frac{E^2}{2I}$

C. $\frac{2I}{E^2}$

D. $\frac{E}{I^2\omega^2}$

Answer: A

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89. The product of torque acting on a body and angular velocity is

A. Energy

B. power

C. workdone

D. kinetic energy

Answer: B

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90. The work done per unit time in rotational motion is given by

A. $\vec{F} . v$

B. $\frac{d\theta}{dt}$

C. $\tau\omega$

D. $I\omega$

Answer: C

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91. While rolling, the path of center of mass of an object is

A. straight line

B. parabola

C. hyperbola

D. circle

Answer: A

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92. In pure rolling, the velocity of the point of the rolling object which comes in contact with the surface line

A. maximum

B. minimum

C. zero

D. $2V_{CM}$

Answer: B

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93. In pure rolling velocity of center of mass is equal to

A. zero

B. $R\omega$

C. $\frac{\omega}{R}$

D. $\frac{R}{\omega}$

Answer: B

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94. In pure rolling, rotational velocity of points at its edges is equal to

A. $R\omega$

B. velocity of centre of mass

C. translational velocity

D. all the above

Answer: A

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95. Sliding of the object occurs when

A. $V_{\text{trans}} < V_{\text{rot}}$

B. $V_{\text{trans}} = V_{\text{rot}}$

C. $V_{\text{trans}} > V_{\text{rot}}$

D. $V_{\text{trans}} = 0$

Answer: C

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96. Sliding of the object occurs while

A. $V_{\text{trans}} = V_{\text{rot}}$

B. $V_{CM} = V_{\omega}$

C. $V_{CM} < R\omega$

D. $V_{CM} > R\omega$

Answer: D

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97. Sliding of the object occurs when

A. $V_{\text{trans}} < V_{\text{rot}}$

B. $V_{\text{trans}} = V_{\text{rot}}$

C. $V_{\text{trans}} > V_{\text{rot}}$

D. $V_{\text{trans}} = 0$

Answer: A

Watch Video Solution

98. Sliding of the object occurs when

A. $V_{\text{trans}} = V_{\text{rot}}$

B. $V_{CM} = V_{\omega}$

C. $V_{CM} < R\omega$

D. $V_{CM} > R\omega$

Answer: C

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99. In sliding, the resultant velocity of a point of contact acts along

A. forward direction

B. backward direction

C. either (a) or (b)

D. tangential direction

Answer: A

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100. In slipping, the resultant velocity of a point of contact acts along

A. forward direction

B. backward direction

C. either (a) or (b)

D. tangential direction

Answer: B

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101. When a solid sphere is undergoing pure rolling, the ratio of translational kinetic energy to rotational kinetic energy is

A. $2:5$

B. $5:2$

C. $1:5$

D. $5:1$

Answer: B

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102. Time taken by the rolling object in inclined plane to reach its bottom is

A. $\sqrt{\frac{1+\frac{k^2}{R^2}}{g\sin^2\theta}}$

B. $\sqrt{\frac{2gh}{1+\frac{k^2}{R^2}}}$

C. $\sqrt{\frac{2h\left(1+\frac{k^2}{R^2}\right)}{g\sin^2\theta}}$

D. $\sqrt{\frac{2h\left(1+\frac{R^2}{k^2}\right)}{g\sin^2\theta}}$

Answer: C

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103. The velocity of the rolling object on inclined plane at the bottom of inclined plane is

A. $\sqrt{\frac{1+\frac{k^2}{R^2}}{g\sin^2\theta}}$

B. $\sqrt{\frac{2gh}{1+\frac{k^2}{R^2}}}$

C. $\sqrt{\frac{2h\left(1+\frac{k^2}{R^2}\right)}{g\sin^2\theta}}$

D. $\sqrt{\frac{2h\left(1+\frac{R^2}{k^2}\right)}{g\sin^2\theta}}$

Answer: B

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104. Moment of inertia of an annular disc about an axis passing through the centre and perpendicula to the plane of disc is

A. $\frac{M}{2}\left(R_1^2+R_2^2\right)$

B. $\frac{M}{2}\left(R_1^2-R_2^2\right)$

C. $\frac{2}{M}\left(R_1^2+R_2^2\right)$

D. $\frac{2}{M}\left(R_1^2-R_2^2\right)$

Answer: A

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105. Moment of inertia of a thin uniform rod about an axis passing through the center of mass and perpendicular to the length is

A. $\frac{Ma^2}{6}$

B. $\frac{1}{3}Ma^2$

C. $\frac{Ma}{6}$

D. $\frac{Ma^2}{12}$

Answer: A

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106. Moment of inertia of a thin uniform rectangular sheet about an axis passing through the center of mass and perpendicular to the plane of the sheet is

A. $\frac{Ml^2}{12}$

B. $\frac{Ma^2}{12}$

C. $\frac{Mb^2}{12}$

D. $\frac{Ml^2}{6}$

Answer: C

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107. Rotational kinetic energy can be calculated by using

A. $\frac{1}{2}I\omega^2$

B. $\frac{L^2}{2I}$

C. $\frac{1}{2}L\omega$

D. all the above

Answer: A

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108. The radius of gyration of a solid sphere of radius about a certain axis is r. The distance of that axis from the centre of the sphere is

A. $\frac{2}{5}r$

B. $\sqrt{\frac{2}{5}}r$

C. $\sqrt{0.6}r$

D. $\sqrt{\frac{5}{3}}r$

Answer: C

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109. A wheel is rotating with angular velocity 2 rad/s. It is subjected to a uniform angular acceleration 2 rad/s2 then the angular velocity after 10s is

A. 12 rad/s

B. 20 rad/s

C. 22 rad/s

D. 120 rad/s

Answer: C

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110. Two rotating bodies A and B of masses mand 2m with moments of inertia I_A and $I_B(I_B > I_A)$ have equal kinetic energy of rotation. If L_A and L_B be their angular momenta respectively, then

A. $L_B > L_A$

B. $L_A > L_B$

C. $L_A = \frac{L_B}{2}$

D. $L_A = 2L_B$

Answer: A

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111. three identical particles lie in x y plane. The (x, y) coordinates of their positions are (3, 2), (1.1) and (5.3), respectively. The (x, y) coordinates of the centre of mass are

A. (1,2)

B. (a,b)

C. (3,2)

D. (2,1)

Answer: C

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112. A solid cylinder of mass 3 kg and radius 10 cm is rotating about its axis with a frequency

$20/\pi$. The rotational kinetic energy of the cylinder

A. $10\pi J$

B. $12J$

C. $\frac{6 \times 10^2}{\pi} J$

D. 3J

Answer: B

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113. A circular dise in rolling down in an inclined plane without slipping. The percentage of rotational energy in its total energy is

A. $66.61\ \%$

B. $33.33\ \%$

C. $22.22\ \%$

D. $50\ \%$

Answer: B

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114. A sphere rolls down in an inclined plane without slipping. The percentage of translational energy in its total energy is

A. $29.6\ \%$

B. $33.4\ \%$

C. $71.4\ \%$

D. $50\ \%$

Answer: C

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115. Two blocks of masses 10 kg and 4 kg are connected by a spring of negligible mass and placed on a frictionless horizontal surface. An impulse gives a velocity of 14 m's to the heavier block in the direction of the lighter block. The velocity of the center of mass is

A. 30 m/s

B. 20 m/s

C. 10 m/s

D. 5 m/s

Answer: C

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116. A mass is whirled in a circular path with constant angular velocity and its angular momentum is L. If the string is now halved keeping the angular velocity the same, the angular momentum is

A. $\frac{L}{4}$

B. $\frac{L}{2}$

C. L

D. 2L

Answer: A

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117. The moment of inertia of a thin uniform ring of mass 1 kg and radius 20 cm rotating about the axis passing through the center and perpendicular to the plane of the ring is

A. $4 \times 10^{-2} kgm^2$

B. $1 \times 10^{-2} kgm^2$

C. $20 \times 10^{-2} kgm^2$

D. $10 \times 10^{-2} kgm^2$

Answer: B

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118. A solid sphere is rolling down in the inclined plane, from rest without slipping. The angle of inclination with horizontal is 30°. The

linear acceleration of the sphere is___ (Assume $g = 10ms^{-2}$)

A. (a) $28ms^{-2}$

B. (b) $3.9ms^{-2}$

C. (c) $\frac{25}{7}ms^{-2}$

D. (d) $\frac{1}{20}ms^{-2}$

Answer: C

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119. An electron is revolving in an orbit of radius $2Å$ with a speed of $4 \times 10^5 m/s$. The angular momentum of the electron is $[M_e 9 = \times 10^{-31} kg]$.

A. $2 \times 10^{-35} kgm^2 s^{-1}$

B. $72 \times 10^{-36} kgm^2 s^{-1}$

C. $7.2 \times 10^{-34} kgm^2 s^{-1}$

D. $0.72 \times 10^{-37} kgm^2 s^{-1}$

Answer: B

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120. A raw egg and hard boiled egg are made to spin on a table with the same angular speed about the same axis. The ratio of the time taken by the eggs to stop is

A. $= 1$

B. < 1

C. > 1

D. none of these

Answer: D

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Additional Questions Solved I Short Answer Questions 1 Mark

1. What is rigid body ?

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2. When an object will have procession? Give one example

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3. Define angular momentum. Give an expression for it.

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4. When an angular momentum of the object will be zero?

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5. When an object be in mechanical equilibrium?

Watch Video Solution

6. Obtain an expression for the power delivered by torque.

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7. A boy sits near the edge of revolving circular dise

(i) What will be the change in the motion of a disc?

(ii) If the boy starts moving from edge to the center of the disc, what will happen?

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8. Are moment of inertia and radius of gyration of a body constant quantities?

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9. A cat is able to land on its feet after a fall. Which principle of physics is being used? Explain

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10. About which axis a uniform cube will have minimum moment of inertia?

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11. Explain the principle of moments of rotational equilibrium? Hence define mechanical advantage?

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12. Write down the moment of inertia of a disc of radius R and mass m about an axis in its plane at a distance R/2 from its centre.

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13. Can the couple acting on a rigid body produce translatory motion?

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14. Which component of linear momentum does not contribute to angular momentum ?

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15. A system is in stable equilibrium. What can we say about its potential energy?

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16. Is radius of gyration a constant quantity?

Watch Video Solution

17. Two solid spheres of the same mass are made of metals of different densities. Which of them has a large moment of inertia about the diameter?

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18. The moment of inertia of two rotating bodies A and B are 1_A and $I_B (I_A > I_B$ and

their angular moments are equal. Which one has a greater kinetic energy?

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19. A particle moves in a circular path with decreasing speed. What happens to its angular momentum?

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20. What is the value of instantaneous speed of the point of contact during pure rolling?

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21. Which physical quantity is conserved when a planet revolves around the sun?

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22. What is the value of torque on the planet due to the gravitational force of sun?

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23. If no external torque acts on a body, will its angular velocity be constant?

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24. Why there are two propellers in a helicopter?

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25. when a child sits stationary at one end of a long trolley moving uniformly with some speed on a smooth horizontal plane. The speed of the centre of mass of system (child and trolley),

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Additional Questions Solved Iii Short Answer Questions 2 Marks

1. State the factors on which the moment of inertia of a body depends.

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2. On what factors does radius of gyration of body depend?

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3. Why the speed of whirl wind in a Tornado is alarmingly high?

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4. Can a body be in equilibrium while in motion? If yes, give an example.

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5. If the object is at rest and no external force is applied on the object, the static friction acting on the object is

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6. If Earth contracts to half of its present radius what would be the length of the day at equator?

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7. An internal force cannot change the state of motion of centre of mass of a body. How does the internal force of the brakes bring a vehicle to rest?

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8. When does a rigid body said to be in equilibrium? State the necessary condition for a body to be in equilibrium.

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9. How will you distinguish between a hard boiled egg and a raw egg by spinning it on a table top?

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10. Equal torques are applied on a cylinder and a sphere. Both have same mass and radius rotates about its axis and sphere rotates about one of its diameter. Which will rotates acquire greater speed and why?

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11. In which condition a body lying in gravitational field is in stable equilibrium?

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12. Mention any two physical significance of moment of inertia.

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Additional Questions Solved Iii Short Answer Questions 3 Marks

1. Three mass points $m_1 m_2$ amd m_3 are located at the vertices of an equilateral triangle of length a. What is the moment of inertia of the system about an axis along the altitude of the triangle passing through m_1?

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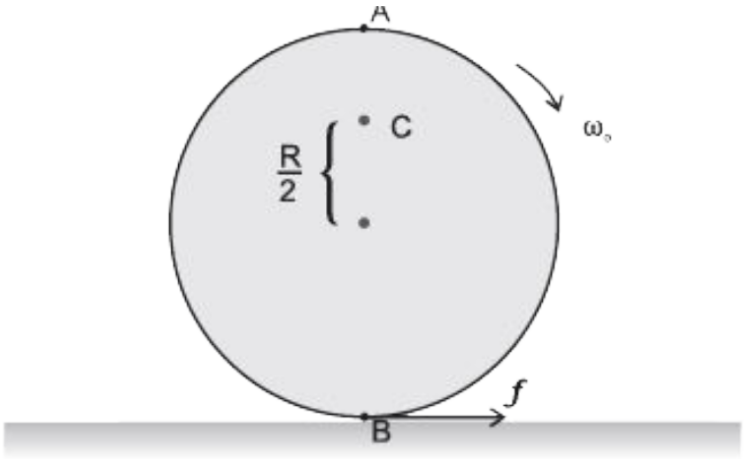
2. A disc rotating about its axis with angular speed ω_o is placed lightly (without any translational push) on a perfectly frictionless table. The radius of the disc is R. What are the linear velocities of the points A, B and C on the disc shown in Fig. 7.41? Will the disc roll in the direction indicated ?



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3. Find the torque of a corce $7\hat{i} - 3\hat{j} - 5\hat{k}$ about the origin which acts on a particle whose position vector is $\hat{i} + \hat{j} - \hat{k}$

Given: $\overrightarrow{F} = 7\hat{i} - 3\hat{j} - 5\hat{k}$

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Additional Questions Solved Iii Numericals

1. Three masses 3 kg 4 kg and 5 kg are located at the comers of an equilateral triangle of side 1 m. Locate the centre of mass of the system.

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2. Two particles mass 100 g and 300 g at a given time have velocities $10\hat{i} - 7\hat{j} - 3\hat{k}$ and $7\hat{i} - 9\hat{j} + 6\hat{k} ms^{-1}$ respectively. Detegnine yelocity of center of mass.

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3. From a uniform disc of radius R, a circular disc of radius R/2 is cut out. The centre of the hole is at R/2 from the centre of original disc. Locate the centre of gravity of the resultant flat body.

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4. The angular speed of a motor wheel is increased from 1200 rpm to 3120 rpm in 16

seconds, (i) What is its angular acceleration (assume the acceleration to be uniform) (ii) How many revolutions does the wheel make during this time?

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5. A metre stick is balanced on a knife edge at its centre. When two coins, each of mass 5 gare put one on top of the other at the 12.0 cm mark, the stick is found to be balanced at 45.0 cm, what is the mass of the meter stick?

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6. A solid sphere is rolling on a frictionless plane surface about its axis of symmetry. Find ratio of its rotational energy to its total energy.

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7. Calculate the ratio of radii of gyration of a circular ring and dise of the same radius with

respect to the axis passing through their centres and perpendicular to their planes.

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8. Two discs of moments of inertia l_1 and I_2 about their respective axes (normal to the disc and passing through the centre), and rotating with angular speed ω_1 and ω_2 are brought into contact face to face with their axes of rotation coincident, (i) What is the angular speed the two-disc system? (i) Show that the

kinetic energy of the combined system is less than the sum of the initial kinetic energies of the two discs. How do you account for this loss in energy? Take $\omega_1 \neq \omega_2$.

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9. In the HCI molecule, the separation between the nuclei of the two atoms is about $1.27\text{Å}\left(1\text{Å} = 10^{10}m\right)$. Find the approximate location of the CM of the molecule, given that the chlorine atom is about 35.5 times as

massive as a hydrogen atom and nearly all the mass of an atom is concentrated in all its nucleus.

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10. A child stands at the centre of turn table with his two arms out stretched. The turn table is set rotating with an angular speed of 40 rpm. How much is the angular speed of the child if he folds his hands back and thereby reduces his moment of inertia to 2/5 times the

initial value? Assume that the turn table rotates without friction (ii) Show that the child's new kinetic energy of rotation is more than the initial kinetic energy of rotation. How do you account for this increase in kinetic energy?

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11. To maintain a rotor at a uniform angular speed of 200 rad san engine needs to transmit a torque of 180 Nm. What is the power

required by the engine? Assume that the engine is 100% cfficient

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12. A car weighs 1800 kg. The distance between its front and back axles is 1.8 m. Its centre of gravity is 1.05 m behind the front axle. Determine the force exerted by the level ground on each front and back wheel.

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Additional Questions Solved Iii Long Answer Questions 5 Marks

1. Derive an expression for center of mass for distributed point masses.

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2. Discuss the center of mass of two point masses with pictorial representation.

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3. Derive an expression for kinetic energy in rotation and establish the relation between rotational kinetic energy and angular momentum.

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4. Discuss how the rolling is the combination of translational and rotational and also possibilities of velocity of different points in pure rolling,

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5. Derive an expression for kinetic energy in pure rolling.

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6. (i) Can a body in translatory motion have angular momentum? Explain

(ii) Why is it more difficult to revolve a stone by tying it to a longer string than by tying it to a shorter string?

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