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NEET, JEE(Mains/Advanced)
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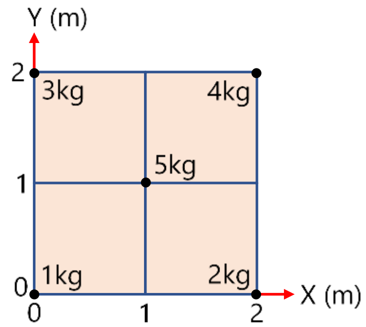
GDPP
GGSRDN DAILY PRACTICE PROBLEM

Centre of Mass of Discrete mass System DPP-01

1. The centre of mass of system of particles does not depend on -

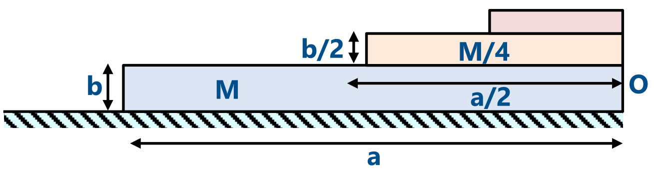
(1) Masses of particles
(2) Internal forces acting on particles
(3) Position of particles
(4) Relative distance between particles

2. Five masses are placed in a plane as shown in figure. The co-ordinates of the centre of mass are nearest to



(1) 1.2, 1.4
(2) 1.3, 1.1
(3) 1.1, 1.3
(4) 1.0, 1.0

3. An infinite number of bricks are placed one over the other as shown in the figure. Each succeeding brick having half the length and breadth of its preceding brick and the mass of each succeeding bricks beings $1/4^{th}$ of the preceding one, take 'O' as the origin, the x-coordinate of centre of mass of the system of bricks is –

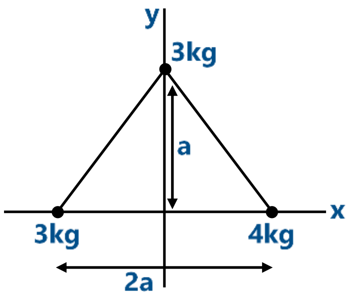


(1) $-\frac{a}{7}$
(2) $\frac{3a}{7}$
(3) $-\frac{3a}{7}$
(4) $-\frac{2a}{7}$

4. The position of centre of mass of a body -

(1) Depends on the choice of coordinate system
(2) Does not depends on the choice of coordinate system
(3) Does not depends on mass of particles
(4) Depends on forces acting on the particle

5. **Find the centre of mass of given system –**



(1) $\left(\frac{a}{10},\frac{3a}{10}\right)$

(2) (0,0)

(3) $\left(\frac{7a}{10},\frac{3a}{10}\right)$

(4) $\left(\frac{3a}{10},\frac{a}{10}\right)$

6. **A body has its centre of mass at the origin. The x-coordinates of the particles**

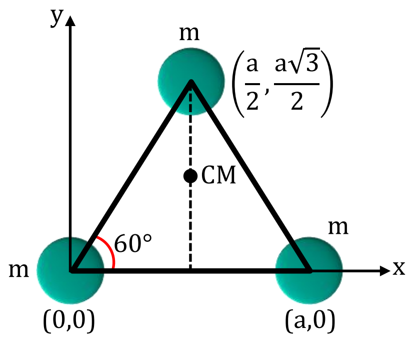
(1) May be all positive

(2) May be all negative

(3) Must be all non-negative

(4) May be positive for some particles and negative for other particles

7. **The coordinate of the centre of mass of a system as show in figure is :**



(1) $\frac{a\sqrt{3}}{2},\frac{a}{2}$

(2) $\frac{a}{2},\frac{a}{6}\sqrt{3}$

(3) $\frac{a}{4},\frac{a}{4}\sqrt{3}$

(4) $\frac{a}{2},\frac{a}{\sqrt{3}}$

Answer key

Question	1	2	3	4	5	6	7
Answer	2	3	3	2	1	4	2

SOLUTIONS DPP-01

1. **(2)**

2. **(3)**

$$x_C = \frac{1(0)+2(2)+5(1)+4(2)+3(0)}{15} = 1.1$$

$$y_C = \frac{1(0)+2(0)+3(2)+4(2)+5(1)}{15} = 1.3$$

3. **(3)**

$$X_{com} = -\frac{\left[M\times\frac{a}{2}+\frac{M}{4}\times\frac{a}{4}+\frac{M}{16}\times\frac{a}{8}+..........\infty\right]}{M+\frac{M}{4}+\frac{M}{16}+..........\infty}$$

$$X_{com} = -\frac{Ma\left[\frac{1}{2}+\frac{1}{16}+\frac{1}{16\times 8}+..........\infty\right]}{M\left[1+\frac{1}{4}+\frac{1}{16}+..........\infty\right]} \qquad \left\{\text{for infinite G.P.} \qquad S_\infty = \frac{a}{1-r}\right\}$$

$$X_{com} = -\left[\frac{\frac{1/2}{1-1/8}}{\frac{1}{1-1/4}}\right] = -\frac{3a}{7}$$

4. **(2)**

5. **(1)**

$$x_C = \frac{4(a)+3(0)+3(-a)}{10} = \frac{a}{10}$$

$$y_C = \frac{4(0)+3(a)+3(0)}{10} = \frac{3a}{10}$$

6. **(4)**

May be positive for some particles and negative for other particles

7. **(2)**

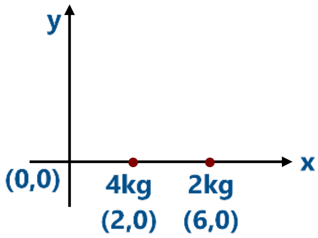
$$X_{CM} = \frac{0\times m+m\times a+m\times\frac{a}{2}}{m+m+m} = \frac{a}{2}, \quad Y_{CM} = \frac{0\times m+0\times m+m\times\frac{a\sqrt{3}}{2}}{m+m+m} = \frac{a\sqrt{3}}{6}$$

Centre of Mass of Two Particle System DPP-02

1. A system consists of two particles having mass 12g and 36g located at coordinate (2cm, 0) and (10 cm, 0). Coordinates of centre of mass will be -

(1) (6 cm, 0)
(2) (8 cm, 0)
(3) (7.5 cm, 0)
(4) (3 cm, 0)

2. For the given arrangement the position of centre of mass will be –



(1) (4,0)
(2) (3,0)
(3) $\left(\frac{10}{3},0\right)$
(4) (5,0)

3. Two homogenous sphere A and B of masses m and 2m having radii 2a and a respectively are placed in touch. The distance of centre of mass from first sphere is :

(1) a
(2) 2a
(3) 3a
(4) None of these

4. Two particles whose masses are 10 kg and 30 kg and their position vectors are $(\hat{i}+\hat{j}+\hat{k})$ and $(-\hat{i}-\hat{j}-\hat{k})$ respectively would have the centre of mass at -

(1) $-\frac{(\hat{i}+\hat{j}+\hat{k})}{2}$
(2) $\frac{(\hat{i}+\hat{j}+\hat{k})}{2}$
(3) $-\frac{(\hat{i}+\hat{j}+\hat{k})}{4}$
(4) $\frac{(\hat{i}+\hat{j}+\hat{k})}{4}$

5. **Two bodies of mass 1 kg and 3 kg have position vector $(\hat{i}+2\hat{j}+\hat{k})$ and $(-3\hat{i}-2\hat{j}+\hat{k})$ respectively. The centre of mass of this system has a position vector**

(1) $-2\hat{i}+2\hat{k}$

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

(3) $2\hat{i}-\hat{j}-2\hat{k}$

(4) $\hat{i}+\hat{j}+\hat{k}$

6. **A rigid body consists of a 3 kg mass connected to a 2 kg mass by a massless rod. The 3 kg mass is located at $\vec{r}_1=(2\hat{i}+5\hat{j})$m and the 2 kg mass at $\vec{r}_2=(4\hat{i}+2\hat{j})$m. Find the coordinate of the centre of mass.**

(1) 3.2, 2.4

(2) 2.8, 4.2

(3) 2.8, 3.8

(4) 3.2, 3.8

7. **The centre of mass of a system of two particles divides the distance between them**

(1) In inverse ratio of square of masses of particles

(2) In direct ratio of square of masses of particles

(3) In inverse ratio of masses of particles

(4) In direct ratio of masses of particles

8. **A system consists of mass M and m (m < M). The centre of mass of the system is: -**

(1) At the middle

(2) Nearer to M

(3) Nearer to m

(4) At the position of larger mass.

Answer key

Question	1	2	3	4	5	6	7	8
Answer	**2**	**3**	**2**	**1**	**2**	**3**	**3**	**2**

SOLUTIONS DPP-02

1. **(2)**

$$x_{com} = \frac{m_1x_1 + m_2x_2}{m_1 + m_2} = \frac{12\times2 + 36\times10}{12+36} = 8\text{cm}$$

Hence (8 cm, 0)

2. **(3)**

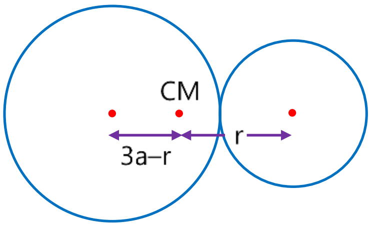
$$x_C = \frac{4(2)+2(6)}{6} = \frac{20}{6} = \frac{10}{3}\text{m}$$

3. **(2)**

We have $m_1r_1 = m_2r_2$

$\Rightarrow$ mr = 2m (3a – r)

$\Rightarrow$ r = 2a



4. **(1)**

$$\vec{r}_{CM} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2}{m_1 + m_2}$$

$$= \frac{10\left(\hat{i}+\hat{j}+\hat{k}\right)+30\left(-\hat{i}-\hat{j}-\hat{k}\right)}{10+30}$$

$$\vec{r}_{CM} = -\frac{\left(\hat{i}+\hat{j}+\hat{k}\right)}{2}$$

5. **(2)**

The position vector of centre of mass

$$\vec{r} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2}{m_1 + m_2}$$

$$= \frac{1\left(\hat{i}+2\hat{j}+\hat{k}\right)+3\left(-3\hat{i}-2\hat{j}+\hat{k}\right)}{1+3} = \frac{1}{4}\left(-8\hat{i}-4\hat{j}+4\hat{k}\right)$$

$$= -2\hat{i}-\hat{j}+\hat{k}$$

6. **(3)**

Centre of mass $\vec{r}_{CM} = \dfrac{m_1\vec{r}_1 + m_2\vec{r}_2}{m_1 + m_2}$

$$= \frac{3}{5}(2\hat{i}+5\hat{j}) + \frac{2}{5}(4\hat{i}+2\hat{j}) = \left(\frac{14}{5}\hat{i} + \frac{19}{5}\hat{j}\right) = 2.8\hat{i}+3.8\hat{j}$$

7. **(3)**

$m_1r_1 = m_2r_2$

$$\frac{r_1}{r_2} = \frac{m_2}{m_1} \Rightarrow r \propto \frac{1}{m}$$

8. **(2)**

Centre of mass is nearer to heavier mass and

$m < M$

So, centre of mass of the system in nearer to M.

Centre of Mass of Continuous Mass Distribution DPP-03

1. The distance of centre of mass of hollow cone from its base is -

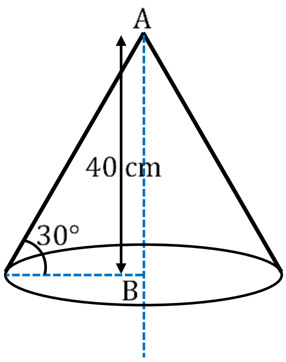
(1) $\frac{h}{4}$

(2) $\frac{3h}{4}$

(3) $\frac{h}{3}$

(4) $\frac{3h}{3}$

2. A uniform solid cone of height 40 cm is shown in figure. The distance of centre of mass of the cone from point B (centre of the base) is :



(1) 20 cm
(2) 10/3 cm
(3) 20/3 cm
(4) 10 cm

3. Mass of a rod is nonuniformly distributed along its length. The rod is divided perpendicular to its length from its centre of mass -

(1) Mass of both parts will be same
(2) Mass of larger density part will be greater
(3) Mass of smaller density part will be smaller
(4) None

4. A rod of length L has non-uniformly distributed mass along its length. For its mass per unit length varying with distance x from one end as $\frac{m_0}{L^2}(L+x)$. Find the position of centre of mass of this system.

(1) L/4
(2) L/2
(3) 3L/9
(4) 5L/9

5. **The linear mass density of a non-uniform rod of length 1m is given by $\lambda(x) = a(1 + bx^2)$ where a and b are constants and $0 \le x \le 1$. The centre of mass of the rod will be at**

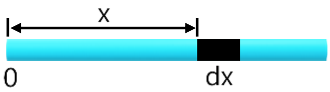
(1) $\frac{3(2+b)}{4(3+b)}$

(2) $\frac{4(2+b)}{3(3+b)}$

(3) $\frac{3(3+b)}{4(2+b)}$

(4) $\frac{4(3+b)}{3(2+b)}$

6. **The linear mass density of a straight rod of length L varies as λ = A + Bx where x is the distance from the left end. Locate the centre of mass.**



(1) $\frac{AL+2BL^2}{(2A+BL)}$

(2) $\frac{2AL+2BL^2}{3(2A+BL)}$

(3) $\frac{3AL+2BL^2}{2(2A+BL)}$

(4) $\frac{3AL+2BL^2}{3(2A+BL)}$

7. **If linear density of a rod of length 2 m varies as λ = 3x + 2, then the position of the centre of gravity of the rod is: -**

(1) $\frac{4}{3}$ m

(2) $\frac{6}{5}$ m

(3) $\frac{5}{6}$ m

(4) 1m

Answer key

Question	1	2	3	4	5	6	7
Answer	3	4	2	4	1	4	2

SOLUTIONS DPP-03

1. **(3)**

2. **(4)**

Centre of mass are $r_{cm} = \frac{h}{4} = \frac{40}{4} = 10 \text{ cm}$

3. **(2)**

4. **(4)**

$$x_{cm} = \frac{\int xdm}{\int dm}$$

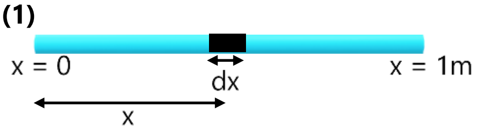
$$x_{cm} = \frac{\int (\lambda dx)\cdot x}{\int \lambda dx}$$

$$= \frac{\frac{m_0}{L^2}\int_0^L (Lx + x^2)dx}{\frac{m_0}{L^2}\int_0^L (L+x)dx}$$

$$= \frac{\left[L\frac{x^2}{2} + \frac{x^3}{3}\right]_0^L}{\left[Lx + \frac{x^2}{2}\right]_0^L}$$

$$= \frac{\frac{L^3}{2} + \frac{L^3}{3}}{L^2 + \frac{L^2}{2}} = \frac{5L}{9}$$

5. **(1)**



Mass of a small element of length dx of the rod at a distance x from the one end of the rod is $dm = \lambda dx = a(1 + bx^2)dx$

The centre of mass of the rod is $X_{CM} = \frac{\int_0^1 xdm}{\int_0^1 dm} = \frac{\int_0^1 xa(1+bx^2)dx}{\int_0^1 a(1+bx^2)dx}$

$$= \frac{\int_0^1 (x+bx^3)dx}{\int_0^1 (1+bx^2)dx} = \frac{\left[\frac{x^2}{2} + \frac{bx^4}{4}\right]_0^1}{\left[x + \frac{bx^3}{3}\right]_0^1} = \frac{\left[\frac{1}{2} + \frac{b}{4}\right]}{\left[1 + \frac{b}{3}\right]} = \frac{3(2+b)}{4(3+b)}$$

6. **(4)**

$dm = \lambda dx = (A + Bx)dx$

$$x_{cm} = \frac{\int x dm}{\int dm}$$

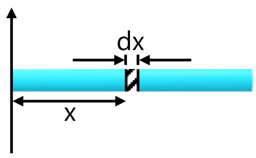
$$= \frac{\int_0^L (A+Bx)x \cdot dx}{\int_0^L (A+Bx)dx}$$

$$= \frac{\left[A\frac{x^2}{2} + B\frac{x^3}{3}\right]_0^L}{\left[Ax + \frac{Bx^2}{2}\right]_0^L}$$

$$= \frac{3AL + 2BL^2}{3(2A+BL)}$$

7. **(2)**

Linear density of the rod varies with distance $\frac{dm}{dx} = \lambda$ (Given) $\therefore dm = \lambda dx$ Positive of centre of mass



$$x_{cm} = \frac{\int x dm}{\int dm}$$

$\lambda = 3x + 2$

$$x_{cm} = \frac{\int x.dm}{\int dm} = \frac{\int_0^2 (3x^2 + 2x)dx}{\int_0^2 (3x+2)dx}$$

$$= \frac{\left(x^3 + x^2\right)_0^2}{\left(\frac{3x^2}{2} + 2x\right)_0^2} = \frac{8+4}{6+4} = \frac{12}{10} = \frac{6}{5} \text{ m}$$

Centre of Mass of composite Bodies DPP-04

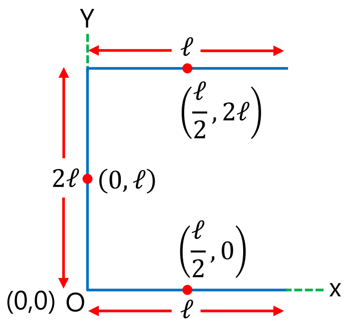
1. All the particles of a body situated at distance d from the origin. The distance of the centre of mass of the body from the origin is :

(1) = d
(2) $\leq$ d
(3) > d
(4) $\geq$ d

2. Four identical spheres, each of mass M and radius R, are placed on a horizontal table touching one another so that their centres are at the corners of a square of side 2R. The centre of mass of the system is

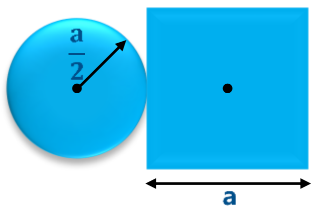
(1) At the centre of the square of side 2R
(2) At a point on the circumference of a circle of radius 2R
(3) At one corner of an equilateral triangle of side R
(4) None of the above

3. A uniform wire of sides $2\ell, \ell$ and ℓ as shown in figure. The x and y co-ordinate of the centre of mass of each side are shown in figure. The x and y co-ordinates of the centre of mass of wire are respectively



(1) $\left(\frac{\ell}{4}, \frac{\ell}{4}\right)$
(2) (ℓ, ℓ)
(3) $\left(\ell, \frac{\ell}{4}\right)$
(4) $\left(\frac{\ell}{4}, \ell\right)$

4. A circular plate of radius $\frac{a}{2}$ is kept in contact with a square plate of side a as shown. The density and thickness are same everywhere. The centre of mass of composite system will be-



(1) Inside the circular plate
(2) Inside the square plate
(3) At the point of contact
(4) Outside the system

5. **Two semi-circular rings of linear mass densities λ and 3λ of radius R each are joined to form a complete ring. The distance of the centre of the mass of complete ring from its geometrical centre is –**

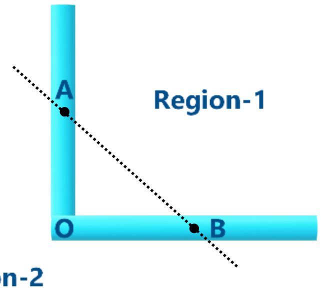
(1) $\frac{2R}{3\pi}$

(2) $\frac{R}{\pi}$

(3) $\frac{2R}{\pi}$

(4) $\frac{R}{3\pi}$

6. **Figure shows two cylindrical rods whose centre of mass is marked as A and B. Line AB divides the region in two parts region 1 and other region 2. Choose the correct option regarding the centre of mass of the combined system?**



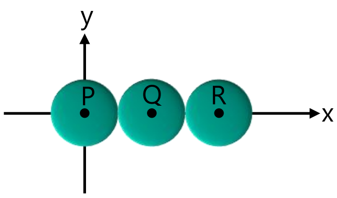
(1) The centre of mass of the system lies in region 1

(2) The centre of mass of the system lies in region 2

(3) The centre of mass of the system lies on line AB

(4) The centre of mass of the system may lie in region 1 or region 2 depending on the mass of the rods

7. **Three identical spheres, each of mass 1 kg are kept as shown in figure, touching each other, with their centres on a straight line. If their centres are marked P, Q, R respectively, the distance of centre of mass of the system from P (origin) is**



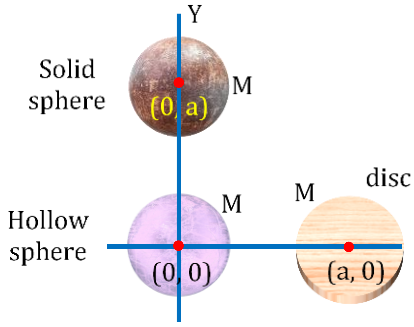
(1) $\frac{PQ+PR+QR}{3}$

(2) $\frac{PQ+PR}{3}$

(3) $\frac{PQ+QR}{3}$

(4) PR + QR

8. **The coordinate of the centre of mass of a system as shown in figure is :**



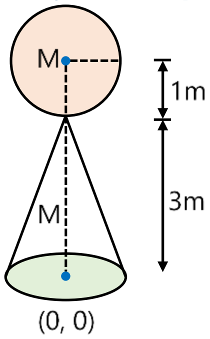
(1) $\left(\frac{a}{3},0\right)$

(2) $\left(\frac{a}{2},\frac{a}{2}\right)$

(3) $\left(\frac{a}{3},\frac{a}{3}\right)$

(4) $\left(0,\frac{a}{3}\right)$

9. Find the co-ordinates of centre of mass of system of sphere and hollow cone :-



(1) $\left(\frac{5}{2},0\right)$

(2) $\left(0,\frac{5}{2}\right)$

(3) $\left(\frac{3}{2},0\right)$

(4) $\left(0,\frac{3}{2}\right)$

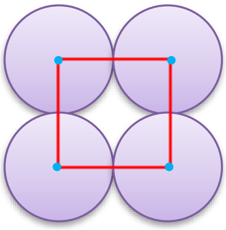
Answer key

Question	1	2	3	4	5	6	7	8	9
Answer	2	1	4	2	2	3	2	3	2

SOLUTIONS DPP-04

1. **(2)**

2. **(1)**



By symmetry at the centre of the square of side 2R.

3. **(4)**

$$x_{CM}=\frac{m\left(\frac{\ell}{2}\right)+2m(0)+m\left(\frac{\ell}{2}\right)}{4m}=\frac{\ell}{4}$$

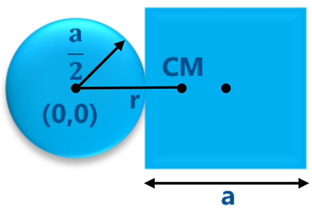
$$y_{CM}=\frac{m(0)+2m(\ell)+m(2\ell)}{4m}=\ell$$

$$\therefore\ (x_{CM},y_{CM})=\left(\frac{\ell}{4},\ell\right)$$

4. **(2)**

$$r_{CM}=\frac{A_1r_1+A_2r_2}{A_1+A_2}=\frac{\frac{\pi a^2}{4}(0)+a^2(a)}{\frac{\pi a^2}{4}+a^2}$$

$$=\frac{a^3}{(\pi+4)a^2}=\left(\frac{4a}{\pi+4}\right)=\frac{4a}{7.14}$$



$$\because\ \frac{4a}{7.14}>\frac{a}{2}$$

$\therefore$ The centre of mass of composite system will be inside the square sphere plate.

5. **(2)**

Let the mass of ring having density λ be M.

Centre of mass is

$$\frac{M_1x_1+M_2x_2}{M_1+M_2}=\frac{M\left(-\frac{2R}{\pi}\right)+3M\frac{2R}{\pi}}{4M}=\frac{R}{\pi}$$

6. **(3)**

Centre of mass will lie on the line joining COM of both the rods.

7. **(2)**

$$x_{CM} = \frac{1(0)+1(PQ)+1(PR)}{3}$$

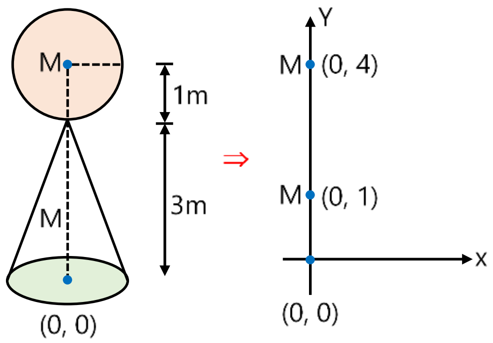
$$x_{CM} = \frac{PQ+PR}{3}$$

8. **(3)**

$$x_{CM} = \frac{M(0)+M(a)+M(0)}{3M} = \frac{a}{3}$$

$$y_{CM} = \frac{M(0)+M(0)+M(a)}{3M} = \frac{a}{3}$$

9. **(2)**



Centre of mass for hollow core = $\frac{h}{3}$ = 1m

Now centre of mass for system :

$$Y_{cm} = \frac{1\times M + 4\times M}{2M} = \frac{5}{2}\text{ m}$$

Co-ordinates of centre of mass of the system (0, 5/2)

Centre of Mass of Truncated Bodies DPP-05

1. From a circular disc of radius R, a square is cut out with a radius as its diagonal. The centre of mass of remainder is at a distance (from the centre)

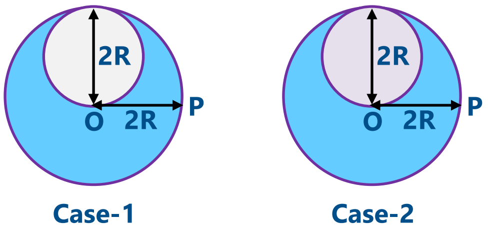
(1) $\frac{R}{(4\pi-2)}$

(2) $\frac{R}{2\pi}$

(3) $\frac{R}{(\pi-2)}$

(4) $\frac{R}{(2\pi-2)}$

2. A lamina is made by removing a small disc of diameter 2R from a bigger disc of uniform mass density and radius 2R, as shown in the figure. A second similar disc is made but instead of hole, a disc of double the density as of first is filled in the hole. Centre of mass is calculated in both the cases and was found at a distance r_1 & r_2 from centre O respectively. Find the ratio $\left|\frac{5r_2}{r_1}\right|$



(1) 3
(2) 4
(3) 5
(4) 1

3. A circular disc of radius R is removed from a bigger circular disc of radius 2R such that the circumference of the discs coincide. The centre of mass of the new disc is αR from the centre of the bigger disc. The value of α is :

(1) 1/3
(2) 1/2
(3) 1/6
(4) 1/4

4. A uniform co-centric metal disc of diameter R is taken out from a disc of radius R from its centre. The centre of mass of the remaining part will be -

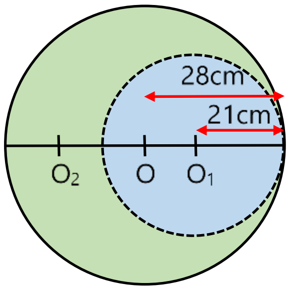
(1) $\frac{R}{4}$ from the centre

(2) $\frac{R}{3}$ from the centre

(3) $\frac{R}{6}$ from the centre

(4) Not change

5. **A circular plate of uniform thickness has a diameter 56 cm. A circular portion of diameter 42 cm is removed from one edge as shown in the figure. The distance of centre of mass of the remaining portion from the centre of plate will be:**



(1) 5 cm

(2) 7 cm

(3) 9 cm

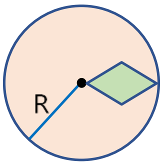
(4) 11 cm

Answer key

Question	1	2	3	4	5
Answer	1	1	1	3	3

SOLUTIONS DPP-05

1. (1)



$$x_{cm} = \frac{(\sigma\pi R^2)(0) - \left(\sigma \times \frac{R^2}{2}\right)\left(\frac{R}{2}\right)}{\sigma\pi R^2 - \sigma\frac{R^2}{2}}$$

$$\frac{-\frac{R}{4}}{\pi - \frac{1}{2}} = \frac{-R}{4\pi - 2}$$

2. (1)

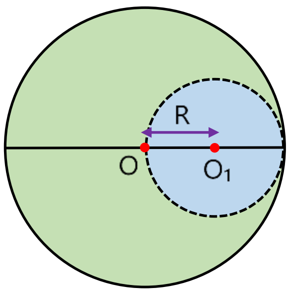
$$r_1 = \frac{[-\sigma \times \pi R^2] \times R}{[-\sigma \times \pi R^2] + [\sigma \times \pi (2R)^2]} = -\frac{R}{3}$$

$$\& \quad r_2 = \frac{[\sigma \times \pi R^2] \times R}{[\sigma \times \pi R^2] + [\sigma \times \pi (2R)^2]} = \frac{R}{5}$$

$$\Rightarrow \left(\frac{5r_2}{r_1}\right) = 3$$

3. (1)

If mass of bigger disc is M then mass of removed disc is $\frac{M}{4}$



$$r_{CM} = \frac{M \times 0 - \frac{M}{4}R}{M - \frac{M}{4}} = \frac{R}{3} = \alpha R$$

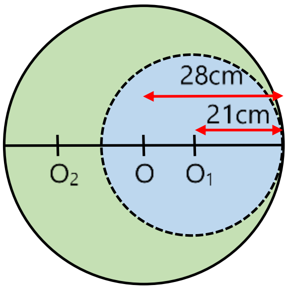
$$\Rightarrow \alpha = \frac{1}{3}$$

4. (3)

$$x_{CM} = \frac{A_1 \times 0 - A_2 x_2}{A_1 - A_2}$$

$$x_{CM} = \frac{-\frac{\pi R^2}{4} \times \frac{R}{2}}{\pi R^2 - \frac{\pi R^2}{4}} = -\frac{R}{6}$$

5. **(3)**



Let mass of circular plate be = M

Mass per unit area $= \frac{M}{\pi(28)^2}$

Mass of part removed $= \frac{M}{\pi(28)^2} \times \pi(21)^2 = \frac{9M}{16}$

Mass of remaining part $= \frac{7M}{16}$

Now, $\frac{7M}{16} \times x = \frac{9M}{16} \times 7$

x = 9 cm

The centre of mass of the remaining portion from the centre of plate is 9 cm.

Motion of Centre of Mass DPP-06

1. **Two particles, each of mass 2kg, attract each other with a force inversely proportional to the square of the distance between them. The particles are initially held at rest and then released. What is the velocity of centre of mass?**
(1) 2
(2) 4
(3) 8
(4) 0

2. **Two balls are thrown simultaneously in air. The acceleration of the centre of mass of the two balls while in air -**
(1) Depends on the direction of the motion of the balls
(2) Depends on the masses of the two balls
(3) Depends on the speeds of two balls
(4) Is equal to g

3. **Initially two stable particles x and y start moving towards each other under mutual attraction. If at one time the velocity of x and y are v and 3v respectively, what will be the velocity of centre of mass of the system -**
(1) v
(2) Zero
(3) v/3
(4) v/5

4. **A particle of mass 200 g is dropped from a height of 50 m and another particle of mass 100 g is simultaneously projected up from the ground along the same line with a speed of 100 m/s. The acceleration of the centre of mass after 1 s is :**
(1) 10 m/s^2
(2) $\frac{10}{3}$ m/s^2
(3) 0
(4) None of these

5. **Two objects of masses 200 gm and 500 gm possess velocities $10\hat{i}$ m/s and $(3\hat{i}+5\hat{j})$ m/s respectively. The velocity of their centre of mas in m/s is -**
(1) $5\hat{i}-25\hat{j}$
(2) $\frac{5}{7}\hat{i}-25\hat{j}$
(3) $5\hat{i}+\frac{25}{7}\hat{j}$
(4) $5\hat{i}-\frac{5}{7}\hat{j}$

6. Two particles of mass 1 kg and 0.5 kg are moving in the same direction with speed of 2m/s and 6m/s respectively on a smooth horizontal surface. The speed of centre of mass of the system is :

(1) $\frac{10}{3}$ m/s

(2) $\frac{10}{7}$ m/s

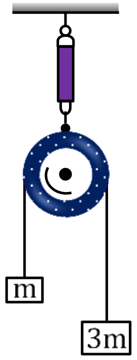
(3) $\frac{11}{2}$ m/s

(4) $\frac{12}{3}$ m/s

7. Two bodies of different masses of 2 kg and 4 kg are moving with velocities 20 m/s and 10 m/s towards each other respectively on a horizontal surface. The velocity of centre of mass of the system is

(1) 5 m/s
(2) 6 m/s
(3) 8 m/s
(4) zero

8. If the system is released, then the acceleration of the centre of mass of the system :



(1) $\frac{g}{4}$

(2) $\frac{g}{2}$

(3) g

(4) 2g

9. Two bodies of mass 10 kg and 2 kg are moving with velocity $2\hat{i} - 7\hat{j} + 3\hat{k}$ m/s and $-10\hat{i} + 35\hat{j} - 3\hat{k}$ m/s respectively. The velocity of their centre of mass is :

(1) $2\hat{i}$ m/s
(2) $2\hat{k}$ m/s
(3) $(2\hat{j} + 2\hat{k})$ m/s
(4) $(2\hat{i} + 2\hat{j} + 2\hat{k})$ m/s

10. Two identical particles move towards each other with velocity 2v and v respectively. This velocity of centre of mass is -

(1) v
(2) v/3
(3) v/2
(4) zero

11. **A body of mass 20 kg is moving with a velocity of 2v and another body of mass 10 kg is moving with velocity v along same direction. The velocity of their centre of mass is**

(1) 5v/3

(2) 2v/3

(3) v

(4) Zero

Answer key

Question	1	2	3	4	5	6	7	8	9	10	11
Answer	4	4	2	1	3	1	4	1	2	3	1

SOLUTIONS DPP-06

1. **(4)**

No external force thus, the centre of mass of the system will remain at rest.

2. **(4)**

$$\vec{a}_{CM} = \frac{m_1 g + m_2 g}{m_1 + m_2} = g$$

3. **(2)**

$$\vec{F}_{ext} = 0$$

$$\vec{a}_{CM} = 0$$

Initial velocity = 0 $\therefore$ Final velocity = 0

4. **(1)**

As acceleration in both will be g = $10\ m/s^2$, hence acceleration of centre of mass will also be g.

5. **(3)**

$$\vec{v}_{COM} = \frac{m_1 \vec{v}_1 + m_2 \vec{v}_2}{m_1 + m_2}$$

$$= \frac{20\hat{i} + 15\hat{i} + 25\hat{j}}{7} = 5\hat{i} + \frac{25}{7}\hat{j}$$

6. **(1)**

$$v_{cm} = \frac{1 \times 2 + \frac{1}{2} \times 6}{1 + 1/2} = \frac{10}{3} \text{ m/sec}$$

7. **(4)**

v_1 = 20 m/s, v_2 = –10 m/s

$$\vec{v}_{CM} = \frac{2(20) - 4(10)}{2 + 4} = 0 \ m/s$$

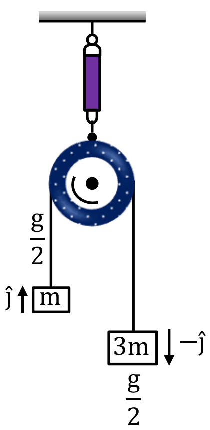
8. **(1)**

Acceleration of the system

$$= \left(\frac{3m - m}{3m + m}\right) g = \frac{g}{2}$$

$$\vec{a}_{CM} = \frac{m_1 \vec{a}_1 + m_2 \vec{a}_2}{m_1 + m_2}$$

$$= \frac{3m\frac{g}{2}\hat{j} + m\frac{g}{2}(-\hat{j})}{4m} = \frac{g}{4}$$



9. (2)

$$\vec{v}_{CM} = \frac{m_1\vec{v}_1 + m_2\vec{v}_2}{m_1 + m_2}$$

$$= \frac{10\left(2\hat{i} - 7\hat{j} + 3\hat{k}\right) + 2\left(-10\hat{i} + 35\hat{j} - 3\hat{k}\right)}{12}$$

$$= \frac{20\hat{i} - 70\hat{j} + 30\hat{k} - 20\hat{i} + 70\hat{j} - 6\hat{k}}{12}$$

$$= \frac{24\hat{k}}{12} = 2\hat{k}$$

10. (3)

$$\vec{v}_{cm} = \frac{m_1\vec{v}_1 + m_2\vec{v}_2}{m_1 + m_2}$$

$$= \frac{m(2v) - m(v)}{m + m}$$

$$= \frac{v}{2}$$

11. (1)

$$\vec{v}_{CM} = \frac{20(2v) + 10(v)}{30} = \frac{5}{3}v$$

Effect of External Force on Centre of Mass DPP-07

1. **A system of particles consists of several particles. Total mass of all the particles is 10 kg. To apply Newton's laws of motion in centroidal frame to one of the particles of mass 2kg, you have to assume a pseudo force of $(4\hat{i} - 2\hat{j})$ N acting on it. What is the net external force acting on the whole system?**

(1) $(10\hat{i} - 20\hat{j})$N
(2) $(-10\hat{i} + 20\hat{j})$N
(3) $(20\hat{i} - 10\hat{j})$N
(4) $(-20\hat{i} + 10\hat{j})$N

2. **Two particles are shown in fig. At t = 0, a constant force F = 6N starts acting on the 3kg mass. The velocity of the centre of mass of these particles at t = 5s.**

(1) 5 m/s
(2) 4 m/s
(3) 6 m/s
(4) 3 m/s

3. **If a force $(2\hat{i} + 3\hat{j} + 5\hat{k})$N acts on a system and given acceleration $(20\hat{i} + 30\hat{j} + 50\hat{k})$ to the centre of mass of the system, the mass of the system is -**

(1) 10 kg
(2) 1 kg
(3) 0.1 kg
(4) 5 kg

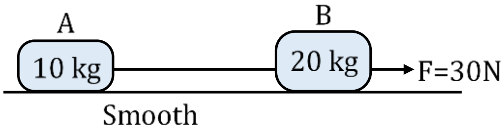
4. **The motion of the centre of mass of a system of two particles is unaffected by their internal forces :**

(1) Irrespective of the actual direction of the internal forces
(2) Only if they are along the line joining the particles
(3) Only if they are at right angles to the line joining the particles
(4) Only if they are obliquely inclined to the line joining the particles.

5. **Two spheres of masses 2M and M are initially at rest at a distance R apart. Due to mutual force of attraction, they approach each other. When they are at separation R/2, the acceleration of the centre of mass of spheres would be**

(1) 0 m/s^2
(2) g m/s^2
(3) 3g m/s^2
(4) 12g m/s^2

6. Two blocks A and B are connected by a massless string (shown in figure). A force of 30 N is applied on block B. The distance travelled by centre of mass in 2s starting from rest is :



(1) 1m
(2) 2m
(3) 3m
(4) None of these

7. Three particles of masses 1 kg, 2 kg and 3 kg are subjected to forces $(3\hat{i} - 2\hat{j} + 2\hat{k})$N, $(-\hat{i} + 2\hat{j} - \hat{k})$N, and $(\hat{i} + \hat{j} + \hat{k})$N respectively. The magnitude of the acceleration of centre of mass of the system is :

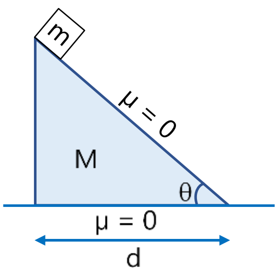
(1) $\frac{\sqrt{11}}{6}ms^{-2}$

(2) $\frac{\sqrt{14}}{6}ms^{-2}$

(3) $\frac{11}{6}ms^{-2}$

(4) $\frac{22}{6}ms^{-2}$

8. A block of mass m is placed on smooth inclined surface of a wedge of mass M which is placed on smooth horizontal surface. If block slides on surface and reaches at bottom of inclined. The horizontal displacement of wedge –



(1) Zero

(2) $\frac{md}{M+m}$

(3) $\frac{md\cos\theta}{M+m}$

(4) $\frac{md\sin\theta}{M+m}$

9. A person of mass 50 kg standing at end of a boat of length 5m. If he moves to other end of boat. Find the displacement of boat w.r.t. to ground (mass of boat is 100 kg)

(1) $\frac{5}{3}$m

(2) $\frac{3}{5}$m

(3) $\frac{10}{3}$m

(4) 0

10. A ball kept in a closed box moves in the box making collisions with the walls. The box is kept on a smooth surface. The centre of mass :

(1) Of the box remains constant
(2) Of the box plus the ball system remains constant
(3) Of the ball remains constant
(4) Of the ball relative to the box remains constant

11. 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 the other end of the plank. If the mass of plank is M/3, the distance that the plank moves relative to the ground is :

(1) 3L/4
(2) L/4
(3) 4L/5
(4) L/3

12. Consider a system of two particles having masses m_1 and m_2. If the particle of mass m_1 is pushed towards the centre of mass of particles through a distance d, by what distance would the particle of mass m_2 move so as to keep the mass centre of particles at the original position?

(1) $\frac{m_1}{m_1+m_2}d$
(2) $\frac{m_1}{m_2}d$
(3) d
(4) $\frac{m_2}{m_1}d$

13. Two particles of masses m_1 and m_2 initially at rest start moving towards each other under their mutual force of attraction. The speed of the centre of mass at any time t, when they are at a distance r apart, is

(1) zero
(2) $\left(G\frac{m_1m_2}{r^2}.\frac{1}{m_1}\right)t$
(3) $\left(G\frac{m_1m_2}{r^2}.\frac{1}{m_2}\right)t$
(4) $\left(G\frac{m_1m_2}{r^2}.\frac{1}{m_1+m_2}\right)t$

14. If no external force is applied on a system then choose incorrect statement -

(1) Velocity of centre of mass may be zero
(2) Velocity of centre of mass may not be zero
(3) Acceleration of centre of mass is zero
(4) Acceleration of centre of mass may not be zero

15. Two particles of equal mass have coordinates (2m, 4m, 6m) and (6m, 2m, 8m). One particle has a velocity $v_1 = (2\hat{i})m/s$ and another particle has velocity $v_2 = (2\hat{j})m/s$ at time t = 0. The coordinate of their centre of mass at time t = 1s will be -

(1) (4m, 4m, 7m)
(2) (5m, 4m, 7m)
(3) (2m, 4m, 6m)
(4) (4m, 5m, 4m)

16. A person sits stationary at one end of long trolley moving uniformly with a speed 10 m/sec on a smooth horizontal floor. If person gets up and runs in trolley in opposite direction. The speed of the centre of mass of system (trolley + person)

(1) Increases

(2) Decreases

(3) No change

(4) Cannot say anything

17. A strip of wood of mass M and length ℓ is placed on a smooth horizontal surface. An insect of mass m starts at one end of the strip and walks to the other end in time t, moving with a constant speed. The speed of the insect as seen from the ground is :

(1) $\frac{\ell}{t}\left(\frac{M}{M+m}\right)$

(2) $\frac{\ell}{t}\left(\frac{m}{M+m}\right)$

(3) $\frac{\ell}{t}\left(\frac{M}{m}\right)$

(4) $\frac{\ell}{t}\left(\frac{m}{M}\right)$

18. Two bodies A and B have masses M and m respectively, where M > m and they are at a distance d apart. Equal force is applied to them so that they approach each other. The position where they hit each other is

(1) Nearer to B

(2) Nearer to A

(3) At equal distance from A and B

(4) Cannot be decided

Answer key

Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Answer	4	3	3	1	1	2	2	2	1	2	1	2	1	4	2
Question	16	17	18												
Answer	3	1	2												

SOLUTIONS DPP-07

1. **(4)**

Acceleration of centre of mass

$= \dfrac{-(4\hat{i}-2\hat{j})}{2} = (-2\hat{i}+\hat{j}) m/s^2$

Net external force acting on the whole system $\sum \vec{F} = M\vec{a}_{cm} = 10(-2\hat{i}+\hat{j}) = (-20\hat{i}+10\hat{j})N$

2. **(3)**

Method-1 : Acceleration of 3kg :

$a_2 = \dfrac{6}{3} = 2 m/s^2$

Velocity of 3kg at t = 5 s

$v_2 = u_2 + a_2 t$

$= 0 + 2 \times 5 = 10$ m/s

$v_{CM(t=5s)} = \dfrac{2\times 0 + 3\times 10}{2+3} = 6 m/s$

Method-2

$a_{CM} = \dfrac{F}{m_1+m_2} = \dfrac{6}{2+3} = 1.2 \, m/s^2$

$v_{CM} = u_{CM} + a_{CM}\, t = 0 + 1.2 \times 5 = 6 m/s$

3. **(3)**

$\vec{F}_{ext} = m\vec{a}_{CM} \Rightarrow m = \dfrac{\vec{F}_{ext}}{\vec{a}_{CM}}$

$m = \dfrac{(2\hat{i}+3\hat{j}+5\hat{k})}{10(2\hat{i}+3\hat{j}+5\hat{k})} = 0.1 kg$

4. **(1)**

Vector sum of internal forces on system is zero.

5. **(1)**

$\vec{F}_{ext} = 0$

$\therefore \; \vec{a}_{CM} = 0$

6. **(2)**

$a_{CM} = \dfrac{30}{(10+20)} = 1 \, m/s^2$

S = 0 (2) + $\dfrac{1}{2}$ (1) $(2)^2$

= 2 m

7. **(2)**

$$\vec{a}_{CM} = \frac{\vec{F}_{ext}}{m}$$

$$= \frac{3\hat{i} - 2\hat{j} + 2\hat{k} - \hat{i} + 2\hat{j} - \hat{k} + \hat{i} + \hat{j} + \hat{k}}{6}$$

$$\vec{a}_{CM} = \frac{1}{2}\hat{i} + \frac{1}{6}\hat{j} + \frac{1}{3}\hat{k}$$

$$= \sqrt{\frac{1}{4} + \frac{1}{9} + \frac{1}{36}} = \sqrt{\frac{9+4}{36} + \frac{1}{36}} = \frac{1}{6}\sqrt{13+1}$$

$$= \frac{\sqrt{14}}{6} ms^{-2}$$

8. **(2)**

When $F_{net} = 0$ then $m_1x_1 = m_2x_2$

$m(d - x) = Mx$

$$x = \frac{md}{M+m}$$

9. **(1)**

$$x = \left(\frac{m}{m+M}\right)\ell = \frac{50}{150} \times 5 = \frac{5}{3} m$$

10. **(2)**

Net external force on box plus ball system is zero.

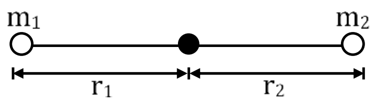
11. **(1)**

$$M(L - x) + \frac{M}{3}(-x) = 0$$

$$x = \frac{3L}{4}$$

12. **(2)**

The system of two given particles of masses m_1 and m_2 are shown in figure.



Initially the centre of mass

$$r_{CM} = \frac{m_1r_1 + m_2r_2}{m_1 + m_2} \quad ...(i)$$

When mass m_1 moves towards centre of mass by a distance d, then let mass m_2 moves a distance d' away from CM to keep the CM in its initial position.

So, $$r_{CM} = \frac{m_1(r_1 - d) + m_2(r_2 + d')}{m_1 + m_2} \quad ...(ii)$$

Equation Eqs. (i) and (ii), we get

$$\frac{m_1r_1+m_2r_2}{m_1+m_2}=\frac{m_1(r_1-d)+m_2(r_2+d')}{m_1+m_2}$$

$\Rightarrow \quad -m_1d+m_2d'=0$

$\Rightarrow \quad d'=\frac{m_1}{m_2}d$

13. **(1)**

$\vec{F}_{ext}=0$

$\Rightarrow \vec{a}_{COM}=0$

Initial velocity = 0 $\therefore$ Final velocity = 0

14. **(4)**

$\vec{F}_{ext}=0$

$\Rightarrow \vec{a}_{COM}=0$

So, $\vec{v}_{COM}=0$ or $\vec{v}_{COM}=\text{constant}$

15. **(2)**

Position of particles after 1sec

(4m, 4m, 6m) and (6m, 4m, 8m)

So, Coordinate of COM

= (5m, 4m, 7m)

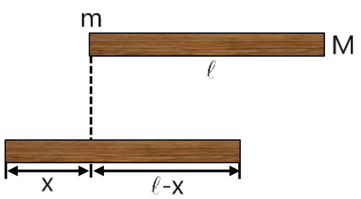
16. **(3)**

$\vec{F}_{ext}=0$

$\Rightarrow \vec{a}_{COM}=0$

$\Rightarrow \vec{v}_{COM}=\text{constant}$

17. **(1)**



m(l–x) = Mx ⇒ x = $\frac{m\ell}{m+M}$

Distance moved by insect w.r.t ground is

l – x = l – $\frac{m\ell}{m+M}=\frac{M\ell}{m+M}$

Speed = $\frac{\text{distance}}{\text{time}}=\frac{M\ell}{t(M+m)}$

18. **(2)**

Here forces are applied in opposite directions. So net external force is zero. Their centre of mass will remain at rest and finally they will meet at centre of mass. And centre of mass lies closer to M.

Conservation of Linear Momentum of System and Impulse DPP-08

1. **A bomb of 50 Kg is fired from a cannon with a velocity 600 m/s. If the mass of the cannon is 10^3 kg, then its recoil velocity will be –**

(1) 600 m/s
(2) –60 m/s
(3) –30 m/s
(4) 30 m/s

2. **A bomb of mass 5.0 kg explodes in air into two pieces of masses 2.0 kg and 3.0 kg. The smaller mass goes at a speed of 60 m/s. The total energy imparted to the two fragments is -**

(1) 2.4 kJ
(2) 6 kJ
(3) 3.6 kJ
(4) 4.8 kJ

3. **A bomb of mass 40 kg at rest explodes into two pieces of masses 22 kg and 18 kg. The velocity of 22 kg mass is 9 m/s. The kinetic energy of the other mass is :-**

(1) 545 J
(2) 1089 J
(3) 486 J
(4) 324 J

4. **A stationary particle explodes into two particles of masses m_1 and m_2 which move in opposite directions with velocities v_1 and v_2. The ratio of their kinetic energies E_1/E_2 is :-**

(1) m_2/m_1
(2) m_1/m_2
(3) 1
(4) m_1v_2/m_2v_1

5. **A bomb of mass m = 1 kg thrown vertically upwards with a speed u = 100 m/s explodes into two parts after t = 5s. A fragment of mass m_1 = 400 g moves downwards with a speed v_1 = 25 m/s, then speed and direction of another mass m_2 will be**

(1) 40 m/s downwards
(2) 40 m/s upwards
(3) 60 m/s upwards
(4) 100 m/s upwards

6. A bullet of mass m is being fired from a stationary gun of mass M. If the velocity of the bullet is v, the velocity of the gun is -

(1) $\frac{Mv}{m+M}$

(2) $\frac{mv}{M}$

(3) $\frac{(M+m)v}{M}$

(4) $\frac{M+m}{Mv}$

7. A bomb explodes in air in two equal fragments. If one of the fragments is moving vertically upwards with velocity v_0, then the other fragment is moving -

(1) Vertically up with velocity v_0

(2) Vertically downwards with velocity v_0

(3) In any arbitrary direction

(4) None of these

8. A bullet of mass m is fired from a gun of mass M. The recoiling gun compresses a spring of force constant k by a distance d. Then the velocity of the bullet is :-

(1) $kd\sqrt{M/m}$

(2) $\frac{d}{M}\sqrt{km}$

(3) $\frac{d}{m}\sqrt{kM}$

(4) $\frac{kM}{m}\sqrt{d}$

9. A metal ball does not rebound when struck on a wall, whereas a rubber ball of same mass when thrown with the same velocity on the wall rebounds. From this it is inferred that –

(1) Change in momentum is same in both

(2) Change in momentum in rubber ball is more

(3) Change in momentum in metal ball is more

(4) Initial momentum of metal ball is more than that of rubber ball

10. A 1 kg stationary bomb is exploded in three parts having mass ratio 4 : 4 : 7. Parts having same mass move in perpendicular directions with velocity 70 m/s, then the velocity of bigger part will be :-

(1) $40\sqrt{2}$ m/s

(2) $\frac{40}{\sqrt{2}}$ m/s

(3) $20\sqrt{2}$ m/s

(4) $\frac{20}{\sqrt{2}}$ m/s

Answer key

Question	1	2	3	4	5	6	7	8	9	10
Answer	3	2	2	1	4	2	2	3	2	1

SOLUTIONS DPP-08

1. **(3)**
By COLM
$m_1v_1 + m_2v_2 = 0$
$50 \times 600 = -10^3 \times v$
$v = -30$ m/s
Negative sign show's opposite direction

2. **(2)**
$2 \times 60 = 3 \times v$
$v = 40$ m/s
Total KE $= \frac{1}{2}\times 2\times(60)^2 + \frac{1}{2}\times 3\times(40)^2$
$= 3600 + 2400 = 6$ kJ

3. **(2)**
$22 \times 9 = 18 \times v$
$v = 11$ m/s
$\therefore\ KE = \frac{1}{2}\times 18\times 11\times 11 = 1089J$

4. **(1)**
$KE = \frac{p^2}{2m}$
$\therefore\ \frac{KE_1}{KE_2} = \frac{m_2}{m_1} \qquad (\because p = same)$

5. **(4)**
By $\vec{v} = \vec{u} + \vec{a}t$
$\vec{v} = 100\hat{j} - 10\hat{j}\times 5 = 50\hat{j}$ m/s
Using COLM $\vec{p}_f = \vec{p}_i$
$0.6\vec{v}_2 - 0.4\times 25\hat{j} = 1\times 50\hat{j}$
$0.6\vec{v}_2 = 60\hat{j}$
$\vec{v}_2 = 100\hat{j}$ m/s

6. **(2)**
$\vec{F}_{ext} = 0$
Apply COLM $m_1v_1 = m_2v_2$
$mv = Mv'$
$v' = \frac{m}{M}v$

7. **(2)**
By conservation of Linear momentum, we can say other fragment is moving vertically downwards with velocity v_0.

8. **(3)**

v = velocity of bullet

V = velocity of gun

By COLM

mv = MV ......(i)

By energy conservation

$$\frac{1}{2}MV^2 = \frac{1}{2}kd^2$$

$$\therefore \ V = \sqrt{\frac{kd^2}{M}} \quad ......(ii)$$

From equation (i) and (ii)

$$\therefore v = \frac{M}{m}\sqrt{\frac{kd^2}{M}} = \frac{d}{m}\sqrt{kM}$$

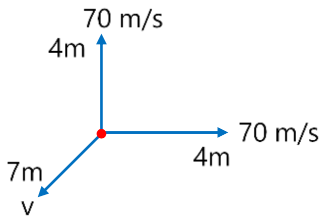
9. **(2)**

For rubber ball $\vec{\Delta p}$ is more

$$\Delta\vec{p} = m(\vec{v}_f - \vec{v}_i)$$

As v_f will be in opposite direction

10. **(1)**



Total momentum = 0

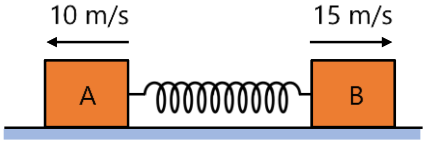
$$4m(70\hat{i}) + 4m(70\hat{j}) = 7m \times v$$

$$\Rightarrow \ 4m \times 70 \times \sqrt{2} = 7m \times v$$

$$\Rightarrow \ v = 40\sqrt{2} \text{ m/s}$$

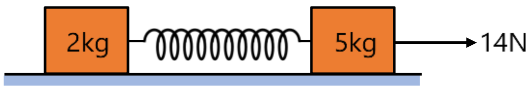
Spring Block System DPP-09

1. Two blocks A and B are joined together with a compressed spring ($K = 500\ Nm^{-1}$). When the system is released, the two blocks appear to be moving with unequal speeds in opposite directions as shown in figure. Select the correct statement:



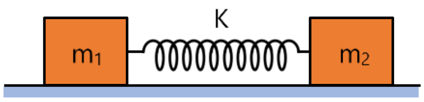
(1) The centre of mass of the system will remain stationary.
(2) Mass of block A is equal to that of block B.
(3) The centre of mass of the system will move towards right.
(4) It is an impossible physical situation.

2. Find acceleration of the centre of mass?



(1) Zero
(2) $\frac{14}{5}$ m/s^2
(3) 7 m/s^2
(4) 2 m/s^2

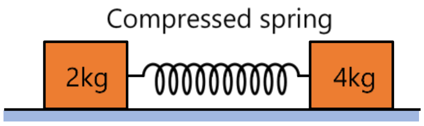
3. When two blocks connected by a stretched spring (as shown) start moving from rest towards each other under mutual interaction, then



Smooth horizontal floor

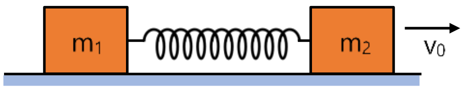
(1) Their velocities are equal and opposite
(2) Their acceleration is equal and opposite
(3) The force acting on the system is not zero
(4) Their momentum is equal and opposite

4. An elastic spring is compressed between two blocks of masses 2 kg and 4 kg resting on a smooth horizontal table as shown. If the spring has 24 J of energy and suddenly released, when spring is in natural length the velocity with which the block of 4 kg moves will be



(1) 2 m/s
(2) 4 m/s
(3) 1 m/s
(4) 8 m/s

5. Two blocks of masses m_1 and m_2 are connected by a spring of spring constant k. The block of mass m_2 is given a sharp impulse so that it acquires a velocity v_0 towards right. Find the maximum elongation that the spring will suffer.



(1) $\left[\frac{m_1 m_2}{m_1 + m_2}\right]^{1/2} v_0$

(2) $\left(\frac{m_1 + m_2}{m_1 - m_2}\right) v_0$

(3) $\left[\frac{m_1 + m_2}{m_1 - m_2}\right]^{1/2} v_0$

(4) $\left[\frac{m_1 + m_2}{m_1 - m_2}\right]^{1/2} v_0$

Answer key

Question	1	2	3	4	5
Answer	1	4	4	1	1

SOLUTIONS DPP-09

1. **(1)**

As net external force on the system = 0 (after being released)

So, centre of mass of the system remains stationary.

2. **(4)**

$$\vec{a}_{CM} = \frac{\vec{F}_{net}}{M} = \frac{14}{7} = 2\,m/s^2$$

3. **(4)**

As the mass of the two blocks is different, their velocity as well as acceleration cannot be the same.

When spring is connected between the blocks, the force on both blocks is same but opposite, so net force on the system will be zero

Therefore, net force is zero in this system and its initial momentum is zero. Thus, net momentum of the system is always zero. Hence momentum of both blocks is equal and opposite.

4. **(1)**

By conservation of linear momentum

$m_1v_1 = m_2v_2$

$\Rightarrow 2v_1 = 4v_2$

$\Rightarrow v_1 = 2v_2$ ......(i)

Now, by energy conservation

Total kinetic energy = potential energy of spring

$$\frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 = 24$$

$$\Rightarrow \frac{1}{2}\times 2(2v_2)^2 + \frac{1}{2}4(v_2)^2 = 24$$

$$\Rightarrow 4v_2^2 + 2v_2^2 = 24$$

$$\Rightarrow v_2^2 = 4$$

$\therefore$ $v_2 = 2$ m/s

5. **(1)**

At maximum elongation the two blocks are moving with same speed, thus, the conservation of linear momentum and energy gives us:

$m_2v_0 = (m_1 + m_2)v$

$$\Rightarrow v = \frac{m_2v_0}{m_1 + m_2}$$

$$\frac{1}{2}m_2v_0^2 = \frac{1}{2}(m_1 + m_2)v^2 + \frac{1}{2}kx^2$$

$$\Rightarrow x = \sqrt{\frac{m_1m_2}{m_1 + m_2}}v_0$$

Head on Collision DPP-10

1. **A sphere of mass m moving with a constant velocity collides with another stationary sphere of same mass. The ratio of velocities of two spheres after collision will be, if the coefficient of restitution is e-**

(1) $\frac{1-e}{1+e}$

(2) $\frac{e-1}{e+1}$

(3) $\frac{1+e}{1-e}$

(4) $\frac{e+1}{e-1}$

2. **A big ball of mass M, moving with velocity u strikes a small ball of mass m, which is at rest. Finally, small ball attains velocity u and big ball v. What is the value of v :-**

(1) $\frac{M-m}{M}u$

(2) $\frac{m}{M+m}u$

(3) $\frac{2m}{M+m}$

(4) $\frac{M}{M+m}v$

3. **Two solid balls of rubber A and B whose masses are 300 gm and 800 gm respectively, are moving in mutually opposite directions. If the velocity of ball A is 0·4 m/s and both the balls come to rest after collision, then the initial velocity of ball B is –**

(1) 0·15 m/s

(2) – 0·15 m/s

(3) 1·5 m/s

(4) None of the above

4. **If two masses m_1 and m_2 collide, the ratio of the magnitude of changes in their respective velocities is proportional to :-**

(1) $\frac{m_1}{m_2}$

(2) $\sqrt{\frac{m_1}{m_2}}$

(3) $\frac{m_2}{m_1}$

(4) $\sqrt{\frac{m_2}{m_1}}$

5. **If two balls each of mass 0.06 kg moving in opposite directions with speed 4 m/s collide and rebound with same speed, then the impulse imparted to each ball due to other is :**

(1) 0.48 kg m/s

(2) 0.24 kg m/s

(3) 0.81 kg m/s

(4) Zero

6. **Two elastic bodies P and Q having equal masses are moving along the same line with velocities of 20 m/s and 15 m/s respectively. Their respective velocities after the elastic collision will be in m/s :-**

(1) 15 and 20

(2) 5 and 20

(3) 20 and 15

(4) 20 and 5

7. **A body of mass m having an initial velocity v makes head on elastic collision with a stationary body of mass M. After the collision, the body of mass m comes to rest and only the body having mass M moves. This will happen only when: -**

(1) m >> M

(2) m << M

(3) m = M

(4) $m = \frac{M}{2}$

8. **A body A experiences perfectly elastic collision with a stationary body B. If after collision the bodies fly apart in the opposite direction with equal speeds, the mass ratio of A and B is :-**

(1) $\frac{1}{2}$

(2) $\frac{1}{3}$

(3) $\frac{1}{4}$

(4) $\frac{1}{5}$

9. **A ball of mass M moving with speed v undergoes a head on elastic collision with a ball of mass nM initially at rest. The fraction of the incident energy transferred to the second ball is :-**

(1) $\frac{n}{1+n}$

(2) $\frac{n}{(1+n)^2}$

(3) $\frac{2n}{(1+n)^2}$

(4) $\frac{4n}{(1+n)^2}$

10. A collision is said to be perfectly inelastic when: -

(1) Coefficient of restitution = 0

(2) Coefficient of restitution = 1

(3) Coefficient of restitution = ∞

(4) Coefficient of restitution < 1

11. A ball of mass 1kg strikes a heavy platform, elastically, moving upwards with a velocity of 5 m/s. The speed of the ball just before collision is 10 m/s downwards. Then the impulse imparted by the platform on the ball is

(1) 15 N-s

(2) 10 N-s

(3) 20 N-s

(4) 30 N-s

12. The bob (mass m) of a simple pendulum of length L is held horizontal and then released. It collides elastically with a block of equal mass lying on a frictionless table. The kinetic energy of the block after collision will be :–

(1) Zero

(2) mgL

(3) 2mgL

(4) $\frac{mgL}{2}$

Answer key

Question	1	2	3	4	5	6	7	8	9	10	11	12
Answer	**1**	**1**	**2**	**3**	**1**	**1**	**3**	**2**	**4**	**1**	**4**	**2**

SOLUTIONS DPP-10

1. **(1)**

By COLM

$mu + 0 = mv_1 + mv_2$ ..... (1)

$e = \frac{v_2 - v_1}{u - 0}$ ..... (2)

$\Rightarrow v_2 - v_1 = eu$ ..... (3)

From (1)

$u = v_1 + v_2$ ..... (4)

Putting (4) in (3)

$v_2 - v_1 = e(v_1 + v_2)$

$\Rightarrow v_2 - ev_2 = v_1 + ev_1$

$\frac{v_1}{v_2} = \frac{1-e}{1+e}$

2. **(1)**

By COLM

$Mu + 0 = mu + Mv \Rightarrow v = \frac{(M-m)u}{M}$

3. **(2)**

$m_1\vec{u}_1 + m_2\vec{u}_2 = 0 + 0$

$300 \times 0.4 + 800 \times \vec{u}_2 = 0$

$300 \times 0.4 = -800 \times \vec{u}_2$

$\vec{u}_2 = -0.15\ m/s$

4. **(3)**

By COLM

$m_1\vec{u}_2 + m_2\vec{u}_2 = m_1\vec{v}_1 + m_2\vec{v}_2$

$\Rightarrow \quad m_1(\vec{v}_1 - \vec{u}_1) = m_2(\vec{v}_2 - \vec{u}_2)$

$\Rightarrow \quad \frac{\vec{v}_1 - \vec{u}_1}{\vec{v}_2 - \vec{u}_2} = \frac{-m_2}{m_1}$

$\Rightarrow \quad \frac{|\vec{v}_1 - \vec{u}_1|}{|\vec{v}_2 - \vec{u}_2|} = \frac{m_2}{m_1}$

5. **(1)**

Impulse = change in momentum

$2mv = 2 \times 0.06 \times 4 = 0.48$

6. **(1)**

For same mass and e = 1 velocities exchange

7. **(3)**

Velocity interchange when m = M

8. **(2)**

before after

mu = (M – m)v ...(1)

$$e = \frac{2v}{u} = 1$$

$$\therefore \ v = \frac{u}{2} \qquad ...(2)$$

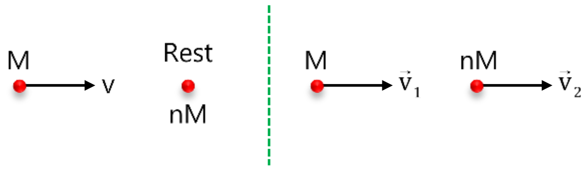
$$\therefore \ m = (M - m) \times \frac{1}{2}$$

2m = M – m

3m = M

$$\frac{m}{M} = \frac{1}{3}$$

9. **(4)**



Before collision After collision

By COLM $Mv + 0 = M\vec{v}_1 + nM\vec{v}_2$

$$\Rightarrow \quad \vec{v}_1 + n\vec{v}_2 = v \qquad ......(1)$$

$$\because \quad e = \frac{\vec{v}_2 - \vec{v}_1}{\vec{u}_1 - \vec{u}_2} \Rightarrow 1 = \frac{\vec{v}_2 - \vec{v}_1}{v - 0}$$

$$\Rightarrow \quad \vec{v}_2 - \vec{v}_1 = v \qquad ......(2)$$

So solving $\vec{v}_2 = \frac{2v}{n+1}$

$$KE_i = \frac{1}{2}Mv^2$$

KE transferred to the second ball after collision

$$= \frac{1}{2}nM\left[\frac{2v}{n+1}\right]^2 = \frac{4nMv^2}{2(n+1)^2} = \frac{4n}{(n+1)^2}KE_i$$

Fraction of KE transferred to second ball

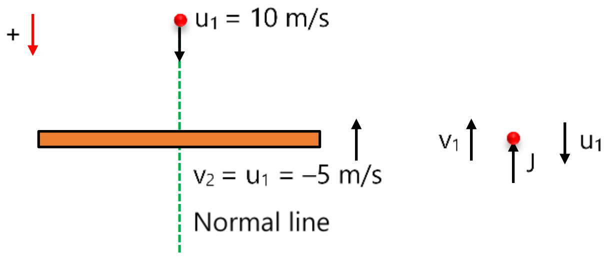
$$= \frac{4n}{(n+1)^2}$$

10. **(1)**

e = 0, for perfectly inelastic.

11. **(4)**

As we know e = $\left[\frac{(v_2 - v_1)}{(u_1 - u_2)}\right]_n$



$1 = \frac{(-5)-(v_1)}{(10)-(-5)} \Rightarrow v_1 = -20 \text{ m/s}$

Hence ball will start moving towards upward direction with velocity 20 m/s.

Let impulse imparted by plate force on the ball is J in upward direction.

$mu_1 - J = -mv_1$

$\Rightarrow \quad J = m(u_1 + v_1) = 1(10 + 20) = 30$ kg m/s = 30 N-s

12. **(2)**

Velocity interchange when mass are equal

So KE = mgL

Bouncing of Ball DPP-11

1. **A ball is dropped from height h on the ground level. If the coefficient of restitution is e then the height upto which the ball will go after n^{th} jump will be –**

(1) $\frac{h}{e^{2n}}$

(2) $\frac{e^{2n}}{h}$

(3) he^{n}

(4) he^{2n}

2. **A 3 Kg ball falls from a height of 64 cm and rebounds upto a height of 25 cm. The coefficient of restitution is –**

(1) 0·62

(2) 0·32

(3) 0·40

(4) 0·56

3. **A particle falls from a height 'h' upon a fixed horizontal plane and rebounds. If 'e' is the coefficient of restitution the total distance travelled before rebounding has stopped is :-**

(1) $h\left(\frac{1+e^2}{1-e^2}\right)$

(2) $h\left(\frac{1-e^2}{1+e^2}\right)$

(3) $\frac{h}{2}\left(\frac{1-e^2}{1+e^2}\right)$

(4) $\frac{h}{2}\left(\frac{1+e^2}{1-e^2}\right)$

4. **A rubber ball is dropped from a height of 10m on a plane, where the acceleration due to gravity is not known. On bouncing it rises to 6.4 m. The ball loses its velocity on bouncing by a factor of :-**

(1) $\frac{1}{5}$

(2) $\frac{2}{5}$

(3) $\frac{3}{5}$

(4) $\frac{4}{5}$

5. A ball is dropped from a height of 20 m. If 50% of its energy is lost on collision with the earth then after collision the ball will rebound to a height of–

(1) 10 m

(2) 8 m

(3) 4 m

(4) 6 m

6. A ball is let fall from a height h_0. There are n collisions with the earth. If the velocity of rebound after n collisions v_n and the ball rises to a height h_n, then coefficient of restitution e is given by

(1) $e^n = \sqrt{\frac{h_n}{h_0}}$

(2) $e^n = \sqrt{\frac{h_0}{h_n}}$

(3) $ne = \sqrt{\frac{h_n}{h_0}}$

(4) $\sqrt{ne} = \sqrt{\frac{h_n}{h_0}}$

Answer key

Question	1	2	3	4	5	6
Answer	4	1	1	1	1	1

SOLUTIONS DPP-11

1. **(4)**

Let a ball fall from a height (h) and let it touch the ground with a velocity v taking time (t) to reach the ground. Let v_1, v_2, v_3....... be the velocities immediately after first, second, third......collisions with the ground.

$$v_1 = ev \Rightarrow \sqrt{2gh_1} = e\sqrt{2gh} \Rightarrow h_1 = e^2h$$

$$v_2 = e^2v \Rightarrow \sqrt{2gh_2} = e^2\sqrt{2gh}, h_2 = e^4h$$

Similarly

Height attained by the ball after the 'n'th rebound

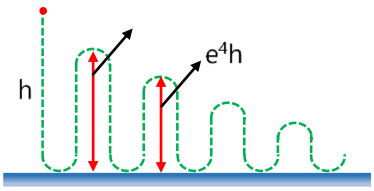
$h_n = e^{2n}h$

2. **(1)**

$$\sqrt{2gh_f} = e\sqrt{2gh_i}$$

$$\Rightarrow e = \sqrt{\frac{h_f}{h_i}} = \sqrt{\frac{25}{64}} = \frac{5}{8} = 0.625$$

3. **(1)**



Total distance $= h + 2e^2h + 2e^4h + \ldots\ldots\ldots\ldots$

$= h + 2e^2h(1 + e^2 + e^4 + \ldots\ldots\ldots)$

$$= h + 2e^2h \times \frac{1}{1-e^2}$$

$$= h\left[1 + \frac{2e^2}{1-e^2}\right] = \left(\frac{1+e^2}{1-e^2}\right)h$$

4. **(1)**

$$e = \sqrt{\frac{h_f}{h_i}} = \sqrt{\frac{6.4}{10}} = 0.8 = \frac{4}{5}$$

Loss in velocity $= 1 - \frac{4}{5} = \frac{1}{5}$

5. **(1)**

Initial energy = mgh = mg(20)

If 50% is lost

Remaining energy = 50% of mg(20)

$$\Rightarrow \frac{50}{100} \times mg(20) = mg(h)$$

$$h = 10m$$

6. **(1)**

In this problem, the velocity of the earth before and after the collision may be assumed zero. Hence, coefficient of restitution will be

$$e^n = \frac{v_1}{v_0} \times \frac{v_2}{v_1} \times \frac{v_3}{v_2} \times \ldots\ldots\ldots \times \frac{v_n}{v_{n-1}}$$

Where v_n is the velocity after n^{th} rebounding and v_0 is the velocity with which the ball strikes the earth first time.

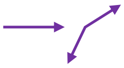
Hence, $e^n = \frac{v_n}{v_0} = \frac{\sqrt{2gh_n}}{\sqrt{2gh_0}}$

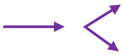
Where h_n is the height to which the ball rises after n^{th} rebounding.

Hence, $e^n = \frac{v_n}{v_0} = \frac{\sqrt{h_n}}{\sqrt{h_0}}$

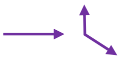
Oblique collision DPP-12

1. **In the diagrams given below the horizontal line represents the path of a ball coming from left and hitting another ball which is initially at rest. The other two lines represents the paths of the two balls after the collision. Which of the diagram shows a physically impossible situation?**

(1) 

(2) 

(3) 

(4) 

2. **A ball moving with velocity of 8m/s collides with another similar stationary ball. After the collision both the balls move in directions making an angle of 60° with the initial direction. After the collision their speed will be –**

(1) 4 m/s
(2) 2 m/s
(3) 8 m/s
(4) 80 m/s

3. **Two ice skaters A and B approach each other at right angles. Skater A has a mass 40 kg and velocity 2 m/s and skater B has a mass 20 kg and velocity 3 m/s. They meet and cling together. The final velocity of the couple is**

(1) 2 m/s
(2) 1.6 m/s
(3) 1 m/s
(4) 3.2 m/s

4. **A particle of mass m moving with speed v towards east strikes another particle of same mass moving with same speed v towards north. After striking, the two particles fuse together. With what speed this new particle of mass 2 m will move in north-east direction?**

(1) v
(2) $\frac{v}{2}$
(3) $\frac{v}{\sqrt{2}}$
(4) $v\sqrt{2}$

5. **A mass 'm' moves with a velocity v and collides inelastically with another identical mass. After collision the 1st mass moves with velocity $\frac{v}{\sqrt{3}}$ in a direction perpendicular to the initial direction of motion as shown in figure. Find the speed of the 2nd mass after collision.**

(1) $\frac{2}{\sqrt{3}}v$

(2) $\frac{v}{\sqrt{3}}$

(3) v

(4) $\sqrt{3}v$

Answer key

Question	1	2	3	4	5
Answer	3	3	2	3	1

SOLUTIONS DPP-12

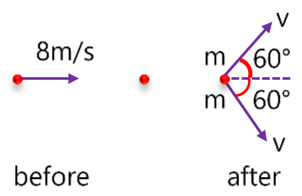
1. **(3)**

It is not possible that after collision one ball moves along the original line of motion while the other ball moves along some angle (α) with original line. The momentum perpendicular to original line of motion cannot be conserved in this situation.

Initial momentum along perpendicular direction=zero

Final momentum along perpendicular direction = $m_2v_2 \sin\alpha$. Hence momentum is not conserved. Hence the situation is physically impossible. Rest option may be physically possible.

2. **(3)**



By COLM in x-direction

m(8) = 2mvcos60°

$\Rightarrow m(8) = 2mv \times \frac{1}{2}$

$\Rightarrow$ v = 8 m/s

3. **(2)**

By COLM

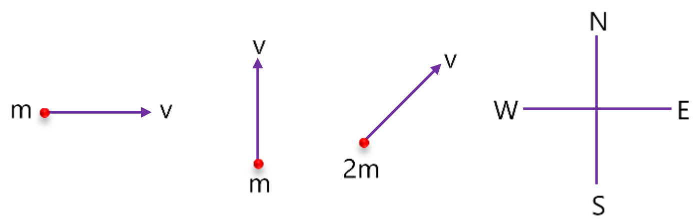
$m_A\vec{v}_A + m_B\vec{v}_B = (m_A + m_B)\vec{v}$

$40(2\hat{i}) + 20(3\hat{j}) = (40+20)\vec{v}$

$\Rightarrow \vec{v} = \frac{80\hat{i}+60\hat{j}}{60}$

$\Rightarrow |\vec{v}| = \frac{1}{60}\sqrt{80^2+60^2} = \frac{100}{60} = 1.6\,m/s$

4. **(3)**



According to the law of conservation of linear momentum along horizontal direction,

$mv + 0 = 2mv_x'$

$v_x' = \frac{v}{2}$

According to the law of conservation of linear momentum along vertical direction,

$$0 + mv = 2mv_x'$$

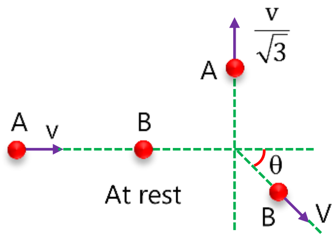
$$v_y' = \frac{v}{2}$$

$\therefore$ Speed of the new mass 2m is

$$v' = \sqrt{v'^2_x + v'^2_y} = \sqrt{\left(\frac{v}{2}\right)^2 + \left(\frac{v}{2}\right)^2} = \frac{v}{\sqrt{2}}$$

5. **(1)**

Let mass A moves with velocity v and collides inelastically with mass B, which is at rest.



According to problem mass A moves in perpendicular direction and let the mass B moves at angle θ with the horizontal with velocity v.

Initial horizontal momentum of system

(before collision) = mv ....(i)

Final horizontal momentum of system

(after collision) = mVcos θ ....(ii)

From the conservation of horizontal linear momentum

mv = mV cos $\theta \Rightarrow$ v = V cos θ ....(iii)

Initial vertical momentum of system (before collision) is zero.

Final vertical momentum of system $\frac{mv}{\sqrt{3}} - mV\sin\theta$

From the conservation of vertical linear momentum

$$\frac{mv}{\sqrt{3}} - mV\sin\theta = 0 \Rightarrow \frac{v}{\sqrt{3}} = V\sin\theta \quad \text{..........(iv)}$$

By solving (iii) and (iv)

$$v^2 + \frac{v^2}{3} = V^2\left(\sin^2\theta + \cos^2\theta\right)$$

$$\Rightarrow \quad \frac{4v^2}{3} = V^2 \Rightarrow V = \frac{2}{\sqrt{3}}v.$$