7 System of Particles and Centre of Mass

JEE-Main

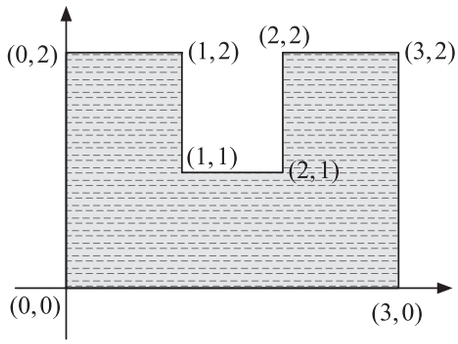
Position of COM

1. The identical spheres each of mass 2M are placed at the corners of a right angled triangle with mutually perpendicular sides equal to 4 m each. Taking point of intersection of these two sides as origin, the magnitude of position vector of the centre of mass of the system is $\frac{4\sqrt{2}}{x}$, where the value of x is _____

[1 Feb, 2024 (Shift-I)]

2. A uniform thin metal plate of mass 10 kg with dimensions is shown. The ratio of x and y coordinates of center of mass of plate in $n/9$. The value of n is_____.

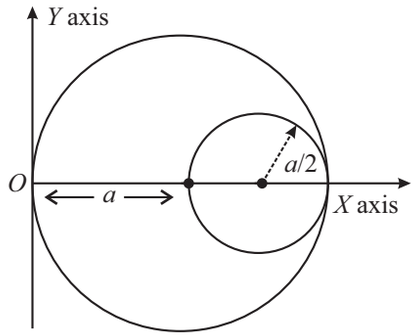
[08 April, 2024 (Shift-I)]



3. The distance of centre of mass from end A of a one dimensional rod (AB) having mass density $Q = Q_0\left(1-\frac{x^2}{L^2}\right)$ kg/m and length L (in meter) is $\frac{3L}{\alpha}m$. The value of α is _____. (where x is the distance from end A)

[28 July, 2022 (Shift-II)]

4. A circular hole of radius $\left(\frac{a}{2}\right)$ is cut of a circular disc of radius 'a' as shown in figure. The centroid of the remaining circular portion with respect to point 'O' will be: **[24 Feb, 2021 (Shift-II)]**



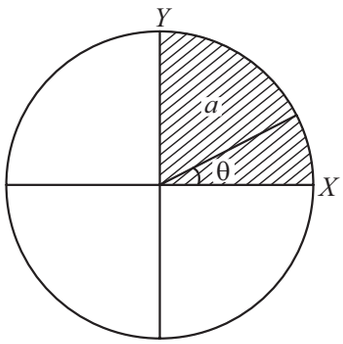
(*a*) $\frac{5}{6}a$ (*b*) $\frac{1}{6}a$

(*c*) $\frac{10}{11}$a (*d*) $\frac{2}{3}a$

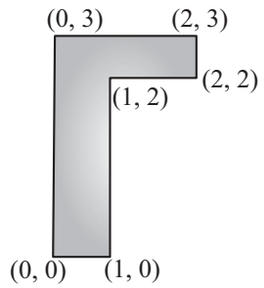
5. The position of the centre of mass of a uniform semi – circular wire of radius 'R' placed in $x-y$ plane with its centre at the origin and the line joining its ends as x-axis is given by $\left(0,\frac{xR}{\pi}\right)$. Then, the value of |x | is _____. **[22 July, 2021 (Shift-II)]**

6. The disc of mass M with uniform surface mass density σ is shown in the figure. The centre of mass of the quarter disc (the shaded area) is at the position $\frac{x}{3}\frac{a}{\pi},\frac{x}{3}\frac{a}{\pi}$ where x is __(Round off to the Nearest Integer) **[17 March, 2021 (Shift-II)]**

[a is an area as shown in the figure]

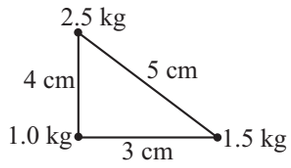


7. The coordinates of centre of mass of a uniform flag shaped lamina (thin flat plate) of mass 4kg. (The coordinates of the same are shown in figure) are: **[8 Jan, 2020 (Shift-I)]**



(*a*) 8.....25 m, 1.50 m)
(*b*) (0.75 m, 0.75 m)
(*c*) (0.75 m, 1.75 m)
(*d*) (1 m, 1.75 m)

8. Three point particles of masses 10 kg, 1.5 kg and 2.5 kg are placed at three corners of a right angle triangle of sides 4.0 cm, 3.0 cm and 5.0 cm as shown in the figure. The center of mass of the system is at a point: **[7 Jan, 2020 (Shift-I)]**



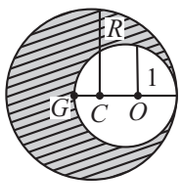
(*a*) 9.....6 cm right and 2.0 cm above 1kg mass
(*b*) 10.....0 cm right and 0.9 cm above 1 kg mass
(*c*) 11.....9 cm right and 2.0 cm above 1kg mass
(*d*) 12.....5 cm right and 1.2 cm above 1kg mass

9. A rod of length L has non-uniform linear mass density given by $\rho(x) = a + b\left(\frac{x}{L}\right)^2$ where a and b are constants and $0 \le x \le L$. The value of x for the centre of mass of the rod is at: **[9 Jan, 2020 (Shift-II)]**

(*a*) $\frac{4}{3}\left(\frac{a+b}{2a+3b}\right)L$ (*b*) $\frac{3}{4}\left(\frac{2a+b}{3a+b}\right)L$

(*c*) $\frac{3}{2}\left(\frac{2a+b}{3a+b}\right)L$ (*d*) $\frac{3}{2}\left(\frac{a+b}{2a+b}\right)L$

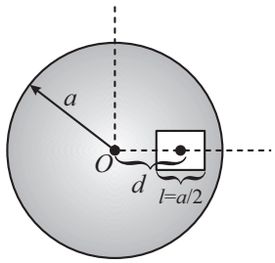
10. As shown in figure. When a spherical cavity (centred at O) of radius 1 is cut out of a uniform sphere of radius R (centred at C), the centre of mass of remaining (shaded) part of sphere is at G, i.e on the surface of the cavity. R can be determined by the equation: **[8 Jan, 2020 (Shift-II)]**



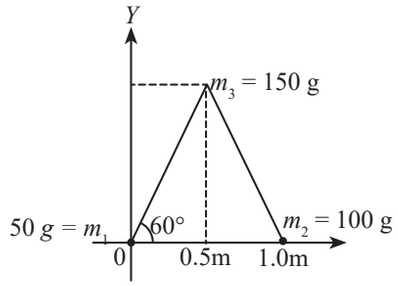
(*a*) $(R^2 + R + 1)(2 - R) = 1$
(*b*) $(R^2 + R - 1)(2 - R) = 1$
(*c*) $(R^2 - ssR + 1)(2 - R) = 1$
(*d*) $(R^2 - R - 1)(2 - R) = 1$

11. The centre of mass of a solid hemisphere of radius 8 cm is x cm from the centre of the flat surface. Then value of x is _____. **[6 Sep, 2020 (Shift-II)]**

12. A square shaped hole of side $l = \frac{a}{2}$ is carved out at a distance $d = \frac{a}{2}$ from the centre 'O' of a uniform circular disk of radius a. If the distance of the centre of mass of the remaining portion from O is $-\frac{a}{x}$, value of x (to the nearest integer) is _____. **[2 Sep, 2020 (Shift-II)]**



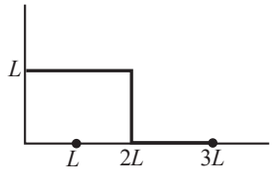
13. Three particles of masses 50 g, 100g and 150g are placed at the vertices of an equilateral triangle of side 1 m (as shown in the figure). The (x, y) coordinates of the centre of mass will be: **[12 April, 2019 (Shift-II)]**



(*a*) $\left(\frac{\sqrt{3}}{7}m, \frac{7}{12}m\right)$ (*b*) $\left(\frac{7}{12}m, \frac{\sqrt{3}}{8}m\right)$

(*c*) $\left(\frac{\sqrt{3}}{4}m, \frac{5}{12}m\right)$ (*d*) $\left(\frac{7}{12}m, \frac{\sqrt{3}}{4}m\right)$

14. The position vector of the centre of mass $\vec{r}$ cm of an asymmetric uniform bar of negligible area of cross-section as shown in figure is: **[12 Jan, 2019 (Shift-I)]**



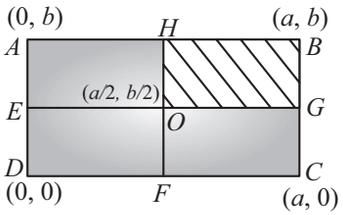
(*a*) $\vec{r}\,(\text{cm}) = \frac{13}{8}L\hat{x} + \frac{5}{8}L\hat{y}$

(*b*) $\vec{r}\,(\text{cm}) = \frac{5}{8}L\hat{x} + \frac{13}{8}L\hat{y}$

(*c*) $\vec{r}\,(\text{cm}) = \frac{3}{8}L\hat{x} + \frac{11}{8}L\hat{y}$

(*d*) $\vec{r}\,(\text{cm}) = \frac{11}{8}L\hat{x} + \frac{3}{8}L\hat{y}$

15. A uniform rectangular thin sheet ABCD of mass M has length a and breadth b, as shown in the figure. If the shaded portion HBGO is cut off, the coordinates of the centre of mass of the remaining portion will be: **[8 April, 2019 (Shift-II)]**



(*a*) $\left(\frac{2a}{3}, \frac{2b}{3}\right)$ (*b*) $\left(\frac{5a}{3}, \frac{5b}{3}\right)$

(*c*) $\left(\frac{3a}{4}, \frac{3b}{4}\right)$ (*d*) $\left(\frac{5a}{12}, \frac{5b}{12}\right)$

16. Two bodies of mass 1 kg and 3 kg have position vectors $\hat{i}+2\hat{j}+\hat{k}$ and $-3\hat{i}-2\hat{j}+\hat{k}$ respectively. The magnitude of position vector of centre of mass of this system will be similar to the magnitude of vector: **[29 July, 2022 (Shift-I)]**

(*a*) $\hat{i}-2\hat{j}+\hat{k}$ (*b*) $-3\hat{i}-2\hat{j}+\hat{k}$

(*c*) $-2\hat{i}+2\hat{k}$ (*d*) $-2\hat{i}-\hat{j}+\hat{k}$

17. Three identical spheres each of mass *M* are placed at the corners of a right angled triangle with mutually perpendicular sides equal to 3 m each. Taking point of intersection of mutually perpendicular sides as origin, the magnitude of position vector of centre of mass of the system will be $\sqrt{x}$ m. The value of *x* is _____. **[25 July, 2022 (Shift-II)]**

Motion of COM

18. In a system two particles of masses m_1 = 3kg and m_2 = 2kg are placed at certain distance from each other. The particle of mass m_1 is moved towards the center of mass of the system through a distance 2 cm. In order to keep the center of mass of the system at the original position, the particle of mass m_2 should move towards the center of mass by the distance ____ cm. **[04 April, 2024**

19. A piece of wood of mass 0.03 kg is dropped from the top of a 100 m height building. At the same time, a bullet of mass 0.02 kg is fired vertically upward, with a velocity 100 ms^{-1}, from the ground. The bullet gets embedded in the wood. Then the maximum height to which the combined system reaches above the top of the building before falling below is:
(g = 10 ms^{-2}) **[10 Jan, 2019 (Shift-I)]**

(*a*) 20 m (*b*) 30 m
(*c*) 40 m (*d*) 10 m

20. Two blocks of masses 10 kg and 30 kg are placed on the same straight line with coordinates (0, 0) and (*x*, 0) respectively. The block of 10 kg is moved on the same line through a distance of 6 cm towards the other block. The distance through which the block of 30 kg must be moved to keep the position of centre of mass of the system unchanged is **[27 June, 2022 (Shift-I)]**

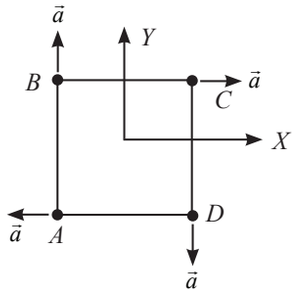
(*a*) 4 cm towards the 10 kg block
(*b*) 2 cm away from the 10 kg block
(*c*) 2 cm towards the 10 kg block
(*d*) 4 cm away from the 10 kg block

21. Two bodies of mass 1 kg and 3 kg have position vectors $\hat{i}+2\hat{j}+\hat{k}$ and $-3\hat{i}-2\hat{j}+\hat{k}$ respectively. The magnitude of position vector of centre of mass of this system will be similar to the magnitude of vector: **[29 July, 2022 (Shift-I)]**

(*a*) $\hat{i}-2\hat{j}+\hat{k}$ (*b*) $-3\hat{i}-2\hat{j}+\hat{k}$

(*c*) $-2\hat{i}+2\hat{k}$ (*d*) $-2\hat{i}-\hat{j}+\hat{k}$

22. Four particles *A*, *B*, *C* and *D* with masses $m_A = m$, $m_B = 2m$, $m_C = 3m$ and m_D = 4m are at the corners of a square. They have accelerations of equal magnitude with directions as shown. The acceleration of the centre of mass of the particles is: **[8 April, 2019 (Shift-I)]**



(*a*) $\frac{a}{5}\left(\hat{i}-\hat{j}\right)$ (*b*) Zero

(*c*) $\frac{a}{5}\left(\hat{i}\times\hat{j}\right)$ (*d*) $a\left(\hat{i}+\hat{j}\right)$

23. A man (mass = 50 kg) and his son (mass = 20 kg) are standing on a frictionless surface facing each other. The man pushes his son so that he starts moving at a speed of 0.70 ms^{-1} with respect to the man. The speed of the man with respect to the surface is:

[12 April, 2019 (Shift-I)]

(*a*) 24.....20 ms^{-1} (*b*) 0.14 ms^{-1}
(*c*) 25.....47 ms^{-1} (*d*) 0.28 ms^{-1}

Impulse, Conservation of Momentum

24. A body of mass 1000 kg is moving horizontally with a velocity 6 m/s. If 200 kg extra mass is added, the final velocity (in m/s) is:

[27 Jan, 2024 (Shift-I)]

(*a*) 6 (*b*) 2 (*c*) 3 (*d*) 5

25. A stationary particle breaks into two parts of masses m_A and m_B which move with velocities v_A and v_B respectively. The ratio of their kinetic energies $(K_B : K_A)$ is:

[08 April, 2024 (Shift-I)]

(*a*) $v_B : v_A$ (*b*) $m_B : m_A$
(*c*) $m_B v_B : m_A v_A$ (*d*) 1 : 1

26. A particle of mass *m* moving with velocity *v* collides with a stationary particle of mass 2*m*. After collision, they stick together and continue to move together with velocity

[10 April, 2023 Shift-1)]

(*a*) v (*b*) $\frac{v}{2}$ (*c*) $\frac{v}{3}$ (*d*) $\frac{v}{4}$

27. A body of mass 5 *kg* is moving with a momentum of 10 *kg ms*$^{-1}$. Now a force of 2 *N* acts on the body in the direction of its motion for 5s. The increase in the Kinetic energy of the body is _____J.

[8 April, 2023 Shift-2)]

28. A body of mass *M* at rest explodes into three pieces, in the ratio of masses 1:1:2 . Two smaller pieces fly off perpendicular to each other with velocities of 30 ms^{-1} and 40 ms^{-1} respectively. The velocity of the third piece will be: **[29 June, 2022 (Shift-I)]**

(*a*) 15 ms^{-1} (*b*) 25 ms^{-1}
(*c*) 35 ms^{-1} (*d*) 50 ms^{-1}

29. Two blocks of masses 10 kg and 30 kg are placed on the same straight line with coordinates (0, 0) and (*x*, 0) respectively. The block of 10 kg is moved on the same line through a distance of 6 cm towards the other block. The distance through which the block of 30 kg must be moved to keep the position of centre of mass of the system unchanged is

[27 June, 2022 (Shift-I)]

(*a*) 4 cm towards the 10 kg block
(*b*) 2 cm away from the 10 kg block
(*c*) 2 cm towards the 10 kg block
(*d*) 4 cm away from the 10 kg block

30. A man of 60 kg is running on the road and suddenly jumps into stationary trolly car of mass 120 kg. Then, the trolly car starts moving with velocity 2 ms^{-1}. The velocity of the running man was ____ ms^{-1}, when he jumps into the car:

[28 June, 2022 (Shift-I)]

31. A block moving horizontally on a smooth surface with a speed of 40 m/s splits into two parts with masses in the ratio of 1:2. If the smaller part moves at 60 m/s in the same direction, then the fractional change in kinetic energy is: **[31 Aug, 2021 (Shift-II)]**

(*a*) 2/3 (*b*) 1/3
(*c*) 1/4 (*d*) 1/8

32. A block moving horizontally on a smooth surface with a speed of 40 ms^{-1} splits into two equal parts. If one of the parts moves at 60 ms^{-1} in the same direction, then the fractional change in the kinetic energy will be *x* : 4 where *x* =_____.

[31 Aug, 2021 (Shift-I)]

33. A particle of mass *m* is moving with speed 2 v collides with a mass 2m moving with speed *v* in the same direction. After collision, the first mass is stopped completely while the second one splits into two particles each of mass *m*, which move at angle 45° with respect to the original direction. The speed of each of the moving particle will be: **[9 April, 2019 (Shift-II)]**

(*a*) $v/(2\sqrt{2})$ (*b*) $2\sqrt{2}v$ (*c*) $\sqrt{2}v$ (*d*) $v/\sqrt{2}$

34. A bullet of '4 g' mass is fired from a gun of mass 4 kg. If the bullet moves with the muzzle speed of 50 ms^{-1}, the impulse imparted to the gun and velocity of recoil of gun are:

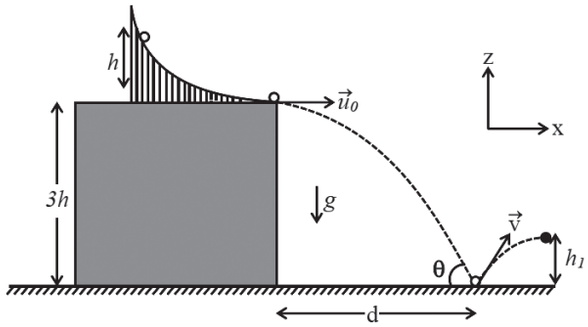
[22 July, 2021 (Shift-II)]

(*a*) 35.....4kg ms^{-1}, 0.1ms^{-1} (*b*) 0.2 kg ms^{-1}, 0.05 ms^{-1}
(*c*) 36.....4 kg ms^{-1}, 0.05 ms^{-1} (*d*) 0.2 kg ms^{-1}, 0.1ms^{-1}

Collisions (Oblique and Head on)

35. A body starts falling freely from height H hits an inclined plane in its path at height h. As a result of this perfectly elastic impact, the direction of the velocity of the body becomes horizontal. The value of $\frac{H}{h}$ for which the body will take the maximum time to reach the ground is _____. **[31 Jan, 2024 (Shift-I)]**

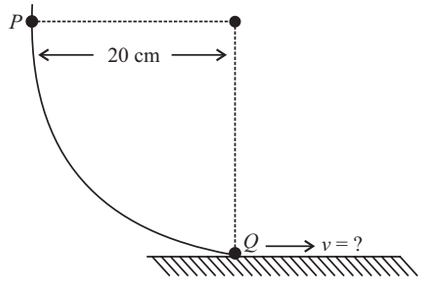
36. A slide with a frictionless curved surface, which becomes horizontal at its lower end, is fixed on the terrace of a building of height 3*h* from the ground, as shown in the figure. A spherical ball of mass m is released on the slide from rest at a height h from the top of the terrace. The ball leaves the slide with a velocity $\vec{u_0} = u_0 \hat{x}$ and falls on the ground at a distance *d* from the building making an angle θ with the horizontal. It bounces off with a velocity $\vec{v}$ and reaches a maximum height h_1. The acceleration due to gravity is *g* and the coefficient of restitution of the ground is $\frac{1}{\sqrt{3}}$. Which of the following statements is/are correct? **[JEE Adv, 2023]**



(*a*) $\vec{u_0} = \sqrt{2gh}\,\hat{x}$ (*b*) $\vec{v} = \sqrt{2gh}\,(\hat{x} - \hat{z})$
(*c*) θ = 60° (*d*) $\frac{d}{h_1} = 2\sqrt{3}$

37. As per the given figure, a small ball P slides down the quadrant of a circle and hits the other ball *Q* of equal mass which is initially at rest. Neglecting the effect of friction and assume the collision to be elastic, the velocity of ball *Q* after collision will be: (g = 10 *m*/*s*^{2})

[30 Jan, 2023 (Shift-I)]



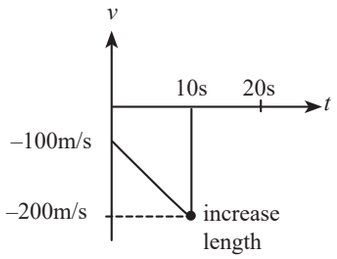
(*a*) 0 (*b*) 25 *m*/*s*
(*c*) 2 *m*/*s* (*d*) 4 *m*/*s*

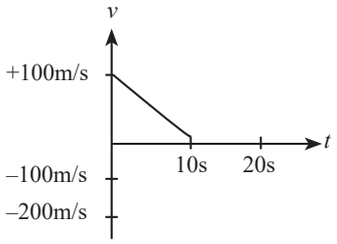
38. A ball of mass 200 g rests on a vertical post of height 20 m. A bullet of mass 10 g, travelling in horizontal direction, hits the centre of the ball. After collision both travels independently. The ball hits the ground at a distance 30 m and the bullet at a distance of 120 m from the foot of the post. The value of initial velocity of the bullet will be (if g = 10 m/s^2): **[30 Jan, 2023 (Shift-I)]**
(*a*) 120 m/s (*b*) 60 m/s (*c*) 400 m/s (*d*) 360 m/s

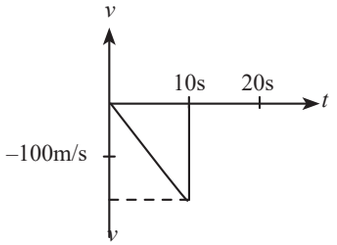
39. A ball is dropped from a height of 20 m. If the coefficient of restitution for the collision between ball and floor is 0.5, after hitting the floor, the ball rebounds to a height of _____ m.
[31 Jan, 2023 (Shift-II)]

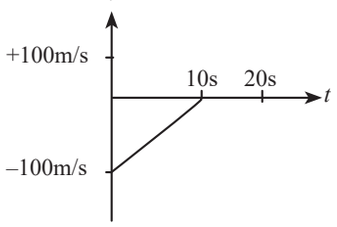
40. A body of mass 1 kg collides head on elastically with a stationary body of mass 3 kg. After collision, the smaller body reverses its direction of motion and moves with a speed of 2m/s. The initial speed of the smaller body before collision is _____ ms^{-1}.
[25 Jan, 2023 (Shift-II)]

41. A bullet is shot vertically downwards with an initial velocity of 100 m/s from a certain height. Within 10s, the bullet reaches the ground and instantaneously comes to rest due to the perfectly inelastic collision. The velocity -time curve for total time t = 20 s will be:
(Take g = 10m/s^2). **[27 July, 2022 (Shift-I)]**

(*a*)


(*b*)


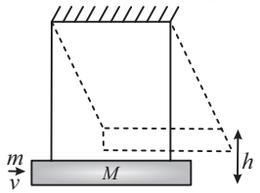
(*c*)


(*d*)


42. What percentage of kinetic energy of a moving particle is transferred to a stationary particle when it strikes the stationary particle of 5 times its mass? (Assume the collision to be head-on elastic collision)
[27 June, 2022 (Shift-I)]
(*a*) 43.....0 % (*b*) 66.6 % (*c*) 55.5 % (*d*) 33.3 %

43. A rubber ball is released from a height of 5 m above the floor. It bounces back repeatedly, always rising to $\frac{81}{100}$ of the height through which it falls. Find the average speed of the ball. (Take g = 10 ms^{-2}) **[17 March, 2021 (Shift-II)]**
(*a*) 44...50 ms^{-1} (*b*) 3.0 ms^{-1} (*c*) 2.0 ms^{-1} (*d*) 3.50 ms^{-1}

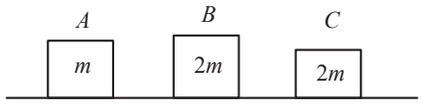
44. A large block of wood of mass M = 5.99 kg is hanging from two long massless cords. A bullet of mass m = 10 g is fired into the block and gets embedded in it. The (block + bullet) then swing upwards, their centre of mass rising a vertical distance h = 9.8 cm before the (block + bullet) pendulum comes momentarily to rest at the end of its arc. The speed of the bullet just before collision is:
(take g = 9.8 ms^{-2}) **[16 March, 2021 (Shift-II)]**



(*a*) 46.....5 m/s (*b*) 811.5 m/s
(*c*) 841.5 m/s (*d*) 47.....5 m/s

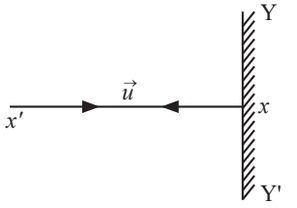
45. Given below are two statements : one is labelled as Assertion *A* and the other is labelled as Reason R.
Assertion A : Body '*P*' having mass *M* moving with speed '*u*' has head - on collision elastically with another body '*Q*' having mass '*m*' initially at rest. If $m << M$, Body will have a maximum speed equal to '2u' after collision.
Reason R : During elastic collision, the momentum and kinetic energy are both conserved. In the light of the above statements, choose the most appropriate answer from the options given below:
[26 Feb, 2021 (Shift-I)]
(*a*) A is correct but R is not correct.
(*b*) A is not correct but R is correct.
(*c*) Both A and R are correct and R is the correct explanation of A.
(*d*) Both A and R correct but R is not the correct explanation of A.

46. Three objects *A, B* and *C* are kept in a straight line on a frictionless horizontal surface. The masses of *A, B* and *C* are m, 2 m and 2 m respectively. A moves towards *B* with a speed of 9 m/s and makes an elastic collision with it. Thereafter *B* makes a completely inelastic collision with *C*. All motions occur along same straight line. The final speed of *C* is: **[27 July, 2021 (Shift-I)]**

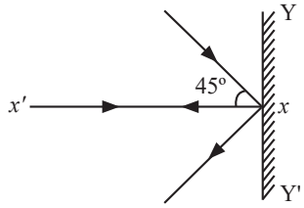


(*a*) 4 m/s (*b*) 6 m/s (*c*) 9 m/s (*d*) 3 m/s

47. Two billiard balls of equal mass 30g strike a rigid wall with same speed of 108 kmph (as shown) but at different angles. If the balls get reflected with the same speed then the ratio of the magnitude of impulses imparted to ball '*a*' and ball '*b*' by the wall along '*X*' direction is: **[25 July, 2021 (Shift-I)]**



Ball(a)



Ball(b)

(*a*) $\sqrt{2}:1$ (*b*) $1:\sqrt{2}$ (*c*) 1 : 1 (*d*) 2 : 1

48. A body of mass M moving at speed V_0 collides elastically with a mass m at rest. After the collision, the two masses move at angles θ_1 and θ_2 with respect to the initial direction of motion of the body of mass M. The largest possible value of the ratio M/m, for which the angles θ_1 and θ_2 will be equal, is: **[31 Aug, 2021 (Shift-I)]**

(a) 3 (b) 1 (c) 2 (d) 4

49. An object of mass m_1 collides with another object of mass m_2, which is at rest. After collision the objects move with equal speeds in the opposite direction. The ratio of the masses $m_2 : m_1$ is:

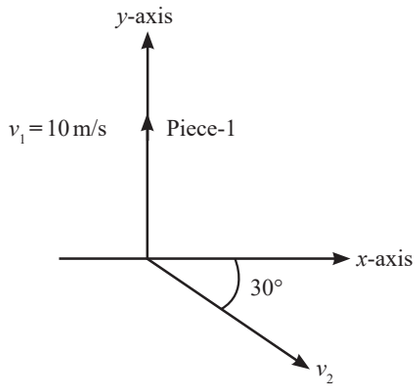
[18 March, 2021 (Shift-II)]

(a) 1 : 1 (b) 3 : 1 (c) 1 : 2 (d) 2 : 1

50. A ball of mass 10kg, moving with a velocity $10\sqrt{3}$m/s along, the x-axis, hits another ball of mass 20kg which is at rest. After the collision, first ball comes to rest while second ball disintegrates into two equal pieces. One piece starts moving along y–axis with a speed of 10 m/s. The second piece starts moving at an angle of 30° with respect to the x-axis.

The velocity of the ball moving at 30° with x-axis is x m/s.

The configuration of pieces after collision is shown in the figure below.



The value of x to the nearest integer is _____.

[18 March, 2021 (Shift-I)]

51. A ball with a speed of 9 m/s collides with another identical ball at rest. After the collision the direction of each ball makes an angle of 30° with the original direction. The ratio of velocities of the balls after collision is $x : y$, where x is_____.

[24 Feb, 2021 (Shift-I)]

52. A body of mass 2 kg moving with a speed of 4 m/s. makes an elastic collision with another body at rest and continues to move in the original direction but with one fourth of its initial speed. The speed of the two body centre of mass is $\frac{x}{10}$ m/s. The value of x is _____. **[25 July, 2021 (Shift-I)]**

53. A bullet of 10 g, moving with velocity v, collides head-on with the stationary bob of a pendulum and recoils with velocity 100 m/s. The length of the pendulum is 0.5 m and mass of the bob is 1 kg. The minimum value of v = _____ m/s so that the pendulum describes a circle. (Assume the string to be inextensible and $g = 10$ m/s^2)

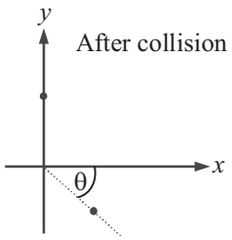
[27 Aug, 2021 (Shift-II)]

54. A ball of mass 10 kg moving with a velocity $10\sqrt{3}\text{ms}^{-1}$ along X–axis, hits another ball of mass 20 kg which is at rest. After collision, the first ball comes to rest and the second one disintegrates into two equal pieces. One of the pieces starts moving along Y–axis at a speed of 10m/s. The second piece starts moving at a speed of 20m/s at an angle θ (degree) with respect to the X–axis.

The configuration of pieces after collision is shown in the figure.

The value of θ to the nearest integer is _____.

[16 March, 2021 (Shift-I)]



55. A block of mass 1.9 kg is at rest at the edge of a table, of height 1m. A bullet of mass 0.1 kg collides with the block and sticks to it. If the velocity of the bullet is 20 m/s in the horizontal direction just before the collision then the kinetic energy just before the combined system strikes the floor, is

[Take $g = 10$ m/s^2. Assume there is no rotational motion and loss of energy after the collision is negligible.] **[3 Sep, 2020 (Shift-II)]**

(a) 19 J (b) 23 J (c) 20 J (d) 21 J

56. Two particles of equal mass m have respective initial velocities $u\hat{i}$ and $u\left(\frac{\hat{i}+\hat{j}}{2}\right)$. They collide completely inelastically. The energy lost in the process is **[9 Jan, 2020 (Shift-I)]**

(a) $\frac{3}{4}mu^2$ (b) $\sqrt{\frac{2}{3}}mu^2$ (c) $\frac{1}{3}mu^2$ (d) $\frac{1}{8}mu^2$

57. A particle of mass m is projected with a speed u from the ground at an angle $\theta = \pi/3$ w.r.t. horizontal (x – axis). When it has reached its maximum height, it collides completely inelastically with another particle of the same mass and velocity $u\hat{i}$. The horizontal distance covered by the combined mass before reaching the ground is:

[9 Jan, 2020 (Shift-II)]

(a) $\frac{3\sqrt{3}}{8}\frac{u^2}{g}$ (b) $2\sqrt{2}\frac{u^2}{g}$ (c) $\frac{5}{8}\frac{u^2}{g}$ (d) $\frac{3\sqrt{2}}{4}\frac{u^2}{g}$

58. A particle of mass m is dropped from a height h above the ground. At the same time another particle of the same mass is thrown vertically upwards from the ground with a speed of $\sqrt{2gh}$. If they collide head-on completely inelastically, the time taken for the combined mass to reach the ground, in units of $\sqrt{\frac{h}{g}}$ is:**[8 Jan, 2020 (Shift-II)]**

(a) $\frac{1}{2}$ (b) $\sqrt{\frac{1}{2}}$ (c) $\sqrt{\frac{3}{4}}$ (d) $\sqrt{\frac{3}{2}}$

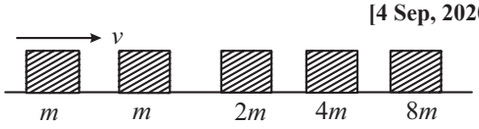
59. Particle A of mass m_1 moving with velocity $(\sqrt{3}\hat{i}+\hat{j})$ ms^{-1} collides with another particle B of mass m_2 which is at rest initially. Let $\vec{V}_1$ and $\vec{V}_2$ be the velocities of particles A and B after collision respectively. If $m_1 = 2m_2$ and after collision $\vec{V}_1 = (\hat{i}+\sqrt{3}\hat{j})$ ms^{-1}, the angle between $\vec{V}_1$ and $\vec{V}_2$ is **[6 Sep, 2020 (Shift-II)]**

(a) $-45°$ (b) $60°$ (c) $15°$ (d) $105°$

60. A particle of mass m with an initial velocity $u\hat{i}$ collides perfectly elastically with a mass $3m$ at rest. It moves with a velocity $v\hat{j}$ after collision, then, v is given by **[2 Sep, 2020 (Shift-I)]**

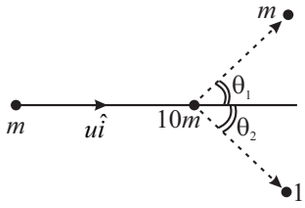
(a) $v = \frac{1}{\sqrt{6}}u$ (b) $v = \frac{u}{\sqrt{3}}$ (c) $v = \sqrt{\frac{2}{3}}u$ (d) $v = \frac{u}{\sqrt{2}}$

61. Blocks of masses m, $2m$, $4m$ and $8m$ are arranged in a line on a frictionless floor. Another block of mass m, moving with speed v along the same line (see figure) collides with mass m in perfectly inelastic manner. All the subsequent collisions are also perfectly inelastic. By the time the last block of mass $8m$ starts moving, the total energy loss is p% of the original energy. Value of 'p' is close to **[4 Sep, 2020 (Shift-I)]**



(a) 37 (b) 77 (c) 87 (d) 94

62. A particle of mass m is moving along the x-axis with initial velocity $u\hat{i}$. It collides elastically with a particle of mass $10m$ at rest and then moves with half its initial kinetic energy(see figure). If $\sin\theta_1 = \sqrt{n}\sin\theta_2$, then value of n is _____. **[2 Sep, 2020 (Shift-II)]**



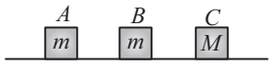
63. Two bodies of the same mass are moving with the same speed, but in different directions in a plane. They have a completely inelastic collision and move together thereafter with a final speed which is half of their initial speed.
The angle between the initial velocities of the two bodies (in degree) is ____. **[6 Sep, 2020 (Shift-I)]**

64. A body A of mass $m = 0.1$ kg has an initial velocity of $3\hat{i}$ ms^{-1}. It collides elastically with another body B of the same mass which has an initial velocity of $5\hat{j}$ ms^{-1}. After collision, A moves with a velocity $\vec{v} = 4(\hat{i}+\hat{j})$ m/s.The energy of B after colision is written as $\frac{x}{10}$J. The value of x is_____. **[8 Jan, 2020 (Shift-I)]**

65. A body of mass m_1 moving with an unknown velocity o $v_1\hat{i}$ undergoes a collinear collision with a body of mass m_2 moving with a velocity $v_2\hat{i}$. After collision, m_1 and m_2 move with velocities of $v_3\hat{i}$ and $v_4\hat{i}$, respectively. If $m_2 = 0.5\, m_1$ and $v_3 = 0.5\, v_1$, then v_1 is : **[8 April, 2019 (Shift-II)]**

(a) $v_4 - \frac{v_2}{4}$ (b) $v_4 - \frac{v_2}{2}$ (c) $v_4 - v_2$ (d) $v_4 + v_2$

66. Three blocks A, B and C are lying on a smooth horizontal surface, as shown in the figure. A and B have equal masses, m while C has mass M. Block A is given an initial speed v towards B due to which it collides with B perfectly inelastically. The combined mass collides with C, also perfectly inelastically if $\frac{5}{6}$th of the initial kinetic energy is lost in whole process. What is value of M/m? **[9 Jan, 2019 (Shift-I)]**

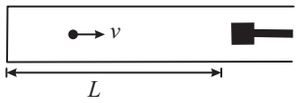


(a) 5 (b) 2 (c) 4 (d) 3

67. A body of mass 2 kg makes an elastic collision with a second body at rest and continues to move in the original direction but with one fourth of its original speed. What is the mass of the second body? **[9 April, 2019 (Shift-I)]**

(a) 68....5 kg (b) 1.2 kg (c) 1.8 kg (d) 1.0 kg

68. A small particle of mass m moving inside a heavy, hollow and straight tube along the tube axis undergoes elastic collision at two ends. The tube has no friction and it is closed at one end by a flat surface while the other end is fitted with a heavy movable flat piston as shown in figure. When the distance of the piston from closed end is $L = L_0$, the particle speed is $v = v_0$. The piston is moved inward at a very low speed V such that $V << \frac{dL}{L}v_0$ where dL is the infinitesimal displacement of the piston. Which of the following statement (s) is/are correct?



[JEE Adv, 2019]

(a) The rate at which the particle strikes the piston is v/L

(b) After each collision with the piston, the particle speed increases by $2V$

(c) The particle's kinetic energy increases by a factor of 4 when the piston is moved inward from L_0 to $\frac{1}{2}L_0$

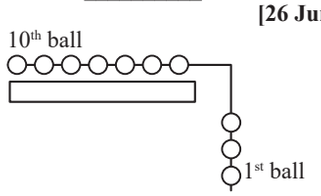
(d) If the piston moves inward by dL, the particle speed increases by $2v\frac{dL}{L}$

69. A particle of mass m is moving with speed 2 v collides with a mass 2m moving with speed v in the same direction. After collision, the first mass is stopped completely while the second one splits into two particles each of mass m, which move at angle 45° with respect to the original direction. The speed of each of the moving particle will be: **[9 April, 2019 (Shift-II)]**

(a) $v/(2\sqrt{2})$ (b) $2\sqrt{2}v$ (c) $\sqrt{2}v$ (d) $v/\sqrt{2}$

Variable Mass Systems

70. A system to 10 balls each of mass 2kg are connected via massless and unstretchable string. The system is allowed to slip over the edge of a smooth table as shown in figure. Tension on the string between the 7th and 8th ball is _____ N when 6th ball just leaves the table. **[26 June, 2022 (Shift-II)]**

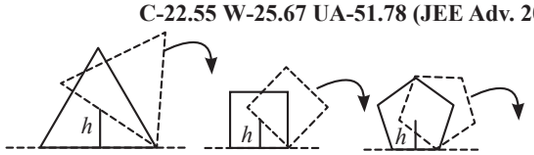


Displacement, Velocity, Acceleration of Com

Single Correct

1. Consider regular polygons with number of sides n = 3,4,5..... as shown in the figure. The centre of mass of all the polygons is at height h from the ground. They roll on a horizontal surface about the leading vertex without slipping and sliding as depicted. The maximum increase in height of the locus of the centre of mass for each polygon is Δ. Then, Δ depends on n and h as

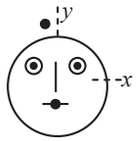
C-22.55 W-25.67 UA-51.78 (JEE Adv. 2017)



(*a*) $\Delta = h\sin^2\left(\frac{\pi}{n}\right)$ (*b*) $\Delta = h\sin\left(\frac{2\pi}{n}\right)$

(*c*) $\Delta = h\tan^2\left(\frac{\pi}{2n}\right)$ (*d*) $\Delta = h\left(\frac{1}{\cos\left(\frac{\pi}{n}\right)}-1\right)$

2. Look at the drawing given in the figure, which has been drawn with ink of uniform line-thickness. The mass of ink used to draw each of the two inner circles, and each of the two line segments is m. The mass of the ink used to draw the outer circle is 6 m. The coordinates of the centres of the different parts are : outer circle (0, 0), left inner circle ($-a$, a), right inner circle (a, a), vertical line (0, 0) and horizontal line (0, $-a$). The y-coordinate of the centre of mass of the ink in this drawing is **(IIT-JEE 2009)**



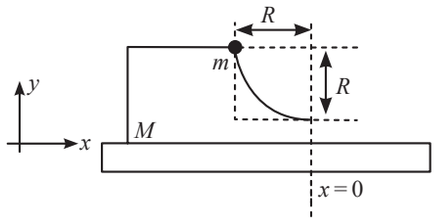
(*a*) $\frac{a}{10}$ (*b*) $\frac{a}{8}$ (*c*) $\frac{a}{12}$ (*d*) $\frac{a}{3}$

3. Two particles A and B initially at rest, move towards each other by mutual force of attraction. At the instant when the speed of A is v and the speed of B is $2v$, the speed of the centre of mass of the system is **(IIT-JEE 1982)**

(*a*) $3v$ (*b*) v (*c*) $1.5v$ (*d*) zero

Multiple Correct

4. A block of mass M has a circular cut with a frictionless surface as shown. The block rests on the horizontal frictionless surface of a fixed table. Initially the right edge of the block is at x = 0, in a coordinate system fixed to the table. A point mass m is released from rest at the topmost point of the path as shown and it slides down. When the mass loses contact with the block, its position is x and the velocity is v. At that instant, which of the following options is/are correct? **C-9.62 W-21.65 UA-52.96 PC-15.78 (JEE Adv. 2017)**



(*a*) The velocity of the point mass m is $v = \sqrt{\frac{2gR}{1+\frac{m}{M}}}$

(*b*) The x component of displacement of the centre of mass of the block M is $-\frac{mR}{M+m}$

(*c*) The position of the point mass is $x = -\sqrt{2}\frac{mR}{M+m}$

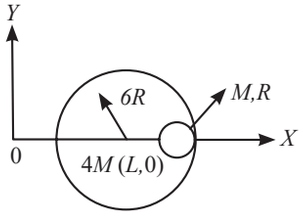
(*d*) The velocity of the block M is $V = -\frac{m}{M}\sqrt{2gR}$

True/False

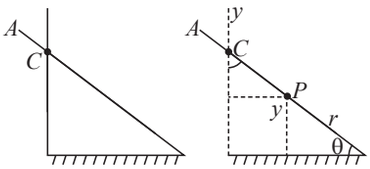
5. Two particles of mass 1 kg and 3 kg move towards each other under their mutual force of attraction. No other force acts on them. When the relative velocity of approach of the two particles is 2 m/s, their centre of mass has a velocity of 0.5 m/s. When the relative velocity of approach becomes 3 m/s, the velocity of the centre of mass is 0.75 m/s. **(IIT-JEE 1989)**

Subjective

6. A small sphere of radius R is held against the inner surface of a larger sphere of radius $6R$. The masses of large and small spheres are $4M$ and M respectively. This arrangement is placed on a horizontal table. There is no friction between any surfaces of contact. The small sphere is now released. Find the coordinates of the centre of the larger sphere when the smaller sphere reaches the other extreme position. **(IIT-JEE 1996)**



7. A uniform thin rod of mass M and length L is standing vertically along the y-axis on a smooth horizontal surface, with its lower end at the origin (0, 0). A slight disturbance at t = 0 causes the lower end to slip on the smooth surface along the positive x-axis, and the rod starts falling.

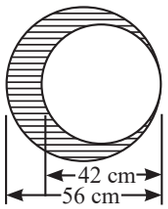


(*a*) What is the path followed by the centre of mass of the rod during its fall?

(*b*) Find the equation of the trajectory of a point on the rod located at a distance r from the lower end. What is the shape of the path of this point? **(IIT-JEE 1993)**

8. A circular plate of uniform thickness has a diameter of 56 cm. A circular portion of diameter 42 cm is removed from one edge of the plate as shown in figure.

Find the position of the centre of mass of the remaining portion. **(IIT-JEE 1980)**



Law of Conservation of Momentum

Single Correct

9. An object of mass 5 kg is projected with a velocity of 60° at an angle of 20 m/s to the horizontal. At the highest point of its path, the projectile explodes and breaks up into two fragments of masses 1 kg and 4 kg. The fragments separate horizontally after the explosion. The explosion releases internal energy such that the kinetic energy of the system at the highest point is doubled. Calculate the separation between the two fragments when they reach the ground. **(IIT-JEE 1990)**

(*a*) 40.25 m (*b*) 35.25 m (*c*) 44.25 m (*d*) 41.25 m

10. A shell is fired from a cannon with a velocity $V(m/s)$ at an angle θ with the horizontal direction. At the highest point in its path it explodes into two pieces of equal mass. One of the pieces retraces its path to the cannon and the speed (m/s) of the other pieces immediately after the explosion is **(IIT-JEE 1986)**

(*a*) $3V\cos\theta$ (*b*) $2V\cos\theta$ (*c*) $\frac{3}{2}V\cos\theta$ (*d*) $\sqrt{\frac{3}{2}}V\cos\theta$

Multiple Correct

11. Two balls, having linear momenta $p_1 = p\hat{i}$ and $p_2 = -p\hat{i}$, undergo a collision in free space. There is no external force acting on the balls. Let p_1' and p_2' be their final momentum. The following option figure (s) is (are) not allowed for any non-zero value of $p, a_1, a_2, b_1, b_2, c_1$ and c_2. **(IIT-JEE 2008)**

(*a*) $p_1' = a_1\hat{i} + b_1\hat{j} + c_1\hat{k},\ p_2' = a_2\hat{i} + b_2\hat{j}$

(*b*) $p_1' = c_1\hat{k},\ p_2' = c_2\hat{k}$

(*c*) $p_1' = a_1\hat{i} + b_1\hat{j} + c_1\hat{k},\ p_2' = a_2\hat{i} + b_2\hat{j} - c_1\hat{k}$

(*d*) $p_1' = a_1\hat{i} + b_1\hat{j},\ p_2' = a_2\hat{i} + b_1\hat{j}$

Fill in the Blanks

12. A particle of mass $4m$ which is at rest explodes into three fragments. Two of the fragments each of mass m are found to move with a speed v each in mutually perpendicular directions. The total energy released in the process of explosion is _____ **(IIT-JEE 1987)**

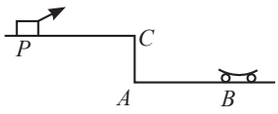
True/False

13. Two particles of masses 1 kg and 3 kg move towards each other under their mutual force of attraction. No other force acts on them. When the relative velocity of approach of the two particles is 2 m/s, their centre of mass has a velocity of 0.5 m/s. When the relative velocity of approach becomes 3 m/s, the velocity of the centre of mass is 0.75 m/s. **(IIT-JEE 1989)**

Subjective

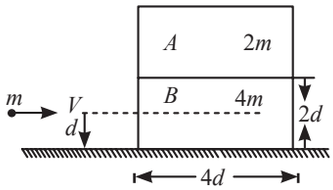
14. A car P is moving with a uniform speed of $5\sqrt{3}$ m/s towards a carriage of mass 9 kg at rest kept on the rails at a point B as shown in figure. The height AC is 120 m. Cannon balls of 1 kg are fired from the car with an initial velocity 100 m/s at an angle 30° with the horizontal. The first cannon ball hits the stationary carriage after a time t_0 and sticks to it. Determine t_0. At t_0, the second cannonball is fired. Assume that the resistive force between the rails and the carriage is constant and ignore the vertical motion of the carriage throughout.

If the second ball also hits and sticks to the carriage, what will be the horizontal velocity of the carriage just after the second impact? **(IIT-JEE 2011)**



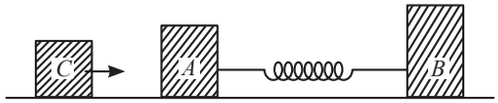
15. A block A of mass 2 m is placed on another block B of mass 4 m which in tum is placed on a fixed table. The two blocks have a same length $4d$ and they are placed as shown in figure. The coefficient of friction (both static and kinetic) between the block B and table is μ. There is no friction between the two blocks. A small object of mass m moving horizontally along a line passing through the center of mass (CM) of the block B and perpendicular to its face with a speed v collides elastically with the block B at a height d above the table.

(*a*) What is the minimum value of v (call it v_0) required to make the block A to topple?



(*b*) If $v = 2v_0$, find the distance (from the point P in the figure) at which the mass m falls on the table after collision. (Ignore the role of friction during the collision.) **(IIT-JEE 1991)**

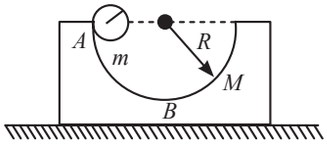
16. Two bodies A and B of masses m and $2m$ respectively are placed on a smooth floor. They are connected by a spring. A third body C of mass m moves with velocity v_0 along the line joining A and B and collides elastically with A as shown in figure. At a certain instant of time t_0 after collision, it is found that the instantaneous velocities of A and B are the same. Further at this instant the compression of the spring is found to be x_0. Determine (*a*) the common velocity of A and B at time t_0 and (*b*) the spring constant. **(IIT-JEE 1984)**



17. A block of mass M with a semicircular track of radius R, rests on a horizontal frictionless surface. A uniform cylinder of radius r and mass m is released from rest at the top point A (see fig.). The cylinder slips on the semicircular frictionless track.

A. How far has the block moved when the cylinder reaches the bottom (point) of the track?

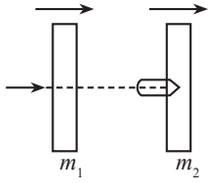
B. How fast is the block moving when the cylinder reaches the bottom of the track? **(IIT-JEE 1983)**



18. A body of mass 1 kg initially at rest, explodes and breaks into three fragments of masses in the ratio 1 : 1 : 3. The two pieces of equal mass fly-off perpendicular to each other with a speed of 30 m/s each. What is the velocity of the heavier fragment?

(IIT-JEE 1981)

19. A 20g bullet pierces through a plate of mass M_1 = 1 kg and then comes to rest inside a second plate of mass M_2 = 2.98 kg as shown in the figure. It is found that the two plates initially at rest, now move with equal velocities. Find the percentage loss in the initial velocity of the bullet when it is between M_1 and M_2. Neglect any loss of material of the plates due to the action of the bullet. Both plates are lying on a smooth table. **(IIT-JEE 1979)**



20. When a ball is thrown up, the magnitude of its momentum decreases and then increases. Does this violate the conservation of momentum principle? **(IIT-JEE 1979)**

21. A body of mass moving with a velocity in the x-direction collides with another body of mass M moving in the y-direction with a velocity V. They coalesce into one body during collision. Find

(a) the direction and magnitude of the momentum of the composite body.

(b) the fraction of the initial kinetic energy transformed into heat during the collision. **(IIT-JEE 1978)**

Impulse

Single Correct

22. A solid horizontal surface is covered with a thin layer of oil. A rectangular block of mass m = 0.4 kg is at rest on this surface. An impulse of 1.0 N s is applied to the block at time t = 0, so that it starts moving along the X-axis with a velocity $v(t) = v_0 e^{-t/\tau}$, where v_0 is a constant and τ = 4 s. The displacement of the block, in meters, at $t = \tau$ is (Take, e^{-1} = 0.37).

C-7.43 W-75.89 UA-16.68 (JEE Adv. 2018)

(a) 3 (b) 4 (c) 5 (d) 6

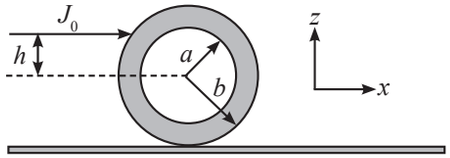
23. Two blocks of masses 10 kg and 4 kg are connected by a spring of negligible mass and placed on a frictionless horizontal surface. An impulse gives a velocity of 14 m/s to the heavier block in the direction of the lighter block. The velocity of the centre of mass is **(IIT-JEE 2002)**

(a) 30 m/s (b) 20 m/s (c) 10 m/s (d) 5 m/s

Multiple Correct

24. An annular disk of mass M, inner radius a and outer radius b is placed on a horizontal surface with coefficient of friction μ, as shown in the figure. At some time, an impulse $J_0\hat{x}$ is applied at a height h above the center of the disk. If $h = h_m$ then the disk rolls without slipping along the x-axis. Which of the following statement(s) is(are) correct?

C-1.17 W-0 UA-57.98 PC-40.84 (JEE Adv. 2023)



(a) For $\mu \neq 0$ and $a \to 0$, $h_m = b/2$

(b) For $\mu \neq 0$ and $a \to b$, $h_m = b$

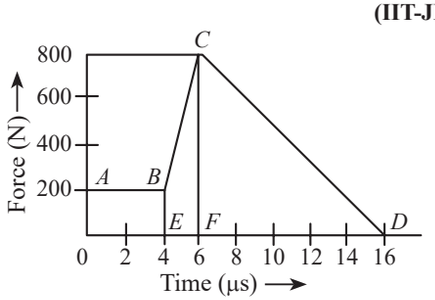
(c) For $h = h_m$, the initial angular velocity does not depend on the inner radius a.

(d) For $\mu = 0$ and $h = 0$. the wheel always slides without rolling.

Numerical Types/Integer Types

25. The magnitude of the force (in Newtons) acting on a body varies with time t (in microseconds as shown in the figure. AB, BC and CD are straight line segments. The magnitude of the total impulse of the force on the body from t = 4μs to t = 16μs is _____N – s.

(IIT-JEE 1994)



Collisions

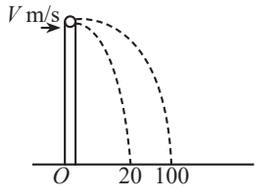
Single Correct

26. A particle of mass m is projected from the ground with an initial speed u_0 at an angle α with the horizontal. At the highest point of its trajectory, it makes a completely inelastic collision with another identical particle, which was thrown vertically upward from the ground with the same initial speed u_0. The angle that the composite system makes with the horizontal immediately after the collision is

C-21.77 W-73.71 UA-4.52 (JEE Adv. 2013)

(a) $\frac{\pi}{4}$ (b) $\frac{\pi}{4}+\alpha$ (c) $\frac{\pi}{4}-\alpha$ (d) $\frac{\pi}{2}$

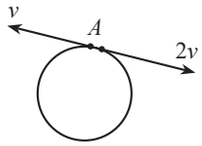
27. A ball of mass 0.2 kg rests on a vertical post of height 5 m. A bullet of mass 0.01 kg, traveling with a velocity vm/s in a horizontal direction, hits the centre of the ball. After the collision, the ball and bullet travel independently. The ball hits the ground at a distance of 20 m and the bullet at a distance of 100 m from the foot of the post. The initial velocity v of the bullet is **(IIT-JEE 2011)**



(*a*) 250 m/s (*b*) $250\sqrt{2}$ m/s

(*c*) 400 m/s (*d*) 500 m/s

28. Two small particles of equal masses start moving in opposite directions from a point A in a horizontal circular orbit. Their tangential velocities are v and $2v$ respectively, as shown in the figure. Between collisions, the particles move with constant speeds. After making how many elastic collisions, other than that at A, these two particles will again reach the point A? **(IIT-JEE 2009)**



(*a*) 4 (*b*) 3 (*c*) 2 (*d*) 1

29. **Statement-I:** In an elastic collision between two bodies, the relative speed of the bodies after collision is equal to the relative speed before the collision.

Statement-II: In an elastic collision, the linear momentum of the system is conserved. **(IIT-JEE 2007)**

Mark your answer as

(*a*) If Statement-I is true, Statement-II is true, Statement-II is the correct explanation for Statement-I

(*b*) If Statement-I is true, Statement-II is true; Statement-II is not a correct explanation for Statement-I

(*c*) If Statement-I is true; Statement-II is false

(*d*) If Statement-I is false; Statement-II is true

30. Two particles of masses m_1 and m_2 in projectile motion have velocities v_1 and v_2 respectively at time $t = 0$. They collide at time t_0. Their velocities become v_1 and v_2 at time $2t_0$ while still moving in the air. The value of $\left|(m_1v_1 + m_2v_2) - (m_1v_1 + m_2v_2)\right|$ is **(IIT-JEE 2001)**

(*a*) Zero (*b*) $(m_1 + m_2)gt_0$

(*c*) $2(m_1 + m_2)gt_0$ (*d*) $\frac{1}{2}(m_1 + m_2)gt_0$

31. A ball hits the floor and rebounds after an inelastic collision. In this case, **(IIT-JEE 1986)**

(*a*) The momentum of the ball just after the collision is the same as that just before the collision

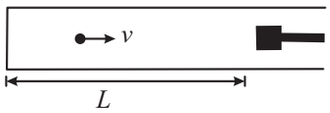
(*b*) The mechanical energy of the ball remains the same in the collision

(*c*) The total momentum of the ball and the earth is conserved

(*d*) The total mechanical energy of the ball and the earth is conserved

Multiple Correct

32. A small particle of mass m moving inside a heavy, hollow and straight tube along the tube axis undergoes elastic collision at two ends. The tube has no friction and it is closed at one end by a flat surface while the other end is fitted with a heavy movable flat piston as shown in figure. When the distance of the piston from closed end is $L = L_0$, the particle speed is $v = v_0$. The piston is moved inward at a very low speed V such that $V << \frac{dL}{L}v_0$ where dL is the infinitesimal displacement of the piston. Which of the following statement (s) is/ are correct? **C-2.9 W-34.73 UA-52.78 PC-9.58 (JEE Adv. 2019)**



(*a*) The rate at which the particle strikes the piston is v/L

(*b*) After each collision with the piston, the particle speed increases by $2V$

(*c*) The particle's kinetic energy increases by a factor of 4 when the piston is moved inward from L_0 to $\frac{1}{2}L_0$

(*d*) If the piston moves inward by dL, the particle speed increases by $2v\frac{dL}{L}$

33. A point mass of 1 kg collides elastically with a stationary point mass of 5 kg. After their collision, the 1 kg mass reverses its direction and moves with a speed of 2 ms^{-1}. Which of the following statement(s) is/are correct for the system of these two masses? **(IIT-JEE 2010)**

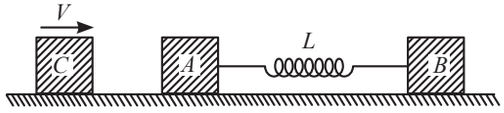
(*a*) Total momentum of the system is 3 kg ms^{-1}

(*b*) Momentum of mass after collision is 4 kg ms^{-1}

(*c*) Kinetic energy of the centre of mass is 0.75 J

(*d*) Total kinetic energy of the system is 4 J

34. Two blocks A and B each of mass m, are connected by a massless spring of natural length L and spring constant k. The blocks are initially resting on a smooth horizontal floor with the spring at its natural length, as shown in figure. A third identical block C, also of mass m, moves on the floor with a speed v along the line joining A and B, and collides elastically with A. Then **(IIT-JEE 1993)**



(*a*) The kinetic energy of the A – D system, at maximum compression of the spring, is zero

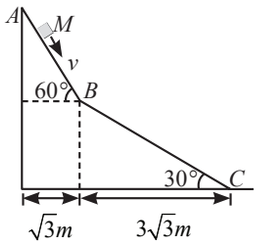
(*b*) The kinetic energy of the A – B system, at maximum compression of the spring, is $mv^2/4$

(*c*) The maximum compression of the spring is $v\sqrt{(m/k)}$

(*d*) The maximum compression of the spring is $v\sqrt{\frac{m}{2k}}$

Comprehension Based/Passage Based

Direction (Q. 35 to 37): A small block of mass M moves on a frictionless surface of an inclined plane, as shown in figure. The angle of the incline suddenly changes from 60° to 30° at point B. The block is Match the Column initially at rest at A. Assume that collisions between the block and the incline are totally inelastic ($g = 10$ m/s^2). **(IIT-JEE 2008)**



35. The speed of the block at point immediately after it strikes the second incline is

(a) $\sqrt{60}$ m/s (b) $\sqrt{45}$ m/s (c) $\sqrt{30}$ m/s (d) $\sqrt{15}$ m/s

36. The speed of the block at point , immediately before it leaves the second incline is

(a) $\sqrt{120}$ m/s (b) $\sqrt{105}$ m/s (c) $\sqrt{90}$ m/s (d) $\sqrt{75}$ m/s

37. If collision between the block and the incline is completely elastic, then the vertical (upward) component of the velocity of the block at point, immediately after it strikes the second incline is

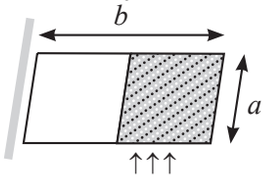
(a) $\sqrt{30}$ m/s (b) $\sqrt{15}$ m/s (c) zero (d) $-\sqrt{15}$ m/s

Numerical Types/Integer Types

38. A ball is projected from the ground at an angle of 45° with the horizontal surface. It reaches a maximum height of 120 m and returns to the ground. Upon hitting the ground for the first time, it loses half of its kinetic energy. Immediately after the bounce, the velocity of the ball makes an angle of 30° with the horizontal surface. The maximum height it reaches after the bounce, in meters, is **C-31.93 W-59 UA-9.07 (JEE Adv. 2018)**

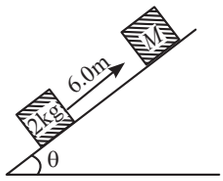
Subjective

39. There is a rectangular plate of mass M kg of dimensions ($a \times b$). The plate is held in horizontal position by striking n small balls uniformly each of mass m per unit area per unit time. These are striking in the shaded half region of the plate. The balls are colliding elastically with velocity v. What is v? **(IIT-JEE 2006)**



It is given $n = 100$, $M = 3$ kg, $m = 0.01$ kg
$b = 2$ m; $a = 1$ m; $g = 10$ m/s^2

40. Two blocks of mass 2 kg and M are at rest on an inclined plane and are separated by a distance of 6.0 m as shown. The coefficient of friction between each block and the inclined plane is 0.25. The 2 kg block is given a velocity of 10.0 m/s up the inclined plane. It collides with M, comes back and has a velocity of 1.0 m/s when it reaches its initial position. The other block M after the collision moves 0.05 m up and comes to rest. Calculate the coefficient of restitution between the blocks and the mass of the block M. **(IIT-JEE 1999)**



[Take $\sin\theta = \tan\theta = 0.05$ and $g = 10$ m/s^2]

41. A cylindrical solid of mass 10^{-2} kg and cross-sectional area 10^{-4} m^2 is moving parallel to its axis (the x-axis) with a uniform speed of 10^3 m/s in the positive direction. At $t = 0$, its front face passes the plane $x = 0$. The region to the right of this plane is filled with stationary dust particles of uniform density 10^{-3} kg/m^3. When a dust particle collides with the face of the cylinder, it sticks to its surface. Assuming that the dimensions of the cylinder remain practically unchanged and that the dust sticks only to the front face of the cylinder find the x-coordinate of the front of the cylinder at $t = 150$ s. **(IIT-JEE 1998)**

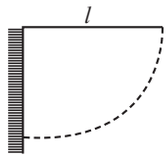
42. A cart is moving along x-direction with a velocity of 4 m/s. A person on the cart throws a stone with a velocity of 6 m/s relative to himself. In the frame of reference of the cart, the stone is thrown in y-z plane making an angle of 30° with vertical z-axis. At the highest point of its trajectory, the stone hits an object of equal mass hung vertically from branch of a tree by means of a string of length L.

A completely inelastic collision occurs, in which the stone gets embedded in the object. Determine ($g = 9.82$ m/s^2) **(IIT-JEE 1997)**

(a) the speed of the combined mass immediately after the collision with respect to an observer on the ground.

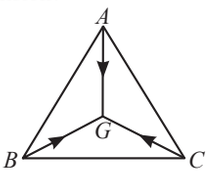
(b) the length L of the string such that tension in the string becomes zero when the string becomes horizontal during the subsequent motion of the combined mass.

43. A simple pendulum is suspended from a peg on a vertical wall. The pendulum is pulled away from the wall to a horizontal position (see fig.) and released. The ball hits the wall, the coefficient of restitution being $\frac{2}{\sqrt{5}}$. What is the minimum number of collisions after which the amplitude of oscillations becomes less than 60°? **(IIT-JEE 1987)**



44. A ball of mass 100 g is projected vertically upwards from the ground with a velocity of 49 m/s. At the same time, another identical ball is dropped from a height of 98 m to fall freely along the same path as that followed by the first ball. After some time, the two balls collide and stick together and finally fall to the ground. Find the time of flight of the masses. **(IIT-JEE 1985)**

45. Three particles A,B and C of equal mass move with equal speed v along the medians of an equilateral triangle as shown in figure. They collide at the centroid G of the triangle. After the collision, A comes to rest, B retraces its path with the speed v. What is the velocity of C after collision? **(IIT-JEE 1982)**



ANSWER KEY

JEE-Main

1. [3]	**2.** [15]	**3.** [8]	**4.** (*a*)	**5.** [2]	**6.** [4]	**7.** (*c*)	**8.** (*c*)	**9.** (*b*)	**10.** (*a*)
11. [03]	**12.** [23]	**13.** (*d*)	**14.** (*a*)	**15.** (*d*)	**16.** (*d*)	**17.** [2]	**18.** [3]	**19.** (*c*)	**20.** (*c*)
21. (*d*)	**22.** (*a*)	**23.** (*a*)	**24.** (*d*)	**25.** (*a*)	**26.** (*c*)	**27.** [30]	**28.** (*b*)	**29.** (*c*)	**30.** [6]
31. (*d*)	**32.** [1]	**33.** (*b*)	**34.** (*b*)	**35.** [2]	**36.** (*a*, *c*, *d*)	**37.** (*c*)	**38.** (*d*)	**39.** [5]	**40.** [4]
41. (*a*)	**42.** (*c*)	**43.** (*a*)	**44.** (*a*)	**45.** (*c*)	**46.** (*d*)	**47.** (*a*)	**48.** (*a*)	**49.** (*b*)	**50.** [20]
51. [1]	**52.** [25]	**53.** [400]	**54.** [30]	**55.** (*d*)	**56.** (*d*)	**57.** (*a*)	**58.** (*d*)	**59.** (*d*)	**60.** (*d*)
61. (*d*)	**62.** [10]	**63.** [120]	**64.** [1]	**65.** (*c*)	**66.** (*c*)	**67.** (*b*)	**68.** (*b*, *c*)	**69.** (*b*)	**70.** [36]

JEE-Advanced

1. (*d*)	**2.** (*a*)	**3.** (*d*)	**4.** (*a*,*b*)	**5.** [False]	**9.** (*c*)	**10.** (*a*)	**11.** (*a, d*)	**13.** [False]	**22.** (*d*)
23. (*c*)	**24.** (*a, b, c, d*)	**25.** [0.005]	**26.** (*a*)	**27.** (*d*)	**28.** (*c*)	**29.** (*b*)	**30.** (*c*)	**31.** (*c*)	**32.** (*b*, *c*)
33. (*a*, *c*)	**34.** (*b*, *d*)	**35.** (*b*)	**36.** (*b*)	**37.** (*c*)	**38.** [30]				