



## PHYSICS

### BOOKS - JEEVITH PUBLICATIONS PHYSICS (KANNADA ENGLISH)

### SYSTEMS OF PARTICLES AND ROTATIONAL MOTION

**One Mark Question And Answers**

1. What is a rigid body?



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2. What is meant by translatory motion ?



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3. What is meant by rotatory motion ?



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4. What is meant by axis of rotation ?



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5. What is precession related to rotatory motion of bodies ?



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6. Give an example for bodies describing both translatory and rotatory motion.



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7. Give the expression for the centre of mass of a system of particles along any one axis.





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8. If  $\vec{R}$  is the position vector of the centre of mass, then express the same in terms of product 'mr' of all the particles and mass M of the rigid body.



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9. If the centre of mass lies at the origin of the frame of reference then what is the magnitude of position vector of the centre of mass of the system ?



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**10.** Express the position vector of centre of mass of a rigid body for a continuous distribution of mass particles.



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**11.** Say whether centre of mass necessarily coincide with the geometric centre of a triangle or not.



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12. How does centre of mass of a system of particles move ?



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13. Say whether internal forces exerted by the particles on one another contribute anything to the motion of the centre of mass or not.



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**14.** What will be the total linear momentum of a system of particles in a rotatory motion ?



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**15.** Under what condition will the total linear momentum of a system be zero ?



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**16.** What will be the velocity of the centre of mass, when the total external force on the system is zero

?



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**17.** Define cross-product of two vectors.



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**18.** Why is  $\hat{i} \times \hat{i} = \hat{j} \times \hat{j} = \hat{k} \times \hat{k} = 0$ ?



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19. Represent cross product of two vectors in determinant form.



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20. Define angular momentum of a rigid body.



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21. What is the direction of angular velocity of a rotating body ?



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22. Write relation between angular velocity and linear velocity,



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23. Define angular velocity.



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24. Define angular acceleration.



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25. Define moment of force or torque.



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26. State the law of conservation of angular momentum.



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27. Define couple



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**28.** How is the moment of couple measured ?



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**29.** State the principle of moments.



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**30.** What will be the moment of force taken about a point and acting on the axis of rotation ?



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**31.** What is a load arm ?



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**32.** What is an effort arm ?



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**33.** Define mechanical advantage (M.A) of a simple machine or state the principle of lever.



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**34.** Define the centre of gravity (C.G) of a body.



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**35.** What is the analogue of mass in rotational motion?



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**36.** Mention the S.I unit of moment of inertia.



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**37.** State whether moment of inertia is a scalar or a vector physical quantity



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**38.** Define the term radius of gyration.



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**39.** What is a flywheel ?



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40. Give any one advantage of using a flywheel in a huge automobile.



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41. State and explain parallel axis theorem and perpendicular axis theorem.



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42. State the theorem of parallel axis.



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**43.** Give the expression for the kinetic energy of a rotating body.



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**44.** Give the expression for the angular displacement in terms of angular acceleration and time taken.



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**45.** Express angular acceleration of a body in terms of angular speed and angular displacement



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**46.** Represent angular acceleration in terms of angular speed and time taken.



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**47.** Relate torque with angular acceleration



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**48.** What is required to overcome the moment of inertia of a body ?



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**49.** Write the expression for work done by a force in a rotational motion of a body.



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**50.** Give the expression for the instantaneous power in the case of a rotating body.



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**51.** State the law of conservation of angular momentum.



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**52.** Give the general expression for the K.E of a rolling body.



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**53.** Write the expression for the final linear speed of centre of mass of rolling body on an inclined plane.



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**54.** What is the radius of gyration for (a) circular ring and (b) circular disc about an axis passing through the centre and perpendicular to their planes ?



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55. What the is radius of gyration of a (a) hollow sphere and (b) solid sphere about an axis passing through the centre along any diameter ?



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56. What is the radius of gyration for a (a) hollow cylinder (b) solid cylinder about an axis passing along the length (axis of cylinder) ?



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**57.** What is the radius of gyration for a thin rod about an axis perpendicular to the length and axis passing through the midpoint of the rod ?



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**58.** Define centre of mass of a body. Give the location of centre of mass of a sphere.



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**59.** Does the centre of mass of a body necessarily be inside the body ?



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**60.** What is a rolling motion ?



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**61.** What are parallel forces ?



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**62.** What are like parallel forces ?



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**63.** What are unlike parallel forces ?



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**64.** How is torque or moment of force measured ?



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**65.** Write the dimensional formula for Force



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**66.** Can a single force balance a couple ?



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**67.** When are the moments of a force, minimum and maximum on a body ?



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**68.** Give the sign conventions for moment of force.



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**69.** What is the effect of a couple acting on a body ?



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**70.** State the law of moment.



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**71.** Mention the SIU of moment of force.



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**72.** Give an example for a couple.



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**73.** Define Moment of Inertia.



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## Two Marks Questions With Answers

1. Give the expression for the velocity of a sliding body on an inclined plane.



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2. Give the expression for the centre of mass of a system of particles along any one axis.



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3. Explain the physical significance of the equation

$M\vec{A} = \vec{F}_{ext}$ , where 'M' is the mass of the whole rotating body and  $\vec{A}$  is the acceleration of the centre of mass of the system of particles.



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4. If

$$A = (x_1, y_1, z_1), B = (x_2, y_2, z_2), C = (x_3, y_3, z_3)$$

represent coordinates of the three vertices of a triangular lamina then find the centre of mass of the lamina.



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5. Represent cross product of two vectors pictorially.



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6. Indicate  $\vec{r}$ ,  $\vec{F}$  and  $\vec{\tau}$  in a diagram, where symbols have their usual meanings.



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7. What are the factors on which the moment of a couple depend ?



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8. Mention the SI unit of torque. Though dimensional formula of work and torque is the same, joule is not used to measure torque. Explain why ?



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9. Express the condition for external torque on a body for a constant angular momentum.



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10. What will be the angular acceleration of a rotating body , in the absence of any external torque ?



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11. Define angular momentum of a rigid body.





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## Three Marks Question With Answers

1. If the coordinates of three mass points are in the  $x, y$  plane, then express the centre of mass with respect to the origin.



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2. If the position vector of the  $i^{th}$  particle is  $x_1 = x_i + y_i \hat{j} + z_i \hat{k}$ , then represent the centre of mass of such a system.



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3. Give an expression for the velocity and acceleration of the centre of mass of a system of particles.



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4. Give the expression for the angular velocity of a body in terms of radius and velocity vectors. Represent the direction of angular velocity with the help of a neat labelled diagram.





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5. Give the expression of torque in terms of radius and force vectors. Represent moment of Force/torque acting on a body with a neat labelled diagram.



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6. Starting from the definition of angular momentum in terms of position vector and linear momentum vectors. S.T. the time derivative of

angular momentum is equal to the torque acting on the particle.



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7. S.T. the time rate of the total angular momentum of a system of particles about a point is equal to the sum of the external torques acting on the system taken about the same point.



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8. Write the general conditions for equilibrium of a rigid body .



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9. S.T the moment of a couple does not depend on the point about which the body rotates.



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10. State the principle of moments.



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11. Define moment of inertia and hence Obtain an expression for rotational kinetic energy.



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12. Explain the law of conservation of angular momentum in the case of ballet dancer



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**13.** Explain the law of conservation of angular momentum in the case of acrobat performing somersault.



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**14.** What are the properties of a couple acting on a body ?



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**15.** State and explain the law of moments.





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**16.** State the conditions of equilibrium of a system of coplanar forces.

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**17.** How is the resultant of two like parallel forces obtained, using the theorem of moments ?

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1. State and explain the theorem of parallel axis with an example



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2. State and explain the theorem of perpendicular axis with an example.



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3. Obtain an expression for the work done by a torque.



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4. What is the moment of a couple ? State any three characteristics of a couple . Give any one illustration for a couple.



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5. (i) Show that (a)  $\omega = \omega_0 + \alpha t$



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6.  $\theta = \theta_0 + \omega_0 t + \frac{1}{2} \alpha t^2$  from the first principles of differentiation.



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## Numerical With Solutions

1. A non-uniform bar of weight 'w' is suspended at rest by two strings of negligible weight. The angles made by the strings with the vertical are  $36.9^\circ$  and  $53.1^\circ$  respectively. The bar is 2m long. Calculate the distance 'd' of the centre of gravity of the bar

from its left. (refer fig).-NCERT



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2. A solid sphere of mass 2kg is rolling down an inclined plane of angle of inclination  $30^\circ$ . What is the agent which supplies the external torque for the rotational motion of the sphere ? Calculate torque if radius is 0.40m ( $g = 10ms^{-2}$ )



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3. If the Earth were to suddenly contract to half its present radius, by how much would the day time decrease ?



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4. If a force of  $\vec{F} = -3\vec{i} + \vec{j} + 5\vec{k}$  acts at a point  $\vec{r} = 7\vec{i} + 3\vec{j} + \vec{k}$ , then calculate the torque produced by the force.



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5. The maximum and minimum distance of a comet from the sun are  $1.4 \times 10^{12} \text{m}$  and  $7 \times 10^{10} \text{m}$ . If its velocity nearest to the sun is  $6 \times 10^4 \text{ms}^{-1}$ , then what is the velocity at the farthest position ? Assume the path of the comet as circular.



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6. Calculate the angular speed of rotation of the Earth



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7. Calculate the angular speeds of the second, minute and hour hands of a 12 hour dial clock.



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8. Four spheres each of diameter  $0.02\text{m}$  and  $0.10\text{ kg}$  are placed with their centres on the vertices of a square of side  $0.05\text{m}$ . Calculate the moment of inertia of the system about one side of the taken as the axis of rotation.



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9. A flywheel initially rotating at 120 rpm retards and its angular speed reduces to 10 rpm. If the retardation is uniform and time taken is 1.5 s, then calculate the number of rotations made before coming to a stop.



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10. A uniform solid rod of mass 40kg and length 10m rests against a vertical smooth wall making an angle of  $30^\circ$  with the vertical. Find the force of friction ( $f$ ) and normal reaction ( $R$ ) exerted by the ground on the rod.



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11. An oxygen molecule has a mass of  $5.30 \times 10^{-26}$  kg and a moment of inertia of  $1.94 \times 10^{-46} \text{ kgm}^2$  about an axis through its centre perpendicular to the lines joining the two atoms. Suppose the mean speed of such a molecule in a gas is  $500 \text{ ms}^{-1}$  and that its kinetic energy of rotation is two thirds of its kinetic energy of translation Find the average angular velocity of the molecule.



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**12.** A solid cylinder rolls up an inclined plane of angle of inclination  $30^\circ$ . At the bottom of the inclined plane the centre of mass of the cylinder has a speed of  $5\text{ms}^{-1}$

How far will the cylinder go up the plane ?



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**13.** A solid cylinder rolls up an inclined plane of angle of inclination  $30^\circ$ . At the bottom of the inclined plane the centre of mass of the cylinder has a speed of  $5\text{ms}^{-1}$

How long will it take to return to the bottom ?





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**14.** A solid rolls down two different inclined planes of the same heights but different angle of inclination.

Will it reach the bottoms with the same speed in each case ?



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**15.** A solid rolls down two different inclined planes of the same heights but different angle of inclination.

Will it take longer to roll down one plane than the other ?



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**16.** A solid rolls down two different inclined planes of the same heights but different angle of inclination.

If so, which one and why ?



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**17.** A rope of negligible mass is wound round a hollow cylinder of mass 5 kg and radius 0.40m. What is the linear acceleration of the cylinder if the rope is pulled with a force of 30N ?



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



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**19.** A metre stick is balanced on knife edge at its centre . When two coins, each of mass 5g are put one on top of the other at the 12.0cm mark, the stick is found to be balanced at 45.0cm. What is the mass of the metre stick ?



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**20.** In the HCl molecule, the separation between the nuclei of the two atoms is about  $1.27\text{\AA}$ . Find the approximate location of the centre of mass 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 its nucleus.



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**21.** A man stands on a rotating platform with his arms outstretched horizontally holding a 5 kg weight in each hand. The angular speed of the platform is 30rpm. The man then brings his arms back to his body with the distance of each weight from the axis changing from 0.90m to 0.20m. The



moment of inertia of the man together with the platform may be taken to be constant and equal to  $7.6\text{kgm}^2$

What is his new angular speed ?



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**22.** A man stands on a rotating platform with his arms outstretched horizontally holding a 5 kg weight in each hand. The angular speed of the platform is 30rpm. The man then brings his arms back to his body with the distance of each weight from the axis changing from 0.90m to 0.20m. The

moment of inertia of the man together with the platform may be taken to be constant and equal to  $7.6\text{kgm}^2$

Is K.E conserved in the process ? If not, from where does the change come about ?



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**23.** A bullet of mass  $10\text{g}$  and speed  $500\text{ms}^{-1}$  is fired into a door and gets embedded exactly at the centre of the door. The door is  $1.0\text{m}$  wide and weighs  $12\text{kg}$ . It is hinged at one end and rotates about a vertical axis practically without friction.

Find the angular speed of the door just after the bullet embeds into it



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**24.** A cylinder of mass 10kg and radius 0.15m is rolling perfectly on a plane of inclination  $30^\circ$ . The coefficient of static friction  $\mu_s = 0.25$

How much is the force of friction acting on the cylinder ?



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25. A cylinder of mass 10kg and radius 0.15m is rolling perfectly on a plane of inclination  $30^\circ$ . The coefficient of static friction  $\mu_s = 0.25$

What is the work done against friction during rolling ?



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26. A cylinder of mass 10kg and radius 0.15m is rolling perfectly on a plane of inclination  $30^\circ$ . The coefficient of static friction  $\mu_s = 0.25$

If the inclination  $\theta$  of the plane is increased, at

what value of  $\theta$  does the cylinder begin to skid and not roll perfectly.



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27. A solid disc and a string, both of radius 0.10m are placed on a horizontal table simultaneously, with the initial angular speed equal to  $10\pi rad^{-1}$ . Which of the two will start to roll earlier ? The coefficient of kinetic friction is  $\mu_k = 0.2$



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28. S.T.  $v^2 = \frac{2gh}{1 + \frac{K^2}{R^2}}$  for the rolling object on an inclined plane of height (h) using dynamical Consideration.



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29. Two boys weighting 25kg and 35kg sit on either end of a light pole. Find the point about which the pole remains horizontal if the pole is 6m long.  
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**30.** Two boys weighing 30kg and 50kg are sitting on either side of the fulcrum of a see saw at distance 2m and 3m respectively. Where should a man of 60kg must sit to balance the see-saw ?



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**31.** A uniform pole of mass 20kg and length 6m is supported horizontally at its ends by two knife edges A and B. A mass of 120kg is now suspended at a distance 2m from A. Calculate reaction forces at the knife edges.



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**32.** A ladder weighing 20kg wt rests with its one end against a smooth vertically wall and the other end against the smooth floor. If the inclination of the ladder to the horizontal is  $60^\circ$  then calculate the horizontal force required at the lower end so that it does not slip.



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**33.** A uniform plank of length 4m and weighing 50kg is supported at two knife edges each at 1m



from the ends of the plank. How close to the end of the plank can a man weighing 70kg walk before it tips.



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**34.** Find the torque about the point 'A' in the following diagram



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