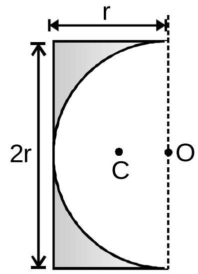
Exercise - I   Objective Problems

1. A semicircular portion of radius 'r' is cut from a uniform rectangular plate as shown in figure. The distance of centre of mass 'C' of remaining plate, from point 'O' is



(A) $\frac{2r}{(3-\pi)}$ (B) $\frac{3r}{2(4-\pi)}$

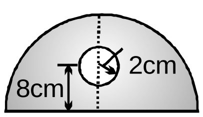
(C) $\frac{2r}{(4+\pi)}$ (D) $\frac{2r}{3(4-\pi)}$

2. From a circle of radius a, an isosceles right angled triangle with the hypotenuse as the diameter of the circle is removed. The distance of the centre of gravity of the remaining position from the centre of the circle is

(A) $3(\pi - 1)a$ (B) $\frac{(\pi-1)a}{6}$

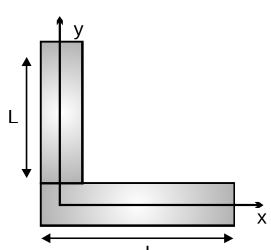
(C) $\frac{a}{3(\pi-1)}$ (D) $\frac{a}{3(\pi+1)}$

3. In the figure shown a hole of radius 2 cm is made in semicircular disc of radius 6π at a distance 8 cm from the centre C of the disc. The distance of the centre of mass of this system from point C is



(A) 4 cm (B) 8 cm
(C) 6 cm (D) 12 cm

4. Centre of mass of two thin uniform rods of same length but made up of different materials & kept as shown, can be, if the meeting point is the origin of co-ordinates



(A) (L/2, L/2) (B) (2L/3, L/2)

(C) (L/3, L/3) (D) (L/3, L/6)

5. A man of mass M stands at one end of a plank of length L which lies at rest on a frictionless surface. The man walks to other end of the plank. If the mass of the plank is $\frac{M}{3}$, then the distance that the man moves relative to ground is :

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

(C) $\frac{4L}{5}$ (D) $\frac{L}{3}$

6. A particle of mass 3m is projected from the ground at some angle with horizontal. The horizontal range is R. At the highest point of its path it breaks into two pieces m and 2m. The smaller mass comes to rest and larger mass finally falls at a distance x from the point of projection where x is equal to

(A) $\frac{3R}{4}$ (B) $\frac{3R}{2}$

(C) $\frac{5R}{4}$ (D) 3R

7. A man weighing 80 kg is standing at the centre of a flat boat and he is 20 m from the shore. He walks 8 m on the boat towards the shore and then halts. The boat weight 200 kg. How far is he from the shore at the end of this time?

(A) 11.2 m (B) 13.8 m
(C) 14.3 m (D) 15.4 m

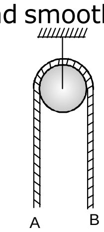
8. Two particles having mass ratio n : 1 are interconnected by a light inextensible string that passes over a smooth pulley. If the system is released, then the acceleration of the centre of mass of the system is :

(A) $(n-1)^2$ g (B) $\left(\frac{n+1}{n-1}\right)^2 g$

(C) $\left(\frac{n-1}{n+1}\right)^2 g$ (D) $\left(\frac{n+1}{n-1}\right) g$

Question No. 9 to 10 (2 questions)

A uniform chain of length 2L is hanging in equilibrium position, if end B is given a slightly downward displacement the imbalance causes an acceleration. Here pulley is small and smooth & string is inextensible



9. The acceleration of end B when it has been displaced by distance x, is

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

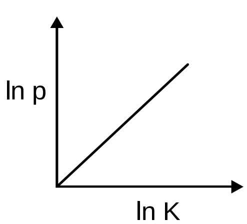
10. The velocity v of the string when it slips out of the pulley (height of pulley from floor > 2L)

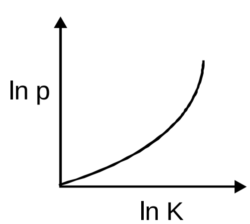
(A) $\sqrt{\frac{gL}{2}}$ (B) $\sqrt{2gL}$
(C) $\sqrt{gL}$ (D) none of these

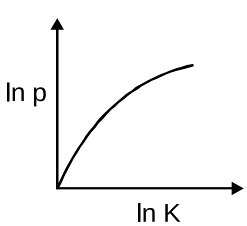
11. Internal forces can change
(A) the linear momentum but not the kinetic energy of the system.
(B) the kinetic energy but not the linear momentum of the system.
(C) linear momentum as well as kinetic energy of the system.
(D) neither the linear momentum nor the kinetic energy of the system.

12. A small sphere is moving at a constant speed in a vertical circle. Below is a list of quantities that could be used to describe some aspect of the motion of the sphere
I - kinetic energy
II - gravitational potential energy
III - momentum
Which of these quantities will change as this sphere moves around the circle ?
(A) I and II only (B) I and III only
(C) III only (D) II and III only

13. Which of the following graphs represents the graphical relation between momentum (p) and kinetic energy (K) for a body in motion ?

(A)


(B)


(C)


(D) none

14. Two balls are thrown in air. The acceleration of the centre of mass of the two balls while in air (neglect air resistance)
(A) depends on the direction of the motion of the balls
(B) depends on the masses of the two balls
(C) depends on the speeds of the two balls
(D) is equal to g

15. There are some passengers inside a stationary railway compartment. The track is frictionless. The centre of mass of the compartment itself (without the passengers) is C_1, while the centre of mass of the compartment plus passengers system is C_2. If the passengers move about inside the compartment along the track.
(A) both C_1 and C_2 will move with respect to the ground
(B) neither C_1 nor C_2 will move with respect to the ground
(C) C_1 will move but C_2 will be stationary with respect to the ground
(D) C_2 will move but C_1 will be stationary with respect to the ground

16. A system of N particles is free from any external forces
(a) Which of the following is true for the magnitude of the total momentum of the system ?
(A) It must be zero
(B) It could be non-zero, but it must be constant
(C) It could be non-zero, and it might not be constant
(D) It could be zero, even if the magnitude of the total momentum is not zero.

(b) Which of the following must be true for the sum of the magnitudes of the momenta of the individual particles in the system ?
(A) It must be zero
(B) It could be non-zero, but it must be constant
(C) It could be non-zero, and it might not be constant
(D) The answer depends on the nature of the internal forces in the system

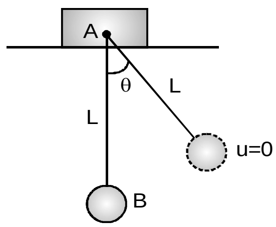
17. An isolated rail car of mass M is moving along a straight, frictionless track at an initial speed v_0. The car is passing under a bridge when a crate filled with N bowling balls, each of mass m, is dropped from the bridge into the bed of the rail car. The crate splits open and the bowling balls bounce around inside the rail car, but none of them fall out.
(a) Is the momentum of the rail car + bowling balls system conserved in this collision ?
(A) Yes, the momentum is completely conserved
(B) Only the momentum component in the vertical direction is conserved
(C) Only the momentum component parallel to the track is conserved
(D) No components are conserved

(b) What is the average speed of the rail car + bowling balls system some time after the collision ?

(A) $(M + Nm)v_0/M$
(B) $Mv_0/(Nm + M)$
(C) Nmv_0/M
(D) The speed cannot be determined because there is not enough information

Question No. 18 to 21

A small ball B of mass m is suspended with light inelastic string of length L from a block A of same mass m which can move on smooth horizontal surface as shown in the figure. The ball is displaced by angle θ from equilibrium position & then released.



18. The displacement of block when ball reaches the equilibrium position is

(A) $\frac{L\sin\theta}{2}$ (B) $L \sin \theta$
(C) L (D) none of these

19. Tension in string when it is vertical, is
(A) mg (B) $mg(2 - \cos\theta)$
(C) $mg\,(3 - 2\cos\theta)$ (D) none of these

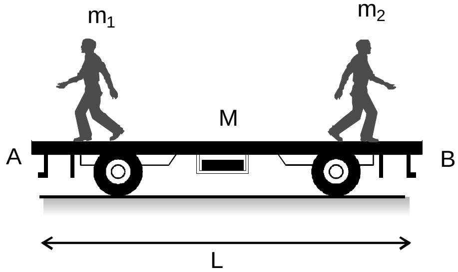
20. Maximum velocity of block during subsequent motion of the system after release of ball is
(A) $[gl(1 - \cos\theta)]^{1/2}$
(B) $[2gl(1 - \cos\theta)]^{1/2}$
(C) $[gl\cos\theta]^{1/2}$
(D) informations are insufficient to decide

21. The displacement of centre of mass of A + B system till the string becomes vertical is

(A) zero (B) $\frac{L}{2}(1-\cos\theta)$
(C) $\frac{L}{2}(1-\sin\theta)$ (D) none of these

Question No. 22 to 26 (5 questions)

Two persons of mass m_1 and m_2 are standing at the two ends A and B respectively, of a trolley of mass M as shown.



22. When the person standing at A jumps from the trolley towards left with u_{rel} with respect to the trolley, then
(A) the trolley moves towards right
(B) the trolley rebounds with velocity $\frac{m_1u_{rel}}{m_1+m_2+M}$
(C) the centre of mass of the system remains stationary
(D) all the above

23. When only the person standing at B jumps from the trolley towards right while the person at A keeps standing, then
(A) the trolley moves towards left
(B) the trolley mones with velocity $\frac{m_2u_{rel}}{m_1+m_2+M}$
(C) the centre of mass of the system remains stationary
(D) all the above

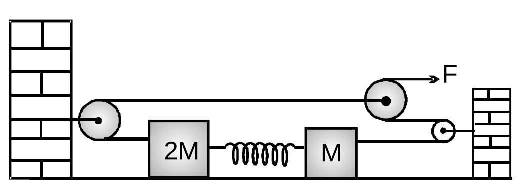
24. When both the persons jump simultaneously with same speed then
(A) the centre of fmass of the systyem remains stationary
(B) the trolley remains stationary
(C) the trolley moves toward the end where the person with heavier mass is standing
(D) None of these

25. When both the persons jump simultaneously with u_{rel} with respect to the trolley, then the velocity of the trolley is

(A) $\frac{|m_1-m_2|u_{rel}}{m_1+m_2+M}$ (B) $\frac{|m_1-m_2|u_{rel}}{M}$
(C) $\left|\frac{m_1u_{rel}}{m_2+M}-\frac{m_2u_{rel}}{m_1+M}\right|$ (D) none of these

26. Choose the incorrect statement, if $m_1 = m_2 = m$ and both the persons jump one by one, then
(A) the centre of mass of the system remains stationary
(B) the final velocity of the trolley is in the direction of the person who jumps first
(C) the final velocity of the trolley is $\left(\frac{mu_{rel}}{M+m}-\frac{mu_{rel}}{M+2m}\right)$
(D) none of these

27. In the diagram shown, no friction at any contact surface. Initially, the spring has no deformation. What will be the maximum deformation in the spring ? Consider all the strings to be sufficiency large. Consider the spring constant to be K



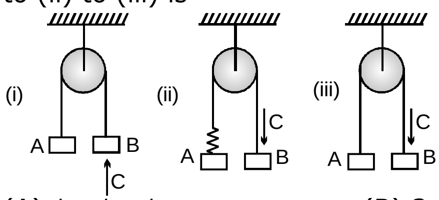
(A) 4F / 3K (B) 8F / 3K
(C) F / 3K (D) none

28. A super-ball is to bounce elastically back and forth between two rigid walls at a distance d from each other. Neglecting gravity and assuming the velocity of super-ball to be v_0 horizontally, the average force being exerted by the super-ball on each wall is :

(A) $\frac{1}{2}\frac{mv_0^2}{d}$ (B) $\frac{mv_0^2}{d}$

(C) $\frac{2mv_0^2}{d}$ (D) $\frac{4mv_0^2}{d}$

29. In the figure (i), (ii) & (iii) shown the objects A, B & C are of same mass. String, spring & pulley are massless. C strikes B with velocity 'u' in each case and sticks to it. The ratio of velocity of B in case (i) to (ii) to (iii) is



(A) 1 : 1 : 1 (B) 3 : 3 : 2
(C) 3 : 2 : 2 (D) none of these

30. A force exerts an impulse I on a particle changing its speed from u to 2u. The applied force and the initial velocity are oppositely directed along the same line. The work done by the force is

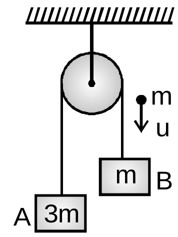
(A) $\frac{3}{2}Iu$ (B) $\frac{1}{2}Iu$
(C) Iu (D) $2Iu$

31. A parallel beam of particles of mass m moving with velocity v impinges on a wall at an angle θ to its normal. The number of particles per unit volume in the beam is n. If the collision of particles with the wall is elastic, then the pressure exerted by this beam on the wall is

(A) $2\ mn\ v^2 \cos\theta$ (B) $2\ mn\ v^2 \cos^2\theta$
(C) $2\ mn\ v \cos\theta$ (D) $2\ mn\ v \cos^2\theta$

32. A boy hits a baseball with a bat and imparts an impulse J to the ball. The boy hits the ball again with the same force, except that the ball and the bat are in contact for twice the amount of time as in the first hit. The new impulse equals.
(A) half the original impulse
(B) the original impulse
(C) twice the original impulse
(D) four times the original impulse

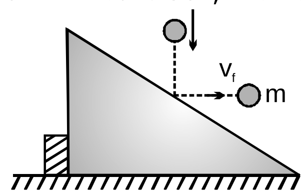
33. A system of two blocks A and B are connected by an inextensible massless strings as shown. The pulley is maselss and frictionless. Initially the system is at rest when, a bullet of mass 'm' moving with a velocity 'u' as shown hits the block 'B' and gets embedded into it. The impulse imparted by tension force to the block of mass 3m is :



(A) $\frac{5mu}{4}$ (B) $\frac{4mu}{5}$
(C) $\frac{2mu}{5}$ (D) $\frac{3mu}{5}$

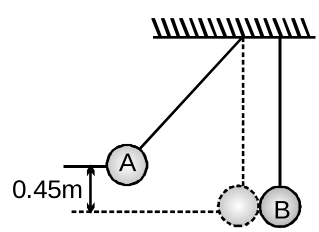
34. A ball strikes a smooth horizontal ground at an angle of 45° with the vertical. What cannot be the possible angle of its velocity with the vertical after the collision. (Assume $e \le 1$).
(A) 45° (B) 30°
(C) 53° (D) 60°

35. As shown in the figure a body of mass m moving vertically with speed 3 m/s hits a smooth fixed inclined plane and rebounds with a velocity v_f in the horizontal direction. If $\angle$ of inclined is 30°, the velocity v_f will be



(A) 3 m/s (B) $\sqrt{3}$ m/s
(C) $1/\sqrt{3}$ m/s
(D) this is not possible

36. Two massless string of length 5 m hang from the ceiling very near to each other as shown in the figure. Two balls A and B of masses 0.25 kg and 0.5 kg are attached to the string. The ball A is released from rest at a height 0.45 m as shown in the figure. The collision between two balls is completely elastic Immediately after the collision. the kinetic energy of ball B is 1 J. The velocity of ball A just after the collision is



(A) 5 ms^{-1} to the right (B) 5 ms^{-1} to the left
(C) 1 ms^{-1} to the right (D) 1 ms^{-1} to the left

37. Two balls A and B having masses 1 kg and 2 kg, moving with speeds 21 m/s and 4 m/s respectively in opposite direction, collide head on. After collision A moves with a speed of 1 m/s in the same direction, then the coefficient of restitution is
(A) 0.1 (B) 0.2
(C) 0.4 (D) None

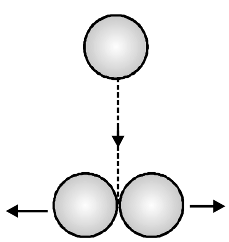
38. A truck moving on horizontal road east with velocity 20ms^{-1} collides elastically with a light ball moving with velocity 25 ms^{-1} along west. The velocity of the ball just after collision
(A) 65 ms^{-1} towards east
(B) 25 ms^{-1} towards west
(C) 65 ms^{-1} towards west
(D) 20 ms^{-1} towards east

39. Two perfectly elastic balls of same mass m are moving with velocities u_1 and u_2. They collide elastically n times. The kinetic energy of the system finally is :

(A) $\frac{1}{2}\frac{m}{u}u_1^2$ (B) $\frac{1}{2}\frac{m}{u}(u_1^2+u_2^2)$

(C) $\frac{1}{2}m(u_1^2+u_2^2)$ (D) $\frac{1}{2}mn(u_1^2+u_2^2)$

40. In the figure shown, the two identical balls of mass M and radius R each, are placed in contact with each other on the frictionless horizontal surface. The third ball of mass M and radius R/2, is coming down vertically and has a velocity = v_0 when it simultaneously hits the two balls and itself comes to rest. The each of the two bigger balls will move after collision with a speed equal to



(A) $4v_0/\sqrt{5}$ (B) $2v_0/\sqrt{5}$

(C) $v_0/\sqrt{5}$ (D) none

41. In the above, suppose that the smaller ball does not stop after collision, but continues to move downwards with a speed = $v_0/2$, after the collision. Then, the speed of each bigger ball after collision is

(A) $4v_0/\sqrt{5}$ (B) $2v_0/\sqrt{5}$

(C) $v_0/2\sqrt{5}$ (D) none

42. A body of mass 'm' is dropped from a height of 'h'. Simultaneously another body of mass 2m is thrown up vertically with such a velocity v that they collide at the height h/2. If the collision is perfectly inelastic, the velocity at the time of collision with the ground will be

(A) $\sqrt{\frac{5gh}{4}}$ (B) $\sqrt{gh}$

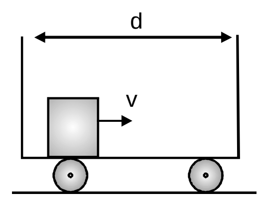
(C) $\sqrt{\frac{gh}{4}}$ (D) $\frac{\sqrt{10gh}}{3}$

43. A sphere of mass m moving with a constant velocity hits another stationary sphere of the same mass, if e is the coefficient of restitution, then ratio of speed of the first sphere to the speed of the second sphere after collision will be

(A) $\left(\frac{1-e}{1+e}\right)$ (B) $\left(\frac{1+e}{1-e}\right)$

(C) $\left(\frac{e+1}{e-1}\right)$ (D) $\left(\frac{e-1}{e+1}\right)$

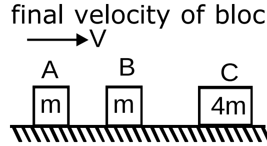
44. In a smooth stationary cart of length d, a small block is projected along it's length with velocity v towards front. Coefficient of restitution for each collision is e. The cart rests on a smooth ground and can move freely. The time taken by block to come to rest w.r.t. cart is



(A) $\frac{ed}{(1-e)v}$ (B) $\frac{ed}{(1+e)v}$

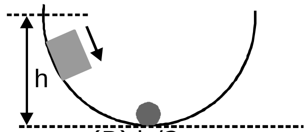
(C) $\frac{d}{e}$ (D) inifinite

45. Three blocks are initially placed as shown in the figure. Block A has mass m and initial velocity v to the right. Block B with mass m and block C with mass 4 m are both initially at rest. Neglect friction. All collisions are elastic. The final velocity of block A is



(A) 0.60 v to the left (B) 1.4 v to the left
(C) v to the left (D) 0.4 v to the left

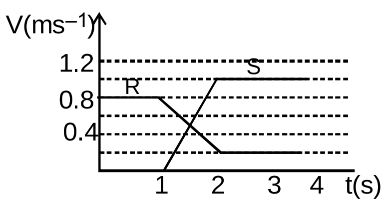
46. A block of mass m starts from rest and slides down a frictionless semi-circular track from a height h as shown. When it reaches the lowest point of the track, it collides with a stationary piece of putty also having mass m. If the block and the putty stick together and continue to slide, the maximum height that the block-putty system could reach is



(A) h/4 (B) h/2
(C) h (D) independent of h

47. Two billiard balls undergo a head-on collision. Ball 1 is twice as heavy as ball 2. Initially, ball 1 moves with a speed v towards ball 2 which is at rest. Immediately after the collision, ball 1 travels at a speed of v/3 in the same direction. What type of collision has occured ?
(A) inelastic (B) elastic
(C) completely inelastic
(D) Cannot be determined from the information given

48. The diagram shows the velocity - time graph for two masses R and S that collided elastically. Which of the following statements is true ?



I. R and S moved in the same direction after the collision.
II. The velocities of R and S were equal at the mid time of the collision.
III. The mass of R was greater than mass of S.
(A) I only (B) II only
(C) I and II only (D) I, II and III

49. A ball is dropped from a height h. As is bounces off the floor, its speed is 80 percent of what it was just before it hit the floor. The ball will then rise to a height of most nearly
(A) 0.80 h (B) 0.75 h
(C) 0.64 h (D) 0.50 h

50. A ball is thrown vertically downwards with velocity $\sqrt{2gh}$ from a height h. After colliding with the ground it just reaches the starting point. Coefficient of restitution is
(A) $1/\sqrt{2}$ (B) 1/2
(C) 1 (D) $\sqrt{2}$

51. A ball is dropped from height 5m. The time after which ball stops rebounding if coefficient of restitution between ball and ground e = 1/2, is
(A) 1 sec (B) 2 sec
(C) 3 sec (D) infinite

52. A ball is projected from ground with a velocity V at an angle θ to the vertical. On its path it makes an elastic collision with a vertical wall and returns to ground. The total time of flight of the ball is
(A) $\frac{2v\sin\theta}{g}$ (B) $\frac{2v\cos\theta}{g}$
(C) $\frac{v\sin 2\theta}{g}$ (D) $\frac{v\cos\theta}{g}$

53. The Gardener water the plants by a pipe of diameter 1 mm. The water comes out at the rate of 10 cm^3/sec. The reactionary force exerted on the hand of the Gardener is : (density of water is 10^3 kg/m^3)
(A) zero (B) 1.27×10^{-2} N
(C) 1.27×10^{-4} N (D) 0.127 N

54. An open water tight railway wagon of mass 5×10^3 kg coasts at an initial velocity 1.2 m/s without friction on a railway track. Rain drops fall vertically downwards into the wagon. The velocity of the wagon after it has collected 10^3 kg of water will be
(A) 0.5 m/s (B) 2 m/s
(C) 1 m/s (D) 1.5 m/s

55. If the force on a rocket which is ejecting gases with a relative velocity of 300 m/s, is 210 N. Then the rate of combustion of the fuel will be
(A) 10.7 kg/sec (B) 0.07 kg/sec
(C) 1.4 kg/sec (D) 0.7 kg/sec

56. A rocket of mass 4000 kg is set for vertical firing. How much gas must be ejected per second so that the rocket may have initial upwards acceleration of magnitude 19.6 m/s^2. [Exhaust speed of fuel = 980 m/s]
(A) 240 kg s^{-1} (B) 60 kg s^{-1}
(C) 120 kg s^{-1} (D) none

57. A wagon filled with sand has a hole so that sand leaks through the bottom at a constant rate λ. An external force $\vec{F}$ acts on the wagon in the direction of motion. Assuming instantaneous velocity of the wagon to be $\vec{v}$ and initial mass of system to be m_0, the force equation governing the motion of the wagon is :
(A) $\vec{F} = m_0 \frac{d\vec{v}}{dt} + \lambda\vec{v}$ (B) $\vec{F} = m_0 \frac{d\vec{v}}{dt} - \lambda\vec{v}$
(C) $\vec{F} = (m_0 - \lambda t)\frac{d\vec{v}}{dt}$ (D) $\vec{F} = (m_0 - \lambda t)\frac{d\vec{v}}{dt} + \lambda\vec{v}$