Ultimate KCET Crash Course 2026

PHYSICS

DPP: 1

System of particles and rotational motion

Q1 The centre of mass of a system of three particles of masses 1 g, 2 g and 3 g is taken as the origin of a coordinate system. The position vector of a fourth particle of mass 4 g such that the centre of mass of the four particle system lies at the point (1, 2, 3) is $\alpha(\hat{i}+2\hat{j}+3\hat{k})$, where a is a constant. The value of α is

(A) $\frac{10}{3}$ (B) $\frac{5}{2}$

(C) $\frac{1}{2}$ (D) $\frac{2}{5}$

Q2 A ball is dropped from a height of 80 m on a ground. Find the height attained by the ball after 2nd collision, if cofficient of restitution, e is 0.5

(A) 5 m (B) 10 m

(C) 40 m (D) 80 m

Q3 Where is the centre of mass located for a uniform ring?

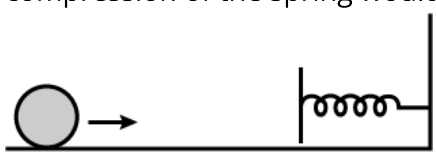
(A) At the geometrical centre

(B) Outside the material where no mass is present

(C) Both (A) and (B)

(D) Within the body

Q4 A mass of 0.5 kg moving with a speed of 1.5 m/s on a horizontal smooth surface, collides with a nearly weightless spring of force constant k = 50 N/m. The maximum compression of the spring would be



(A) 0.15 m

(B) 0.12 m

(C) 1.5 m

(D) 0.5 m

Q5 Centre of mass of 3 particles 10 kg,20 kg and 30 kg is at (0,0,0). Where should a particle of mass 40 kg be placed so that the combined centre of mass will be at (3,3,3) ?

(A) (0,0,0) (B) (7.5,7.5,7.5)

(C) (1,2,3) (D) (4,4,4)

Q6 A system consists of masses M and m (M). The centre of mass of the system is

(A) at the middle.

(B) nearer to M.

(C) nearer to m.

(D) at the position of larger mass.

Q7 A ball of mass m is thrown upward and another ball of same mass is thrown downward so as to move freely under gravity. The acceleration of centre of mass is:

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

(C) 2 g (D) Zero

Q8 Three bodies having masses 5 kg, 4 kg and 2 kg is moving at the speed of 5 m/s, 4 m/s and 2 m/s respectively along X-axis. The magnitude of velocity of CM is

(A) 1.0 m/s (B) 4 m/s

(C) 0.9 m/s (D) 1.3 m/s

Q9 During inelastic collision between two objects, which of the following quantity always remains conserved?

(A) Total mechanical energy

(B) Speed of each body

(C) Total kinetic energy

(D) Total linear momentum

Q10 A thin uniform wire is bent in the form of a semicircle of radius R. The distance of its centre of mass from its geometrical centre is:

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

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

Q11 **A simple pendulum is made of bob which is a hollow sphere full of sand suspended by means of a wire. If all the sand is drained out, the period of the pendulum will**

(A) increase (B) decrease

(C) remain same (D) become erratic

Q12 Two particles which are initially at rest move towards each other under the action of their mutual attraction. If their speeds are v and 2v at any instant, then the speed of center of mass of the system is,

(A) Zero (B) v

(C) 2v (D) 1.5 v

Q13 The angular speed of a motor wheel is increased from 1200rpm to 3120rpm in 16 seconds. The angular acceleration of the moto wheel is

(A) $6\pi rad/s^2$ (B) $8\pi rad/s^2$

(C) $2\pi rad/s^2$ (D) $4\pi rad/s^2$

Q14 A ball of mass is moving towards a batsman at a speed *v*. The batsman
strikes the ball and deflectes it by an angle without changing its speed
The impulse imparted to the ball is given by

(A) $mv\cos\theta$ (B) $mv\sin\theta$

(C) $mv\cos\frac{\theta}{2}$ (D) $2mv\cos\frac{\theta}{2}$

Q15 A thin uniform circular disc of mass M and radius R is rotating in a horizontal plane about an axis passing through its centre and perpendicular to its plane with an angular velocity ω. Another disc of the same dimensions but of mass M/4 is placed gently on the first disc coaxially. The angular velocity of the system now is

(A) $\frac{1}{3}\omega$ (B) $\frac{2}{3}\omega$

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

Q16 A body of mass 3 kg collides elastically with another body at rest and then continues to move in the original direction with one half of its original speed. What is the mass of the target body?

(A) 1 kg (B) 1.5 kg

(C) 2 kg (D) 5 kg

Q17 A ball moving with speed (μ_1) impinges directly on a similar ball at rest. The first ball is brought to rest by the impact. If half of the kinetic energy is lost by impact, then the velocity of second ball after the impact is

(A) $\frac{u_1}{2\sqrt{2}}$ (B) $\frac{u_1}{\sqrt{2}}$

(C) $\frac{u_1}{\sqrt{2}}$ (D) $\frac{\sqrt{3u_1}}{2}$

Q18 When two bodies collide elastically, then:

(A) kinetic energy of the system alone is conserved.

(B) only momentum is conserved.

(C) both kinetic energy and momentum are conserved.

(D) neither energy nor momentum is conserved.

Q19 For which of the following does the centre of mass lie outside the body?

(A) A shotput (B) A pencil

(C) A bangle (D) A dice

Q20 Two identical balls *A* and *B* having velocities of 0.5 m/s and –0.3 m/s respectively collide elastically in one dimension. The velocities of *B* and *A* after the collision respectively will be

(A) –0.5 m/s and 0.3 m/s
(B) 0.5 m/s and –0.3 m/s
(C) –0.3 m/s and 0.5 m/s
(D) 0.3 m/s and 0.5 m/s

Q21 A 12 kg bomb at rest explodes into two pieces of 4 kg and 8 kg piece. If the momentum of 4kg piece is 20 Ns, the kinetic energy of the 8 kg piece is

(A) 25 J (B) 20 J
(C) 50 J (D) 40 J

Q22 The centre of mass of three particles of masses 1 kg, 2 kg, and 3 kg is at (2, 2, 2). The position of the fourth mass of 4 kg to be placed in the system so that the new centre of mass is at (0, 0, 0) is

(A) −3,−3,−3
(B) −3, 3, −3
(C) 2, 3, −3
(D) 2, −2, 3

Q23 The center of gravity of a uniform solid sphere near the surface of earth is:

(A) at the surface of the sphere.
(B) at the center of the sphere.
(C) at the edge of the sphere.
(D) at any point that lies along the horizontal diameter of the sphere.

Q24 The centre of mass of an extended body on the surface of the earth and its centre of gravity

(A) Can never be at the same point
(B) Centre of mass coincides with the centre of gravity of a body if the size of the body is negligible as compared to the size (or radius) of the earth
(C) Are always at the same point for any size of the body
(D) Are always at the same point only for spherical bodies

Q25 The centre of mass of a system of two particles of masses m_1 and m_2 is at a distance d_1 from m_1 and at a distance d_2 from mass m_2 such that

(A) $\frac{d_1}{d^2} = \frac{m_2}{m_1}$ (B) $\frac{d_1}{d^2} = \frac{m_1}{m_2}$
(C) $\frac{d_1}{d^2} = \frac{m_1}{m_1+m_2}$ (D) $\frac{d_1}{d^2} = \frac{m_2}{m_1+m_2}$

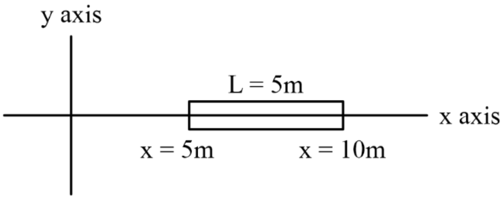
Q26 Two ice skaters A and B approach each other at right angles. Skater A has a mass 30 kg and velocity 1 m/s and skater B has a mass 20 kg and velocity 2m/s. They meet and cling together. The final velocity of the couple is

(A) 2 m/s
(B) 1.5 m/s
(C) 1 m/s
(D) 2.5 m/s

Q27 A body of mass 2 kg collides with a wall with speed 100 m/s and rebounds with the same speed. If the time of contact was 1/50 second, the force exerted on the wall is

(A) 8 N
(B) 2×10^4 N
(C) 4 N
(D) 10^4 N

Q28 A uniform rod of length 5 m is placed along x-axis as shown in the figure. The position of centre of mass of the rod from the origin is



(A) 2.25 m (B) 5 m
(C) 7.5 m (D) 10 m

Q29 Three identical metal balls, each of the radius r are placed touching each other on a horizontal surface such that an equilateral triangle is formed when centres of three balls are joined. The centre of the mass of the system is located at

(A) line joining centres of any two balls
(B) centre of one of the balls
(C) horizontal surface
(D) point of intersection of the medians.

Q30 After an elastic collision between two balls of equal masses, one is observed to have a speed of 3m along the positive x axis and the other has a speed of 2ms along negative x axis What were the original velocities of the balls (in ms) ?

(A) $\frac{-2i}{3i}$ (B) 0, 0
(C) $\frac{4i}{6i}$ (D) $\frac{2i}{2j}$

Answer Key

Q1	B
Q2	B
Q3	C
Q4	A
Q5	B
Q6	B
Q7	A
Q8	B
Q9	D
Q10	A
Q11	C
Q12	A
Q13	D
Q14	C
Q15	C
Q16	A
Q17	C
Q18	C
Q19	C
Q20	B
Q21	A
Q22	A
Q23	B
Q24	B
Q25	A
Q26	C
Q27	B
Q28	C
Q29	D
Q30	A

Hints & Solutions

Note: scan the QR code to watch video solution

Q1 Text Solution:

Let (x, y, z) coordinates of three particles of masses 1g, 2g and 3g be (x_1, y_1, z_1), (x_2, y_2, z_2) and (x_3, y_3, z_3) respectively.

The x-coordinate of the centre of mass is

$X_{CM} = \frac{m_1 x_1 + m_2 x_2 + m_3 x_3}{m_1 + m_2 + m_3}$

or $0 = \frac{1x_1 + 2x_2 + 3x_3}{1+2+3}$ or $x_1 + 2x_2 + 3x_3 = 0$ ...(i)

Let the fourth particle of mass 4g be placed at (x_4, y_4, z_4) so that the centre of mass of the four particles system lies at (1, 2, 3).

$1 = \frac{x_1 + 2x_2 + 3x_3 + 4x_4}{1+2+3+4}$ or $x_1 + 2x_2 + 3x_3 + 4x_4 = 10$ ...(ii)

$4x_4 = 10$ or $x_4 = \frac{10}{4} = \frac{5}{2}$;

$\alpha = \frac{5}{2}$

Video Solution:

Q2 Text Solution:

$H' = e^{2n} H$

$= e^4 \times 80$

$= 1/8 \times 80$

$= 10m$

Video Solution:

Q3 Text Solution:

Both (A) and (B)

Video Solution:

Q4 Text Solution:

The kinetic energy of mass is converted into energy required to compress a spring which is given by

$\frac{1}{2} mv^2 = \frac{1}{2} kx^2$

$\Rightarrow x = \sqrt{\frac{mv^2}{k}} = \sqrt{\frac{0.5 \times (1.5)^2}{50}} = 0.15 \text{ m}$

Video Solution:

Q5 Text Solution:

Let the position coordinates of 40 kg be (x,y,z).

$\therefore X_{CM} = \frac{\sum m_i x_i}{\sum m_i}$ or 3

$= \frac{10\times0 + 20\times0 + 30\times0 + 40\times x}{10+20+30+40}$

$\therefore x = \frac{300}{40} = 7.5$

$Y_{CM} = \frac{\sum m_i y_i}{\sum m_i}$

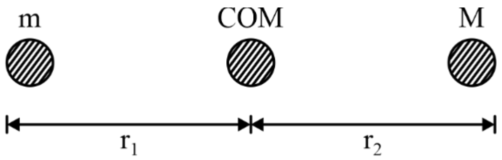
$3 = \frac{10\times0 + 20\times0 + 30\times0 + 40\times y}{10+20+30+40} \Rightarrow y = \frac{300}{40} = 7.5$

$Z_{CM} = \frac{\sum m_i z_i}{\sum m_i}$

$3 = \frac{10\times0 + 20\times0 + 30\times0 + 40\times z}{10+20+30+40} \Rightarrow z = \frac{300}{40} = 7.5$

Video Solution:

Q6 **Text Solution:**



Distribution of mass is more towards M(m << M)

Centre of mass will be farther from m

$r_1 > r_2$

So, centre of mass will be closer to M.

Video Solution:

Q7 **Text Solution:**

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

$$\vec{a}_{cm} = \frac{mg + mg}{2m} = \frac{2mg}{2m} = g$$

Video Solution:

Q8 **Text Solution:**

$$V_{CM} = \frac{m_1 v_1 + m_2 v_2 + m_3 v_3}{m_1 + m_2 + m_3}$$

$$= \frac{5\times5 + 4\times4 + 2\times2}{5+4+2} = \frac{45}{11}$$

$$= 4.09 = 4m/s$$

Video Solution:

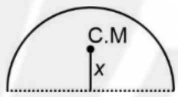
Q9 **Text Solution:**

During inelastic collision only promotion

Video Solution:

Q10 **Text Solution:**

Answer (1)



$$X = \frac{2R}{\pi}$$

Video Solution:

Q11 Text Solution:

$T=\pi\sqrt{\frac{T_{\text{eff}}}{a_{\text{eff}}}}$

$T\propto I_{\text{en}}$

$COM\ shifts\ downwards$

$\left(Towards\ heavier\ body\right)$

$l_{\text{eff}}\ =l+R$

Video Solution:

Q12 Text Solution:

Zero

Video Solution:

Q13 Text Solution:

$\alpha=\frac{W_2-W_1}{t}=\frac{2\pi n_2-2\pi n_1}{t}$

Video Solution:

Q14 Text Solution:

The ball moving along *AB* with velocity *v* is deflected along *BC* with velocity *v*'. The magnitude of vectors *v* and *v*' is the same = v

Change in velocity is $\Delta v=V'-v=v+(-v), ie\Delta V$ the resultant of vectors v' and -v. As shown in figure, the magnitude of $\Delta v$is given by

$\Delta v=\sqrt{v^2+v^2+2v^2\cos\theta}$

$=\sqrt{2\text{v}^2\left(1+\cos\theta\right)}$

$=2\text{v}\cos\left(\frac{\theta}{2}\right)$

Video Solution:

Q15 Text Solution:

Here, $I_1=\frac{1}{2}MR^2,\omega_1=\omega$

$I_2=\frac{1}{2}MR^2+\frac{1}{2}\frac{M}{4}R^2=\frac{5}{8}MR^2$

$\omega_2=\frac{I_1}{I_2}\omega_1=\frac{\frac{1}{2}MR^2}{\frac{5}{8}MR^2}\omega=\frac{8}{10}\omega=\frac{4}{5}\omega$

Video Solution:

Q16 Text Solution:

Here e = 1.

$e = \frac{v_2 - v_1}{u_1 - u_2}$

$\Rightarrow v_2 - v_1 = u_1 - u_2$

$v_2 = u_1 + \frac{u_1}{2} = \frac{3u_1}{2}$

$From\ conservation\ of\ momentum,$

$m_1 v_1 + m_2 v_2 = m_1 u_1 + m_2 u_2$

$3\left[\frac{u_1}{2}\right] + m_2\left[\frac{3u_1}{2}\right] = 3[u_1]$

$3u_1 + m_2[3u_1] = 6u_1$

$m_2 = \frac{6u_1 - 3u_1}{3u_1} = 1kg$

Video Solution:

Q17 Text Solution:

C

Video Solution:

Q18 Text Solution:

For elastic collision both energy and momentum are conserved.

Video Solution:

Q19 Text Solution:

Out of the four given bodies, the centre of mass of a bangle lies outside it whereas in all other three bodies it lies within thebody.

Video Solution:

Q20 Text Solution:

It is given that mass of balls are same and collision is perfectly elastic (e = 1), so their velocities will be interchanged.

Thus, $v'_A = v_B = -0.3$ m/s,

$v'_B = v_A = 0.5$ m/s.

Video Solution:

Q21 Text Solution:

Initial momentum of the system is zero.

According to the law of conservation of momentum, Initial momentum = final momentum So, final momentum of the system must also be zero .

Hence, Momentum of 8kg piece must be equal, opposite to the momentum of 4kg piece.

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Hence, Momentum of 8kg piece must be equal, opposite to the momentum of 4kg piece.

⇒ For 8kg piece, P = 20 Ns

K.E. of 8kg piece, $K = \frac{P^2}{2m} = \frac{(20)^2}{2 \times 8} = 25J$

Video Solution:

Q22 Text Solution:

As the c. m. of three particles is at 2, 2, 2

The total mass = 1 + 2 + 3 = 6 kg

Now consider the 4 kg mass at the position (x, y, z)

Now centre of mass of total system at (0, 0, 0)

$\therefore \frac{6 \times 2 + 4x}{10} = 0$

12 = −4x

x = −3

Similarly,

y = −3

Similarly, $\frac{6 \times 2 + 4z}{12} = 0$

z = −3

From the above we can conclude that

x = −3, y = −3, z = −3

Video Solution:

Q23 Text Solution:

Centre of gravity coincides with centre of mass if acceleration due to gravity does not vary throughout object.

Video Solution:

Q24 Text Solution:

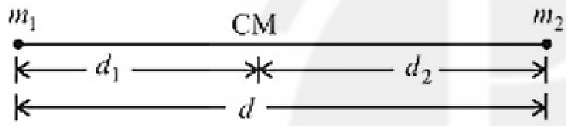
Centre of mass coincides with the centre of gravity of a body if the size of the body is negligible as compared to the size (or radius) of the earth

Video Solution:

Q25 Text Solution:

Refer to the figure, the distances of centre of mass CM from masses m_1 and m_2 are

$d_1 = \frac{m_2 d}{m_1+m_2}$ and $d_2 = \frac{m_1 d}{m_1+m_2}$ $\therefore \frac{d_1}{d_2} = \frac{m_2}{m_1}$



Video Solution:

Q26 Text Solution:

Applying principle of conservation of linear momentum,

$p = \sqrt{p_1^2 + p_2^2}$ or $(m_1 + m_2)v$

$= \sqrt{(m_1 v_1)^2 + (m_2 v_2)^2}$

$(30 + 20)v = \sqrt{(30 \times 1)^2 + (20 \times 2)^2} = 50$

$\therefore v = \frac{50}{50} = 1$ m/s

Video Solution:

Q27 Text Solution:

$\Delta P = 2(100 - (-100)) = 400 kgm/s$

$F = \frac{\Delta P}{\Delta t} = \frac{400}{1/50} = 2 \times 10^4 N$

Video Solution:

Q28 Text Solution:

Let the mass of uniform rod be M

Mass per unit length of the rod = $\left(\frac{M}{L}\right)$

Let dm be the mass of an element of length dx at a distance x from origin.

$\therefore dm = \left(\frac{M}{L}\right)dx = \left(\frac{M}{5}\right)dx$

Position of centre of mass, $x_{com} = \frac{\int xdm}{\int dm}$

$$x_{com} = \frac{\int_5^{10} x\left(\frac{M}{L}\right)dx}{\int_5^{10} \frac{M}{L}dx} = \frac{\int_5^{10} xdx}{\int_5^{10} dx}$$

$$= \frac{1}{5}\left(\frac{x^2}{2}\right)_5^{10}$$

$= \frac{1}{5}\left(\frac{10^2-5^2}{2}\right)$

$= \frac{75}{10} = 7.5 \text{ m}$

Alternate method:

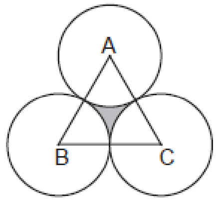
As from symmetry we can say that the COM of the rod will lie at

$\frac{L}{2}$ since rod is uniform.

So, from origin COM will be at $5 + \frac{5}{2} = 7.5m$

Video Solution:

Q29 Text Solution:



Centre of mass of each ball lies on the centre. Centre of mass of combined body will be at the centroid of equilateral triangle.

Video Solution:

Q30 Text Solution:

velocities get interchanged after the collision with equal masses

Video Solution: