KD EDUCATION ACADEMY [9582701166]

Time : 7 Hour | **Physics** | **Total Marks : 410**

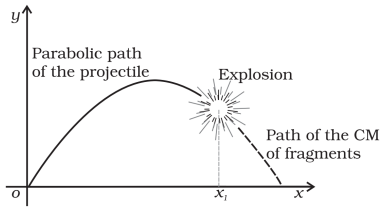
kd 90+ ch-6 system of particles and rotational motion

*** Choose The Right Answer From The Given Options.[1 Marks Each] [44]**

1. A particle performing uniform circular motion has angular momentum L. If its angular frequency is doubled and its kinetic energy halved, then the new angular momentum is:

(A) $4L$ (B) $\frac{L}{2}$ (C) $\frac{L}{4}$ (D) $2L$

2. A projectile is fired at an angle and it was following a parabolic path. Suddenly, it explodes into fragments. Choose the correct option regarding this situation.



(A) Due to explosion CM shifts upwards.

(B) Due to explosion CM shifts downwards.

(C) Due to explosion CM traces its path back to origin.

(D) CM continues to move along same parabolic path.

3. If a girl rotating on a chair bends her hand as shown in figure the (neglecting frictional force).

(A) I girl will reduce. (B) I girl will increase.

(C) Girl will reduce. (D) None of the above.

4. A wheel of radius 20cm is pushed to move it on a rough horizontal surface. It is found to move through a distance of 60cm on they road during the time it completes one revolution about the centre. Assume that the linear and the angular accelerations are uniform. The frictional force acting on the wheel by the surface is:

(A) Along the velocity of the wheel.

(B) Opposite to the velocity of the wheel.

(C) Perpendicular to the velocity of the wheel.

(D) Zero.

5. A torque of 0.5Nm is required to drive a screw into a wooden frame with the help of a screw driver. If one of the two forces of couple produced by screw driver is 50N, the width of the screw driver is:

(A) 0.5cm (B) 0.75cm (C) 1cm (D) 1.5cm

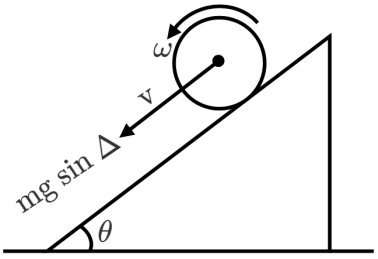
6. A body of mass 5kg undergoes a change in speed from 30 to 40m/ s. Its momentum would increase by:

(A) 50kgm/ s (B) 75kgm/ s (C) 150kgm/ s (D) 350kgm/ s

7. A metallic sphere having mass 2kg is moving with a velocity of 10m/ s. The momentum of the sphere in kg metre/ sec. will be-

(A) $\frac{1}{5}$ (B) 5 (C) 12 (D) 20

8. Sphere is in pure accelerated rolling motion in the figure shown,



Choose the correct option:

(A) The direction of f, is upwards.

(B) The direction of f, is downwards.

(C) The direction of gravitational force is upwards.

(D) The direction of normal reaction is downwards.

9. A bomb travelling in a parabolic path explodes in mid air. The centre of mass of fragments will:

(A) Move vertically upwards and then downwards.

(B) Move vertically downwards.

(C) Move irregularly.

(D) Move in parabolic path, the unexploded bomb would have travelled.

10. If a body of mass M collides against a wall with velocity V and rebounds with the same speed, then its change of momentum will be:

(A) Zero (B) MV (C) 2MV (D) -2MV

11. If there is no external force acting on a nonrigid body, which of the following quantities must remain constant?

(A) Angular momentum. (B) Linear momentum.

(C) Kinetic energy. (D) Moment of inertia.

12. A flywheel making 120r.p.m is acted upon by a retarding torque producing angular retardation of π rad/ s^2. Time taken by it to come to rest is:

(A) 1s (B) 2s (C) 3s (D) 4s

13. A cylindrical solid of mass M has radius R and length L. Its moment of inertia about a generator is:

(A) $\mathrm{M}\left(\frac{1}{2\mathrm{R}}+\frac{\mathrm{R}^2}{4}\right)$ (B) $\mathrm{M}\left(\frac{\mathrm{L}}{3}+\frac{\mathrm{R}^2}{4}\right)$

(C) $\frac{1}{2}MR^2$ (D) $\frac{3}{2}MR^2$

14. A hollow sphere and a solid sphere having same mass and same radii are rolled down a rough inclined plane:

(A) The hollow sphere reaches the bottom first.

(B) The solid sphere reaches the bottom with greater speed.

(C) The solid sphere reaches the bottom with greater kinetic energy.

(D) The two spheres will reach the bottom with same linear momentum.

15. Three objects of same mass but different geometries, capable of rotating have radius of gyration as 0.2, 0.5 and 0.7. A torque is applied to these objects when they are rotating with constant angular velocity. Which object will have a larger response time for showing the change in their angular velocity:

(A) Object with a radius of gyration of 0.7 will take a long time to respond to the torque.

(B) Object with a radius of gyration of 0.5 will take a long time to respond to the torque.

(C) Object with a radius of gyration of 0.2 will take a long time to respond to the torque.

(D) All objects with have same response time.

16. A body rolls down an inclined plane. If its kinetic energy of rotational motion is 40% of its kinetic energy of translational motion, then the body is a:

(A) Ring. (B) Cylinder.

(C) Spherical shell. (D) Solid sphere.

17. Let $\overrightarrow{A}$ be a unit vector along the axis of rotation of a purely rotating body and $\overrightarrow{B}$ be a unit vector along the velocity of a particle P of the body away from the axis. The value of $\overrightarrow{A} . \overrightarrow{B}$ is:

(A) 1 (B) -1 (C) 0 (D) None of these.

18. The radius of gyration of a uniform rod of length L about an axis passing through its centre of mass is:

(A) $\frac{L}{\sqrt{12}}$ (B) $\frac{L}{\sqrt{2}}$ (C) $\frac{L^2}{12}$ (D) $\frac{L^2}{\sqrt{3}}$

19. Two spheres of same size one of mass 2kg and another of mass 4kg are dropped simultaneously from the top of Qutab Minar (height = 72m). When they are 1m above the ground, the two spheres have the same:

(A) momentum (B) kinetic energy

(C) potential energy (D) acceleration

20. A body of mass 100g is moving with a velocity of 15m/ s. The momentum associated with the ball will be:

(A) 0.5kg m/ s (B) 1.5kg m/ s (C) 2.5kg m/ s (D) 3.2Ns

21. Rolling of ball on the ground is the instance of _____ as well as _____?

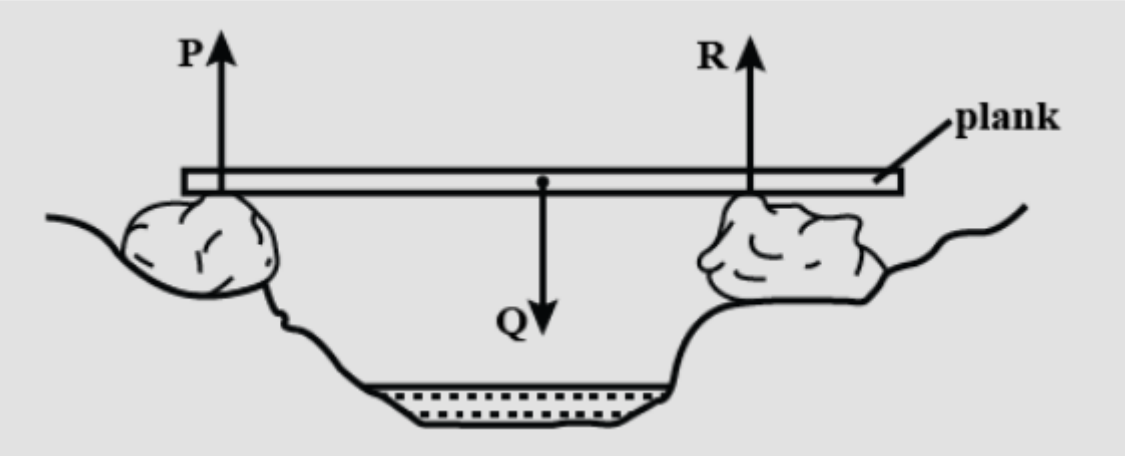
(A) Periodic motion, rotational motion.

(B) Oscillatory motion, rotational motion.

(C) Curvilinear motion, rotational motion.

(D) Rectilinear motion, rotational motion.

22. A wooden plank rests in equilibrium on two rocks on opposite sides of a narrow stream. Three forces P, Q and R act on the plank. How are the sizes of the forces related?



(A) P + Q = R (B) P + R = Q (C) P = Q = R (D) P = Q + R

23. Two particles A and B initially at rest move towards each other under a mutual force of attraction. The speed of centre of mass at the instant when the speed of A is v and the speed of B is 2v is:

(A) V (B) Zero (C) 2v (D) 3v/ 2

24. The centre of mass of a system particles does not depend on:

(A) Masses of the particles.

(B) Internal forces on the particle.

(C) Position of the particles.

(D) Relative distance between the particles.

25. Two balls of different masses have the same KE. Then the:

(A) Heavier ball has greater momentum than the lighter ball.

(B) Lighter Will has greater momentum than the heavier ball.

(C) Both bans have equal momentum.

(D) Both balls have zero momentum.

26. A man of mass M is standing at the centre of a rotating turn table rotating with an angular velocity ω. The man holds two 'dumb bells' of mass $\frac{M}{4}$ each in each of his two hands. If he stretches his arms to a horizontal position, the turn table acquires a new angular velocity ω' where

(A) $\omega' = 2\omega$ (B) $\omega' = \frac{\omega}{2}$ (C) $\omega' > \omega$ (D) $\omega' < \omega$

27. The theorem of perpendicular axes is applicable for:

(A) Only planar bodies. (B) Only regular shaped bodies.

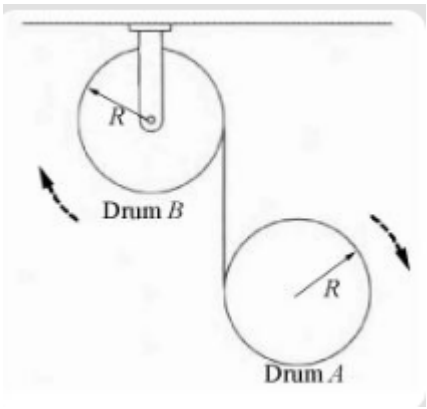
(C) Only three dimensional bodies. (D) None of the above.

28. The angular velocity of a wheel increases from 100 rps to 300 rps in 10 s. The number of revolutions made during that time is:

(A) 600 (B) 1500 (C) 1000 (D) 2000

29. The moment of inertia of a uniform semicircular wire of mass M and radius r about a line perpendicular to the plane of the wire through the centre is:

(A) Mr^2 (B) $\frac{1}{2}Mr^2$ (C) $\frac{1}{4}Mr^2$ (D) $\frac{2}{5}Mr^2$



30. Drum A undergoes:

(A) Rotational motion.

(B) Translational motion.

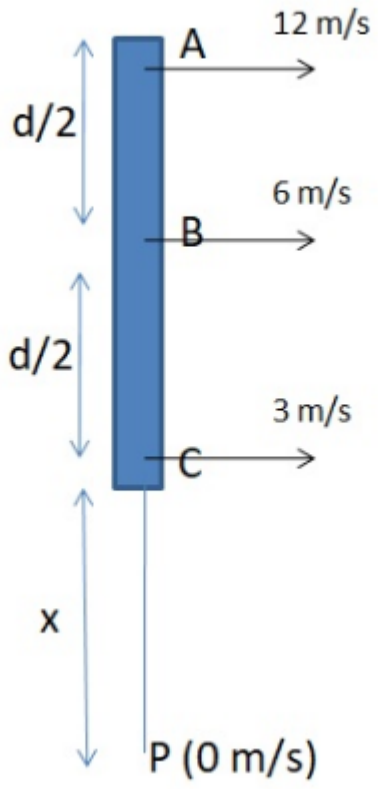
(C) Rotational as well as translational motion.

(D) None of these.

31. If the K.E. of a body is increased by 300%, its momentum will increase by _____.

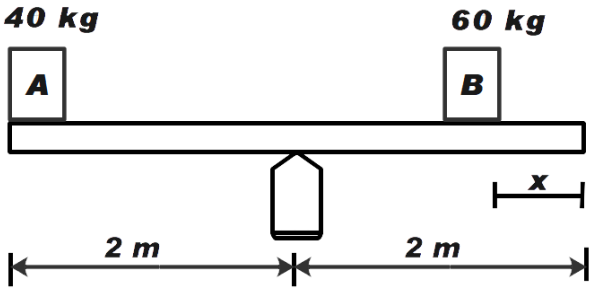
(A) 100% (B) 150% (C) $\sqrt{300}\%$ (D) 175%

32. In the image shown. AC is a rigid rod of length 12cms rotating about point P, whose velocities are shown in the figure. Find the distance PC = x



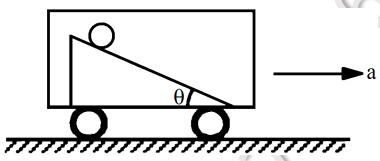
(A) 12cms (B) 8cms (C) 4cms (D) 2cms

33. In the game of see-saw, what should be the displacement of boy B from right edge to keep the see-saw in equilibrium? (M = 40kg, M_2 = 60kg.)



(A) $\frac{4}{3}$m (B) 1m (C) $\frac{2}{3}$m (D) Zero

34. Figure shows a smooth inclined plane fixed in a car accelerating on a horizontal road. The angle of incline 0 is related to the acceleration a of the car as a = g tan°. If the



sphere is set in pure rolling on the incline:

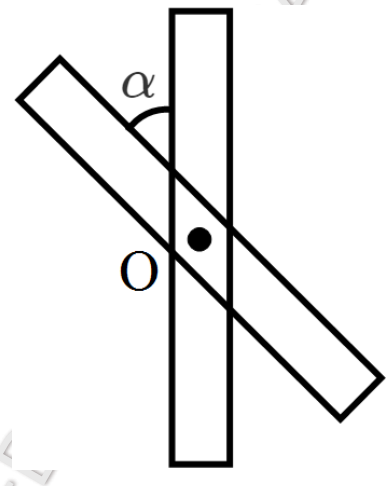
(A) It will continue pure rolling. (B) It will slip down the plane.

(C) Its linear velocity will increase. (D) Its linear velocity will slowly decrease.

35. A Merry-go-round, made of a ring-like platform of radius R and mass M, is revolving with angular speed ω A person of mass M is standing on it. At one instant, the person jumps off the round, radially away from the centre of the round (as seen from the round). The speed of the round afterwards is:

(A) 2ω (B) ω (C) $\frac{\omega}{2}$ (D) 0

36. Two identical rods of mass M and length I are lying in a horizontal plane at an angle a. The MI of the system of two rods about an axis passing through O and perpendicular to



the plane of the rods is:

(A) $\frac{Ml^2}{3}$ (B) $\frac{Ml^2}{12}$ (C) $\frac{Ml^2}{4}$ (D) $\frac{Ml^2}{6}$

37. A dancer on ice spins faster when she folds her arms. This is due to:

(A) Increase in energy and increase in angular momentum.

(B) Decrease in friction at the skates.

(C) Constant angular momentum and increase in kinetic energy.

(D) Increase in energy and decrease in angular momentum.

38. A sphere can roll on a surface inclined at an angle θ if the friction coefficient is more than $\frac{2}{7}g\tan\theta$. Suppose the friction coefficient is $\frac{1}{7}g\tan\theta$. If a sphere is released from rest on the incline:

(A) It will stay at rest.

(B) It will make pure translational motion.

(C) It will translate and rotate about the centre.

(D) The angular momentum of the sphere about its centre will remain constant.

39. A constant torque acting on a uniform circular wheel changes its angular momentum from L to 4L in 4 seconds. The magnitude of this torque is:

(A) $\frac{3L}{4}$ (B) 4L (C) L (D) 12L

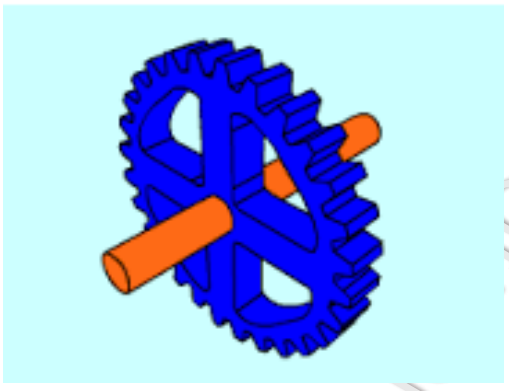
40. A body of mass 1kg is thrown with a velocity of $10ms^{-1}$ at an angle of 60° with the horizontal. Its momentum at the highest point is:

(A) $2kg\ ms^{-1}$ (B) $3kg\ ms^{-1}$ (C) $4kg\ ms^{-1}$ (D) $5kg\ ms^{-1}$

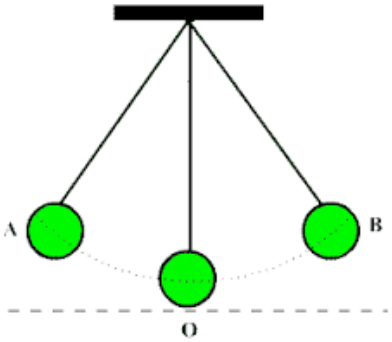
41. Which of the following doesn't represent rotatory motion?

(A)

(B)



(C)



(D) Both A and C

42. A particle of mass Mkg describes a circle of radius 1m. The centripetal acceleration of the particle is 4m/ s^2. What will be the momentum of the particle ?

(A) 4M (B) 2M (C) 8M (D) M

43. A person sitting firmly over a rotating stool has his arms stretched. If he folds his arms, his angular momentum about the axis of rotation:

(A) Increases. (B) Decreases.

(C) Remains unchanged. (D) Doubles.

44. What is the moment of inertia of a ring about a tangent to the periphery of the ring?

(A) $\frac{1}{2}\mathrm{MR}^2$ (B) $\frac{3}{2}\mathrm{MR}^2$ (C) MR^2 (D) $\mathrm{MR}^2\frac{2}{9}$

*** Answer The Following Questions In One Sentence.[1 Marks Each] [8]**

45. A rifle barrel has a spiral groove which imparts spin to the bullet. Why?

46. What type of motion is produced by couple?

47. Why do we place handles at maximum possible distance from the hinges in a door?

48. What is the moment of inertia of a sphere of mass 20kg and radius m about its diameter?

49. If the ice on the polar caps of the earth melts, how will it affect the duration of the day? Explain.

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

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

52. Explain how a cat is able to land on its feet after a fall taking advantage of the principle of conservation of angular momentum.

*** Given Section consists of questions of 2 marks each. [30]**

53. Find the scalar and vector products of two vectors. $a = (3\hat{i} - 4\hat{j} + 5\hat{k})$ and $b = (-2\hat{i} + \hat{j} + 3\hat{k})$

54. Find the torque of a force $7\tilde{i} + 3\bar{j} - 5\tilde{k}$ about the origin. The force acts on a particle whose position vector is $\tilde{i} - \tilde{j} + \tilde{k}$.

55. Give the location of the centre of mass of a:

i. Sphere.
ii. Cylinder.
iii. Ring, and
iv. Cube, each of uniform mass density.

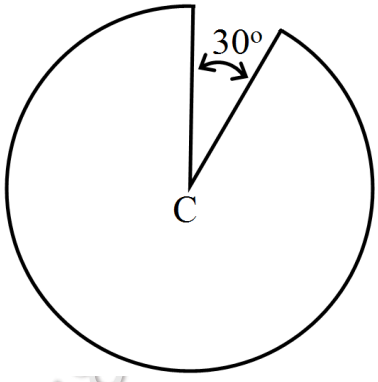
Does the centre of mass of a body necessarily lie inside the body?

56. A cylinder rolls on a horizontal plane surface. If the speed of the centre is 25m/s, what is the speed of the highest point?

57. A ring, a disc and a sphere all of the same radius and same mass roll down on an inclined plane from the same height h. Which of the three reaches the bottom (i) earliest (ii) latest?

58. If earth contracts to half its radius, what would be the duration of the day? Ans. According to the law of conservation of angular momentum,

59. From a complete ring of mass M and radius R, a 30° sector is removed. What is the moment of inertia of the incomplete ring about an axis passing through the centre of



the ring and perpendicular to the plane of the ring?

60. Two bodies of masses 1kg and 2kg are located at (1, 2) and (-1, 3) respectively. Calculate the coordinates of the centre of mass.

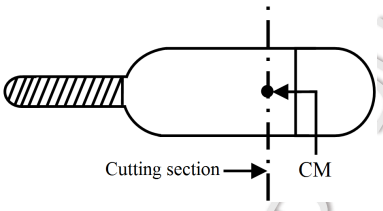
61. Why does a girl have to lean towards right when carrying a bag in her left hand?

62. A boy is seated in a revolving chair revolving at an angular speed of 120 revolutions per minute. Two heavy balls form part of the revolving system and the boy can pull the balls closer to himself or may push them apart. If by pulling the balls closer, the boy decreases the moment of inertia of the system from 6kg-m^2 to 2kg-m^2, what will be the new angular speed?

63. A wheel is making revolutions about its axis with uniform angular acceleration. Starting from rest, it reaches 100rev/sec in 4 seconds. Find the angular acceleration. Find the angle rotated during these four seconds.

64. Find the torque of a force $(7\hat{i} + 3\hat{j} - 5\hat{k})$ N about the origin, the force acts on a particle whose position vector is $(7\hat{i} - \hat{j} + \hat{k})$m.

65. A cricket bat is cut through its centre of mass into two parts as shown



Then, state whether both parts are of same mass or not. Also, give reason.

66. A car is moving on road with speed 54kmh. What should be the value of torque if the car is brought to rest in 15 seconds? Radius and moment of inertia of wheel about the axis of rotation are 0.35m and 3kgm respectively.

67. A boy is standing on a platform which is free to rotate about its axis. The boy holds an open umbrella in his hand. The axis of the umbrella coincides with that of the platform. The moment of inertia of ''the platform plus the boy system'' is 3.0 × 10^{-3}kg-m^2 and that of the umbrella is 2.0 × 10^{3}kg-m^2. The boy starts spinning the umbrella about the

axis at an angular speed of 2.0rev/s with respect to himself. Find the angular velocity imparted to the platform.

*** Given Section consists of questions of 3 marks each. [111]**

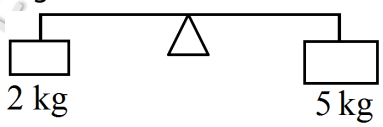
68. A bullet of mass 10g and speed 500m/s is fired into a door and gets embedded exactly at the centre of the door. The door is 1.0m wide and weighs 12kg. It is hinged at one end and rotates about a vertical axis practically without friction. Find the angular speed of the door just after the bullet embeds into it. (**Hint:** The moment of inertia of the door about the vertical axis at one end is $ML^2/3$).

69. Given the moment of inertia of a disc of mass M and radius R about any of its diameters to be $\frac{MR^2}{4}$, find its moment of inertia about an axis normal to the disc and passing through a point on its edge.

70. Find the moment of inertia of a sphere about a tangent to the sphere, given the moment of inertia of the sphere about any of its diameters to be $2MR^2/5$, where M is the mass of the sphere and R is the radius of the sphere.

71. A solid cylinder rolls up an inclined plane of angle of inclination 30°. At the bottom of the inclined plane the centre of mass of the cylinder has a speed of 5m/s.
    a. How far will the cylinder go up the plane?
    b. How long will it take to return to the bottom?

72. A light rod of length 1m is pivoted at its centre and two masses of 5kg and 2kg are hung from the ends as shown in figure. Find the initial angular acceleration of the rod assuming that it was horizontal in the beginning.



73.
    a. Why do you prefer to use a wrench of long arm?
    b. A 3m long ladder weighing 20kg leans on a frictionless wall. Its feet rest on the floor 1m from the wall. Find the reaction forces of the wall and the floor.

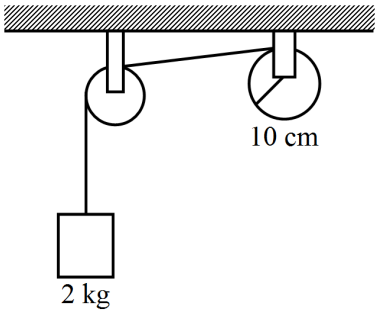
74. A particle starts rotating from rest and displaces according to the formula. $\theta = \frac{3t^3}{20} - \frac{t^2}{3}$ Calculate the angular velocity and angular acceleration at the end of 5sec.

75. A wheel of mass 10kg and radius 20cm is rotating at an angular speed of 100rev/min when the motor is turned off. Neglecting the friction at the axle, calculate the force that must be applied tangentially to the wheel to bring it to rest in 10 revolutions.

76. Two blocks of masses 10kg and 30kg are placed along a vertical line. The first block is raised through a height of 7cm. By what distance should the second mass be moved to raise the centre of mass by 1cm?

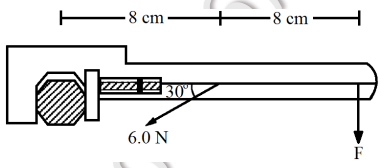
77. If ice on poles melts, then what is the change in duration of day?

78. A string is wrapped on a wheel of moment of inertia 0.20kg-m^2 and radius 10cm and goes through a light pulley to support a block of mass 2.0kg as shown in figure. Find the

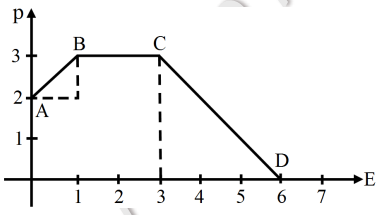


acceleration of the block.

79. When a force of 6.0N is exerted at 30° to a wrench at a distance of 8cm from the nut, it is just able to loosen the nut. What force F would be sufficient to loosen it if it acts perpendicularly to the wrench at 16cm from the nut?



80. Figure shows momentum versus time graph for a particle moving along x-axis. In which region, force on the particle is large. Why?



81. Two blocks of mares 10kg and 20kg are placed on the X-axis. The first mass is moved on the axis by a distance of 2cm. By what distance should the second mass be moved to keep the position of the centre of mass unchanged?

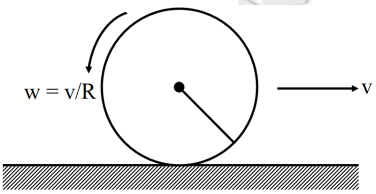
82. A rod of weight W is supported by two parallel knife edges A and B and is in equilibrium in a horizontal position. The distance between the knife edges is d and the centre of mass of the rod is at a distance x from A. Find the value of normal reactions at the knife edges A and B.

83.

a. State the theorem of parallel axis. Using it derive an expression to find the moment of inertia of a rod of mass M, length 1 about an axis perpendicular to it passing through one of its ends.
b. Find the centre of mass of a uniform L shaped lamina (a thin flat plate) with dimension as shown in fig. The mass of lamina is 3kg.

84. A solid sphere is set into motion on a rough horizontal surface with a linear speed v in the forward direction and an angular speed $\frac{v}{R}$ in the anticlockwise direction as shown in figure. Find the linear speed of the sphere:

a. When it stops rotating.
b. When slipping finally ceases and pure rolling starts.



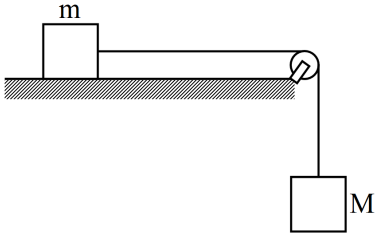
85. What is the difference between rotational kinetic energy and rolling kinetic energy? Show that rolling kinetic energy of a rolling body is given by $\frac{1}{2}mv^2\left(\frac{K^2}{r^2}+1\right)$ where r is

radius of the body and K is the radius of gyration of the body.

86. Given the moment of inertia of a disc of mass M and radius R about any of its diameters to be $\frac{MR^2}{4}$, find its moment of inertia about an axis normal to the disc and passing through a point on its edge.

87. A wheel of moment of inertia 0.10kg-m^2 is rotating about a shaft at an angular speed of 160rev/ minute. A second wheel is set into rotation at 300rev/ minute and is coupled to the same shaft so that both the wheels finally rotate with a common angular speed of 200rev/ minute. Find the moment of inertia of the second wheel.

88. Figure shows two blocks of masses m and M connected by a string passing over a pulley. The horizontal table over which the mass m slides is smooth. The pulley has a radius r and moment of inertia I about its axis and it can freely rotate about this axis. Find the acceleration of the mass M assuming that the string does not slip on the pulley.



89. Three particles, each of mass 200g, are kept at the corners of an equilateral triangle of side 10cm. Find the moment of inertia of the system about an axis:
    a. Joining two of the particles.
    b. Passing through one of the particles and perpendicular to the plane of the particles.

90. A solid cylinder rolls up an inclined plane of angle of inclination 30°. At the bottom of the inclined plane the centre of mass of the cylinder has a speed of 5m/s.
    a. How far will the cylinder go up the plane?
    b. How long will it take to return to the bottom?

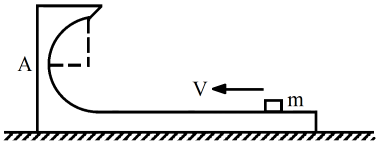
91. A ball of mass 0.50kg moving at a speed of 5.0m/s collides with another ball of mass 1.0kg. After the collision the balls stick together and remain motionless. What was the velocity of the 1.0kg block before the collision?

92. Two blocks of masses 10kg and 30kg are placed along a vertical line. The first block is raised through a height of 7cm. By what distance should the second mass be moved to raise the centre of mass by 1cm?

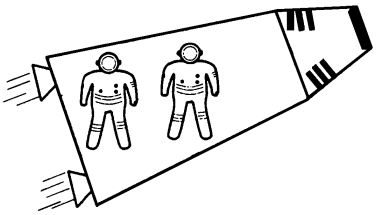
93. A 60kg man skating with a speed of 10m/s collides with a 40kg skater at rest and they cling to each other. Find the loss of kinetic energy during the collision.

94. Find the ratio of the linear momenta of two particles of masses 1.0kg and 4.0kg if their kinetic energies are equal.

95. Figure shows a small block of mass m which is started with a speed v on the horizontal part of the bigger block of mass M placed on a horizontal floor. The curved part of the surface shown is semicircular. All the surfaces are frictionless. Find the speed of the bigger block when the smaller block reaches the point A of the surface.



96. A block at rest explodes into three equal parts. Two parts start moving along X and Y axes respectively with equal speeds of 10m/s. Find the initial velocity of the third part.

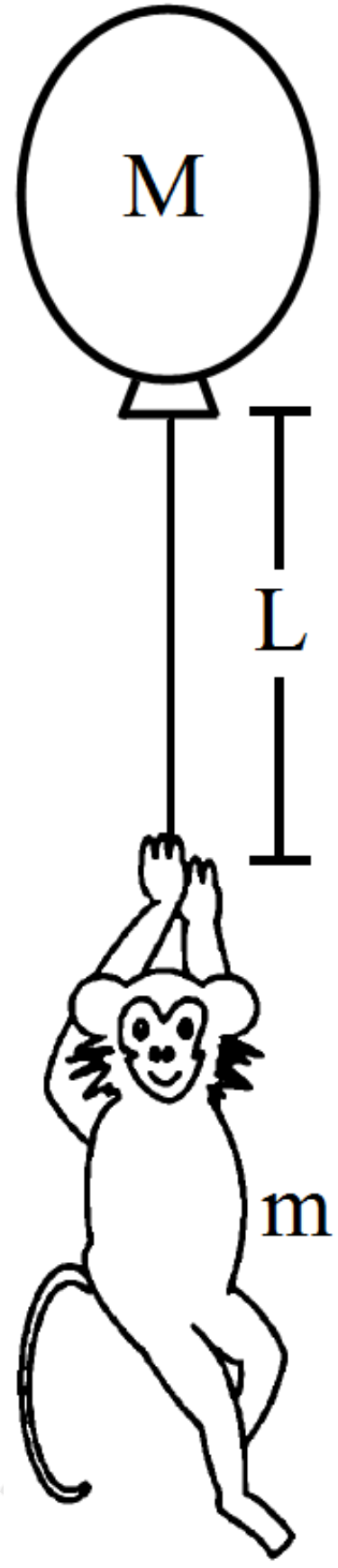


97. Two blocks of mares 10kg and 20kg are placed on the X-axis. The first mass is moved on the axis by a distance of 2cm. By what distance should the second mass be moved to keep the position of the centre of mass unchanged?

98. In a typical Indian Bugghi (a luxury cart drawn by horses), a wooden plate is fixed on the rear on which one person can sit. A bugghi of mass 200kg is moving at a speed of 10km/h. As it overtakes a school boy walking at a speed of 4km/h, the boy sits on the wooden plate. If the mass of the boy is 25kg, what will be the new velocity of the bugghi?

99. During a heavy rain, hailstones of average size 1.0cm in diameter fall with an average speed of 20m/s. Suppose 2000 hailstones strike every square meter of a 10m × 10m roof perpendicularly in one second and assume that the hailstones do not rebound. Calculate the average force exerted by the falling hailstones on the roof. Density of a hailstone is 900kg/m^3.

100. The balloon, the light rope and the monkey shown in figure are at rest in the air. If the monkey reaches the top of the rope, by what distance does the balloon descend ? Mass of the balloon = M, mass of the monkey = m and the length of the rope ascended by

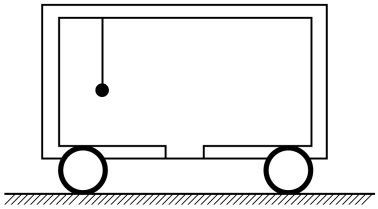


the monkey = L.

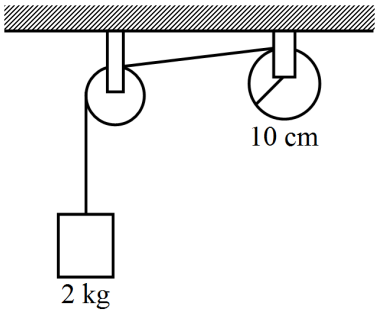
101. A ball falls on the ground from a height of 2.0m and rebounds up to a height of 1.5m. Find the coefficient of restitution.

102. A cart of mass M is at rest on a frictionless horizontal surface and a pendulum bob of mass m hangs from the roof of the cart. The string breaks, the bob falls on the floor, makes several collisions on the floor and finally lands up in a small slot made in the

floor. The horizontal distance between the string and the slot is L. Find the displacement of the cart during this process.



103. A string is wrapped on a wheel of moment of inertia 0.20kg-m^2 and radius 10cm and goes through a light pulley to support a block of mass 2.0kg as shown in figure. Find the acceleration of the block.



104. Three particles, each of mass 200g, are kept at the corners of an equilateral triangle of side 10cm. Find the moment of inertia of the system about an axis:
   a. Joining two of the particles.
   b. Passing through one of the particles and perpendicular to the plane of the particles.

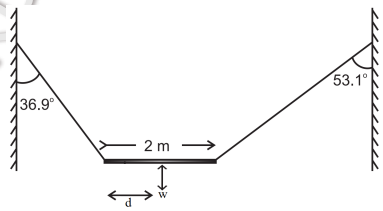
*** Given Section consists of questions of 5 marks each. [185]**

105. A 3m long ladder weighing 20 kg leans on a frictionless wall. Its feet rest on the floor 1 m from the wall as shown in Fig.6.27. Find the reaction forces of the wall and the floor.

106. From a uniform disk of radius R, a circular hole of radius $\frac{R}{2}$ is cut out. The centre of the hole is at $\frac{R}{2}$ from the centre of the original disc. Locate the centre of gravity of the resulting flat body.

107. In the HCl molecule, the separation between the nuclei of the two atoms is about $1.27\text{Å}\left(1\text{Å} = 10^{-10}\text{m}\right)$. Find the approximate location of the CM of the molecule, given that a 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.

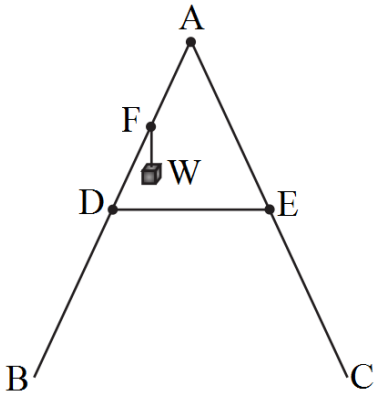
108. A non-uniform bar of weight W is suspended at rest by two strings of negligible weight as shown in. The angles made by the strings with the vertical are 36.9° and 53.1° respectively. The bar is 2m long. Calculate the distance d of the centre of gravity of the bar from its left end.



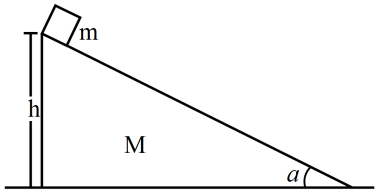
109. Prove the result that the velocity v of translation of a rolling body (like a ring, disc, cylinder or sphere) at the bottom of an inclined plane of a height h is given by

$v^2 = \frac{2gh}{\left(\frac{1+k^2}{R^2}\right)}$ using dynamical consideration (i.e. by consideration of forces and torques). **Note:** k is the radius of gyration of the body about its symmetry axis, and R is the radius of the body. The body starts from rest at the top of the plane.

110. As shown in the two sides of a step ladder BA and CA are 1.6m long and hinged at A. A rope DE, 0.5m is tied half way up. A weight 40kg is suspended from a point F, 1.2m from B along the ladder BA. Assuming the floor to be frictionless and neglecting the weight of the ladder, find the tension in the rope and forces exerted by the floor on the ladder. (Take g = 9.8m/s^2) (**Hint:** Consider the equilibrium of each side of the ladder separately).



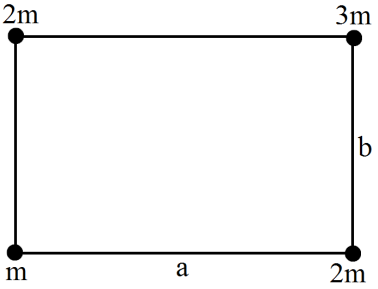
111. A block of mass m is placed on a triangular block of mass M, which in turn is placed on a horizontal surface as shown in figure. Assuming frictionless surfaces find the velocity of the triangular block when the smaller block reaches the bottom end.



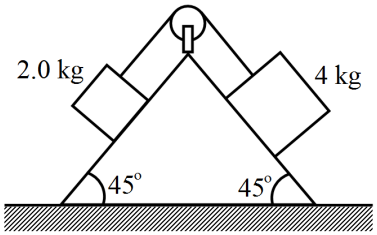
112. A car weighs 1800kg. The distance between its front and back axles is 1.8m. Its centre of gravity is 1.05m behind the front axle. Determine the force exerted by the level ground on each front wheel and each back wheel.

113. Prove the result that the velocity v of translation of a rolling body (like a ring, disc, cylinder or sphere) at the bottom of an inclined plane of height h given by $v^2 = \frac{2gh}{\left(1+\frac{K^2}{R^2}\right)}$ using dynamical consideration. Note K is the radius of gyration of the body about its symmetry axis, and R is the radius of the body. The body starts from rest at the top of the plane.

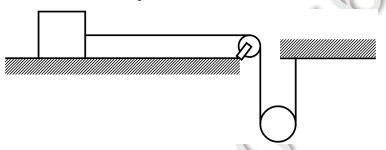
114. Four bodies have been arranged at the corners of a rectangle shown in figure. Find the centre of mass of the system.



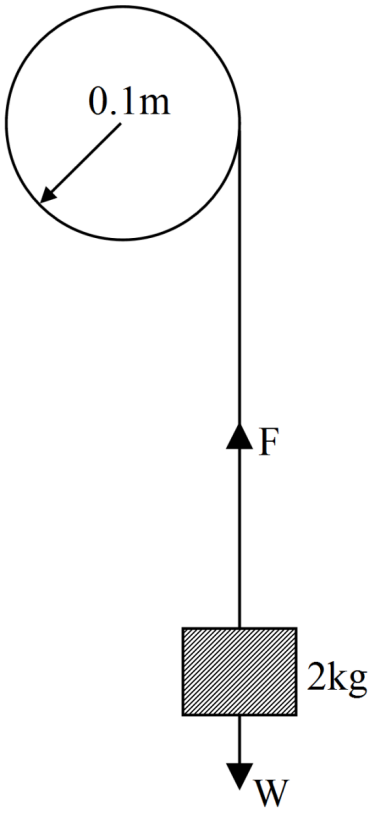
115. The pulley shown in figure has a radius 10cm and moment of inertia 0.5kg-m^2 about its axis. Assuming the inclined planes to be frictionless, calculate the acceleration of the 4.0kg block.



116. The descending pulley shown in figure has a radius 20cm and moment of inertia 0.20kg-m^2. The fixed pulley is light and the horizontal plane frictionless. Find the acceleration of the block if its mass is 1.0kg.



117. The moment of inertia of a solid flywheel about its axis is 0.1kg-m^2. A tangential force of 2kg/ wt is applied round the circumference of the flywheel with the help of a string and mass arrangement as shown in Fig. If the radius of the wheel is 0.1m, find the acceleration of the mass.



118. A threaded rod with 12turns/ cm and diameter 1.18cm is mounted horizontally. A bar with a threaded hole to match the rod is screwed onto the rod. The bar spins at 216rev/ min. How long will it take for the bar to move 1.50cm along the rod?

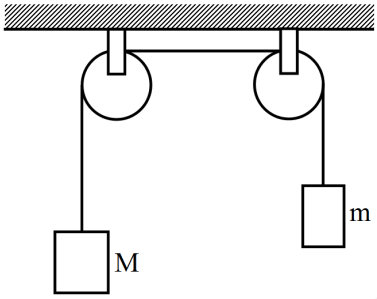
119. A disc of radius R is cut out from a larger disc of radius 2R in such a way that the edge of the hole touches the edge of the disc. Locate the centre of mass of the residual disc.

120. A uniform rod of mass m and length l is struck at an end by a force F perpendicular to the rod for a short time interval t. Calculate:
    a. The speed of the centre of mass.
    b. The angular speed of the rod about the centre of mass.

c. The kinetic energy of the rod.

d. The angular momentum of the rod about the centre of mass after the force has stopped to act. Assume that t is so small that the rod does not appreciably change its direction while the force acts.

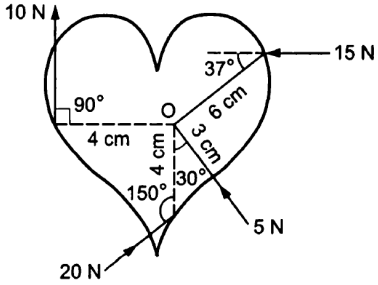
121. The pulleys in figure are identical, each having a radius R and moment of inertia I.



Find the acceleration of the block M.

122. A comet revolves around the sun in a highly elliptical orbit having a minimum distance of 7×10^{10}m and a maximum distance of 1.4×10^{13}m. If its speed while nearest to the Sun is 60km s^{-1}, find its linear speed when situated farthest from the Sun.

123. Calculate the total torque acting on the body shown in figure about the point O.



124. A 6.5m long ladder rests against a vertical wall reaching a height of 6.0m. A 60kg man stands half way up the ladder.

a. Find the torque of the force exerted by the man on the ladder about the upper end of the ladder.

b. Assuming the weight of the ladder to be negligible as compared to the man and assuming the wall to be smooth, find the force exerted by the ground on the ladder.

125. A grindstone has a moment of inertia of 6kg m^2. A constant torque is applied and the grindstone is found to have a speed of 150rpm, 10s. after starting from rest. Calculate the torque.

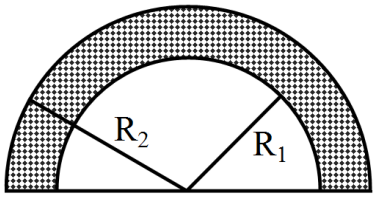
126. A uniform rod pivoted at its upper end hangs vertically. It is displaced through an angle of 60° and then released. Find the magnitude of the force acting on a particle of mass dm at the tip of the rod when the rod makes an angle of 37° with the vertical.

127. A bullet of mass 25g is fired horizontally into a ballistic pendulum of mass 5.0kg and gets embedded in it. If the centre of the pendulum rises by a distance of 10cm, find the speed of the bullet.

128. A disc of radius R is cut out from a larger disc of radius 2R in such a way that the edge of the hole touches the edge of the disc. Locate the centre of mass of the residual disc.

129. Three particles of masses 1.0kg, 2.0kg and 3.0kg are placed at the corners A, B and C respectively of an equilateral triangle ABC of edge 1m. Locate the centre of mass of the system.

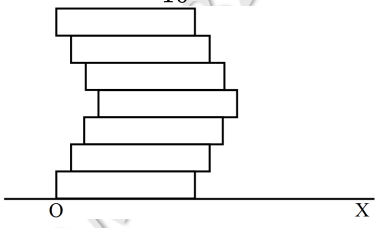
130. Find the centre of mass of a uniform plate having semicircular inner and outer boundaries of radii R_1 and R_2.



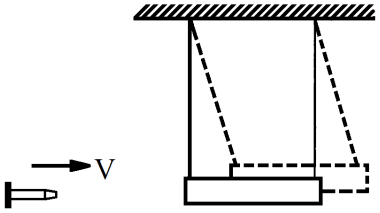
131. A gun is mounted on a railroad car. The mass of the car, the gun, the shells and the operator is 50m where m is the mass of one shell. If the velocity of the shell with respect to the gun (in its state before firing) is 200m/s, what is the recoil speed of the car after the second shot? Neglect friction.

132. A ball of mass m is dropped onto a floor from a certain height. The collision is perfectly elastic and the ball rebounds to the same height and again falls. Find the average force exerted by the ball on the floor during a long time interval.

133. Seven homogeneous bricks, each of length L, are arranged as shown in figure. Each brick is displaced with respect to the one in contact by $\frac{L}{10}$. Find the x-coordinate of the centre of mass relative to the origin shown.



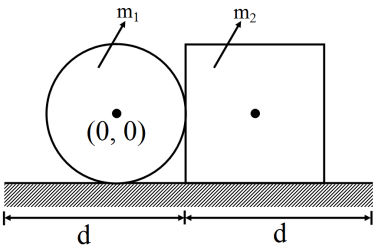
134. A block of mass 200g is suspended through a vertical spring. The spring is stretched by 1.0cm when the block is in equilibrium. A particle of mass 120g is dropped on the block from a height of 45cm. The particle sticks to the block after the impact. Find the maximum extension of the spring. Take g = 10m/s^2.



135. A uniform disc of radius R is put over another uniform disc of radius 2R of the same thickness and density. The peripheries of the two discs touch each other. Locate the centre of mass of the system.

136. A bullet of mass 20g travelling horizontally with a speed of 500m/s passes through a wooden block of mass 10.0kg initially at rest on a level surface. The bullet emerges with a speed of 100m/s and the block slides 20cm on the surface before coming to rest. Find the friction coefficient between the block and the surface.

137. A square plate of edge d and a circular disc of diameter d are placed touching each other at the midpoint of an edge of the plate as shown in figure. Locate the centre of mass of the combination, assuming same mass per unit area for the two plates.

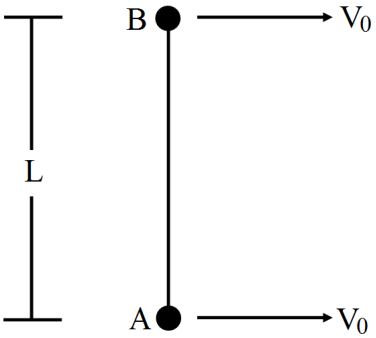


138. Two small balls A and B, each of mass m, are joined rigidly to the ends of a light rod of lengh L (figure). The system translates on a frictionless horizontal surface with a velocity vo in a direction perpendicular to the rod. A particle P of mass m kept at rest on the surface sticks to the ball A as the ball collides with it. Find:

a. The linear speeds of the balls A and B after the collision.

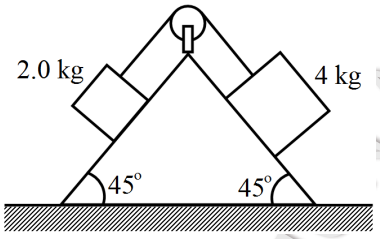
b. The velocity of the centre of mass C of the system A + B + P.

c. The angular speed of the system about C after the collision.



[**Hint:** The light rod will exert a force on the ball B only along its length.]

139. The pulley shown in figure has a radius 10cm and moment of inertia 0.5kg-m^2 about its axis. Assuming the inclined planes to be frictionless, calculate the acceleration of the 4.0kg block.



140. A uniform ladder of length 10.0m and mass 16.0kg is resting against a vertical wall making an angle of 37° with it. The vertical wall is frictionless but the ground is rough. An electrician weighing 60.0kg climbs up the ladder. If he stays on the ladder at a point 8.00m from the lower end, what will be the normal force and the force of friction on the ladder by the ground? What should be the minimum coefficient of friction for the elctrician to work safely?

141. A ball is whirled in a circle by attaching it to a fixed point with a string. Is there an angular rotation of the ball about its centre? If yes, is this angular velocity equal to the angular velocity of the ball about the fixed point?

* Case study based questions [32]

142. Read the passage given below and answer the following questions from 1 to 5.

Moment of Inertia A heavy wheel called flywheel is attached to the shaft of steam engine, automobile engine etc., because of its large moment of inertia, the flywheel opposes the sudden increase or decrease of the speed of the vehicle. It allows a

gradual change in the speed and prevents jerky motion and hence ensure smooth ride of passengers.

i. Moment of inertia of a body depends upon:
   a. axis of rotation
   b. torque
   c. angular momentum
   d. angular velocity

ii. A particle of mass 1 kg is kept at (1m, 1m, 1m). The moment of inertia of this particle about Z-axis would be:
   a. 1 kg-m^2
   b. 2 kg-m^2
   c. 3 kg-m^2
   d. (None of the above)

iii. Moment of inertia of a rod of mass m and length l about its one end is I. If one-fourth of its length is cut away, then moment of inertia of the remaining rod about its one end will be:
   a. $\frac{3}{4}\mathrm{I}$
   b. $\frac{9}{16}\mathrm{I}$
   c. $\frac{27}{64}\mathrm{I}$
   d. $\frac{\mathrm{I}}{16}$

iv. A circular disc is to be made by using iron and aluminium, so that it acquires maximum moment of inertia about its geometrical axis. It is possible with:
   a. iron and aluminium layers in alternate order
   b. aluminium at interior and iron surrounding it
   c. iron at interior and aluminium surrounding it
   d. Either (a) or (c)

v. Three thin rods each of length L and mass M are placed along X ,Y and Z -axes such that one end of each rod is at origin. The moment of inertia of this system about Z-axis is:
   a. $\frac{2}{3}\mathrm{ML}^2$
   b. $\frac{4\mathrm{ML}^2}{3}$
   c. $\frac{5\mathrm{ML}^2}{3}$
   d. $\frac{\mathrm{ML}^2}{3}$

143. Read the passage given below and answer the following questions from 1 to 5. **Centre of Mass:**

The centre of mass of a body or a system of bodies is the point which moves as though all of the mass were concentrated there and all external forces were applied to it. Hence, a point at which the entire mass of the body or system of bodies is supposed to be concentrated is known as the centre of mass. If a system consists of more than one particles (or bodies) and net external force on the system in a particular direction is zero with centre of mass at rest. Then, the centre of mass will not move along that direction. Even though some particles of the system may move along that direction.

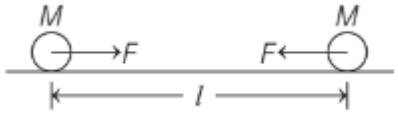
i. The centre of mass of a system of two particles divides, the distance between them:

a. in inverse ratio of square of masses of particles
b. in direct ratio of square of masses of particles
c. in inverse ratio of masses of particles
d. in direct ratio of masses of particles

ii. Two bodies of masses 1kg and 2 kg are lying in xy-plane at (-1, 2) and (2, 4) respectively. What are the coordinates of the centre of mass?

a. $\left(1, \frac{10}{3}\right)$
b. (1, 10)
c. (0, 1)
d. None of these

iii. Two balls of same masses start moving towards each other due to gravitational attraction, if the initial distance between them is l. Then, they meet at:



a. $\frac{l}{2}$
b. l
c. $\frac{l}{3}$
d. $\frac{l}{4}$

iv. All the particles of a body are situated at a distance R from the origin. The distance of centre of mass of the body from the origin is:

a. $= \mathrm{R}$
b. $\leq \mathrm{R}$
c. $> \mathrm{R}$
d. $\geq \mathrm{R}$

v. Two particles A and B initially at rest move towards each other under a mutual force of attraction. At the instant, when the speed of A is v and the speed of B is 2v, the speed of centre of mass of the system is:

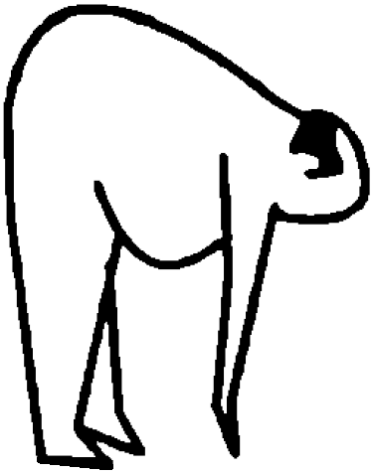
a. zero
b. v
c. 1. 5v
d. 3v

144. A kid of mass M stands at the edge of a platform of radius R which can be freely rotated about its axis. The moment of inertia of the platform is I. The system is at rest when a friend throws a ball of mass m and the kid catches it. If the velocity of the ball is v horizontally along the tangent to the edge of the platform when it was caught by the kid, find the angular speed of the platform after the event.

145. Mr. Verma (50kg) and Mr. Mathur (60kg) are sitting at the two extremes of a 4m long boat (40kg) standing still in water. To discuss a mechanics problem, they come to the middle of the boat. Neglecting friction with water, how far does the boat move on the water during the process?

146. What can be said about the centre of mass of a uniform hemisphere without making any calculation? Will its distance from the centre be more than $\frac{\mathrm{r}}{2}$ or less than $\frac{\mathrm{r}}{2}$?

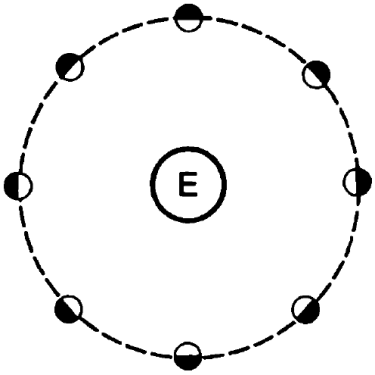
147. When a fat person tries to touch his toes, keeping the legs straight, he generally falls.



Explain with reference to figure.

148. When tall buildings are constructed on earth, the duration of day-night slightly increases. Is it true?

149. The moon rotates about the earth in such a way that only one hemisphere of the moon faces the earth. Can we ever see the ''other face'' of the moon from the earth? Can a person on the moon ever see all the faces of the earth?



----- Know what sparks the light in you. Then use that light to illuminate the world.”
