Varun JEE Advanced (2026)

Physics

Center of Mass and Collision

DPP: 2

Time duration - 70 min

Q1 Three particles each $1\ \text{kg}$ mass are placed at the corners of right angled triangle AOB, O being the origin of the co-ordinate system OA and OB along +ve x direction and +ve y-direction. The position vector of the centre of mass is $(\text{OA} = \text{OB} = 1\ \text{m})$ (in meters)

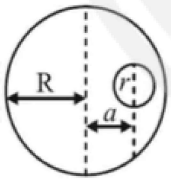
(A) $\frac{i+j}{3}$

(B) $\frac{i-j}{3}$

(C) $\frac{2(i+j)}{3}$

(D) $(i-j)$

Q2 A circular hole of radius r is made in a disk of radius R and of uniform thickness at a distance a from the centre of the disk. The distance of the new centre of mass from the original centre of mass is



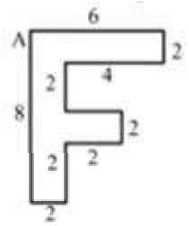
(A) $\frac{aR^2}{R^2-r^2}$

(B) $\frac{ar^2}{R^2-r^2}$

(C) $\frac{a(R^2-r^2)}{r^2}$

(D) $\frac{a(R^2-r^2)}{R^2}$

Q3 The centre of mass of the letter F which is cut from a uniform metal sheet from point A is



(A) $15/7, 33/7$

(B) $15/7, 23/7$

(C) $22/7, 33/7$

(D) $33/7, 22/7$

Q4 The centre of mass of two particles lies

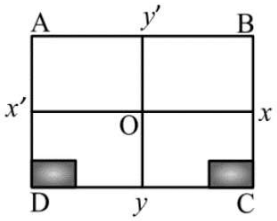
(A) on the line perpendicular to the line joining the particles

(B) on a point outside the line joining the particles

(C) on the line joining the particles

(D) none of the above

Q5 A uniform square plate ABCD has a mass of $10\ \text{kg}$. If two point masses of $3\ \text{kg}$ each are placed at the corners C and D as shown in the adjoining figure, then the centre of mass shifts to the point which is lie on -

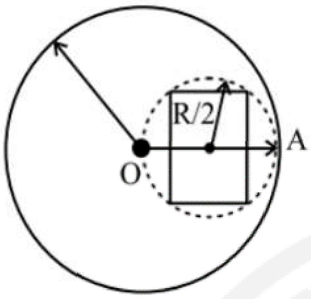


(A) OC

(B) OD

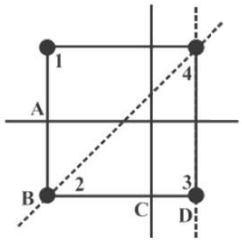
(C) OY
(D) OX

Q6 There is a thin uniform disc of radius R and mass per unit area σ, in which a hole of radius $\mathrm{R}/2$ has been cut out as shown in the figure. Inside the hole a square plate of same mass per unit area σ is inserted so that its corners touch the periphery of the hole. Find centre of mass of the system.



(A) $\frac{R[2+\pi]}{2[3\pi+2]}$
(B) $\frac{R[2-\pi]}{2[3\pi-2]}$
(C) $\frac{R[2-\pi]}{2[3\pi+2]}$
(D) $\frac{R[2-\pi]}{[3\pi+2]}$

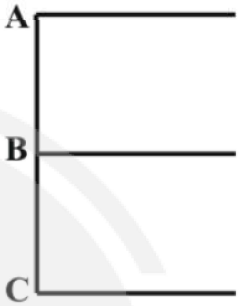
Q7 In the adjacent diagram, objects 1 and 2 each have mass m while objects 3 and 4 each have mass $2m$. Note four lines A, B, C and D. The center of mass of the system is most likely to be at the intersection of lines:



(A) A and B
(B) B and C
(C) A and D
(D) A and C

Q8 For particles of mass 5,3,2,4 kg are at the points $(1,6),(-1,5),(2,-3),(-1,-4)$. Find the coordinates of their centre of mass.
(A) $\left(\frac{2}{7},\frac{23}{14}\right)$
(B) $\left(\frac{1}{7},\frac{23}{14}\right)$
(C) $\left(\frac{2}{7},\frac{11}{14}\right)$
(D) $\left(\frac{1}{7},\frac{23}{3}\right)$

Q9 As shown in diagram there are five identical rods. Length of each rod is ℓ and mass m. Find out distance of C.O.M. of system From (C)

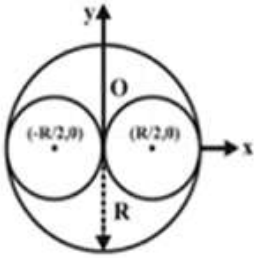


(A) $\ell\sqrt{\frac{109}{50}}$
(B) $\ell\sqrt{\frac{190}{50}}$
(C) $\ell\sqrt{\frac{190}{100}}$
(D) $\ell\sqrt{\frac{109}{100}}$

Q10 The position vectors of three particles of mass $\mathrm{m}_1=1\ \mathrm{kg},\ \mathrm{m}_2=2\ \mathrm{kg}$ and $\mathrm{m}_3=3\ \mathrm{kg}$ are $\vec{r}_1=(\hat{i}+4\hat{j}+\hat{k}),\vec{r}_2=(\hat{i}+\hat{j}+\hat{k})$ and $\vec{r}_3=(2\hat{i}-\hat{j}-2\hat{k})$ respectively. Find the position vector of their centre of mass.
(A) $1.5\hat{i}+0.5\hat{j}-0.5\hat{k}$
(B) $2.5\hat{i}+\hat{j}-\hat{k}$
(C) $2.0\hat{i}+\hat{j}-\hat{k}$
(D) $3.5\hat{i}+\hat{j}-\hat{k}$

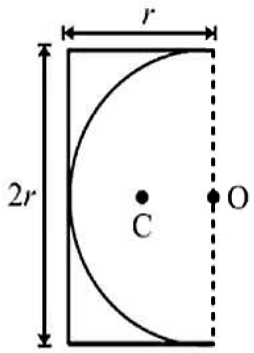
Q11 In the figure a uniform disc of radius R, from which a hole of radius $\mathrm{R}/2$ has been cut out from left of the centre and is placed on right of

the centre of disc. Find the centre of mass of the resulting disc.



(A) $\frac{R}{3}, 0$
(B) $\frac{R}{2}, 0$
(C) $\frac{R}{4}, 0$
(D) $\mathrm{R}, 0$

Q12 A semicircular portion of radius r is cut from a uniform rectangular plate as shown in figure. The distance of centre of mass C of remaining plate, from point O is

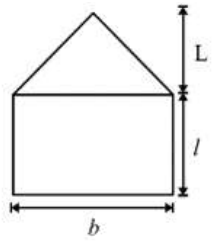


(A) $\frac{2r}{(3-\pi)}$
(B) $\frac{3r}{2(4-\pi)}$
(C) $\frac{2r}{(4+\pi)}$
(D) $\frac{2r}{3(4-\pi)}$

Q13 A circular disc of radius R is removed from a bigger circular disc of radius $2\mathrm{R}$ such that the circumferences of the discs coincide. The centre of mass of the new disc is $\alpha\mathrm{R}$ distance from the centre of the bigger disc. The value of α is

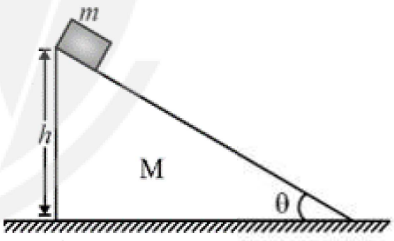
(A) $1/3$ (B) $1/2$
(C) $1/6$ (D) $1/4$

Q14 The figure shows a metallic plate of uniform thickness and density. The value of l in terms of L so that the centre of mass of the system lies at the interface of the triangular and rectangular portion is;



(A) $l = \frac{L}{3}$
(B) $l = \frac{L}{2}$
(C) $l = \frac{L}{\sqrt{3}}$
(D) $l = \sqrt{\frac{2}{3}}\,L$

Q15 A small block of mass m is placed at rest on the top of a smooth wedge of mass M, which in turn is placed at rest on a smooth horizontal surface as shown in figure. If h be the height of wedge and θ is the inclination, then the distance moved by the wedge as the block reaches the foot of the wedge is



(A) $\frac{Mh\cot\theta}{M+m}$
(B) $\frac{mh\cot\theta}{M+m}$
(C) $\frac{Mh\,\mathrm{cosec}\,\theta}{M+m}$
(D) $\frac{mh\,\mathrm{cosec}\,\theta}{M+m}$

Q16 Three identical particles with velocities, $v_0\,\hat{i}$, $-3v_0\,\hat{j}$ and $5v_0\,\hat{k}$ collide successively with each other in such a way that they form a single particle. The velocity vector of resultant particle is

(A) $\frac{v_0}{3}(\hat{i}+\hat{j}+\hat{k})$
(B) $\frac{v_0}{3}(\hat{i}-\hat{j}+\hat{k})$
(C) $\frac{v_0}{3}(\hat{i}-3\hat{j}+\hat{k})$
(D) $\frac{v_0}{3}(\hat{i}-3\hat{j}+5\hat{k})$

Q17 Two particles A and B initially at rest move towards each other under a mutual force of attraction. At the instant when velocity of A is v and that of B is $2v$ the velocity of center of mass of the system
(A) v (B) $2v$
(C) $3v$ (D) zero

Q18 A $2\ \mathrm{kg}$ body and a $3\ \mathrm{kg}$ body are moving along the x-axis. At a particular instant the $2\ \mathrm{kg}$ body has a velocity of $3\ \mathrm{m/s}$ and the $3\ \mathrm{kg}$ body has the velocity of $2\ \mathrm{m/s}$. The velocity of the centre of mass at that instant is
(A) $5\ \mathrm{m/s}$
(B) $1\ \mathrm{m/s}$
(C) zero
(D) $2.4\ \mathrm{m/s}$

Q19 If two particles of masses $3\ \mathrm{kg}$ and $6\ \mathrm{kg}$ which are at rest are separated by a distance of $15\ \mathrm{m}$. The two particles are moving towards each other under a mutual force of attraction. Then the ratio of distance travelled by the particles before collision is
(A) $2:1$
(B) $1:2$
(C) $1:3$
(D) $3:1$

Q20 Two bodies of $6\ \mathrm{kg}$ and $4\ \mathrm{kg}$ masses have their velocity $(5\hat{i}-2\hat{j}+10\hat{k})$ and $(10\hat{i}-2\hat{j}+5\hat{k})$ respectively. Then the velocity of their centre of mass is
(A) $5\hat{i}+2\hat{j}-8\hat{k}$
(B) $7\hat{i}+2\hat{j}-8\hat{k}$
(C) $7\hat{i}-2\hat{j}+8\hat{k}$
(D) $5\hat{i}-2\hat{j}+8\hat{k}$

Q21 A body of mass $50\ \mathrm{kg}$ is standing at one end of a boat of length $9\ \mathrm{m}$ and mass $400\ \mathrm{kg}$. He runs to the end The distance through, which the centre of mass of the boat boy system moves is
(A) zero
(B) $1\ \mathrm{m}$
(C) $2\ \mathrm{m}$
(D) $3\ \mathrm{m}$

Q22 Two blocks of masses $10\ \mathrm{kg}$ and $4\ \mathrm{kg}$ and are connected by a spring of negligible mass and placed on a frictionless horizontal surface. An impulse gives a velocity of $14\ \mathrm{m/s}$ to the heavier block in the direction of the lighter block. The velocity of the centre of mass is
(A) $4\ \mathrm{m/s}$
(B) $10\ \mathrm{m/s}$
(C) $14\ \mathrm{m/s}$
(D) $6\ \mathrm{m/s}$

Q23 A dog weighing $5\ \mathrm{kg}$ is standing on a flat boat such that it is 10 metres from the shore. It walks $4\ \mathrm{m}$ on the boat towards the shore and then halts. The boat weighs $20\ \mathrm{kg}$ and one can assume that there is no friction between it and water. The dog from the shore at the end of this time is
(A) $3.4\ \mathrm{m}$
(B) $6.8\ \mathrm{m}$
(C) $12.6\ \mathrm{m}$
(D) $10\ \mathrm{m}$

Q24 Two blocks of masses $3\ \mathrm{m}$ and m are connected by a massless and inextensible string which passes over a massless and frictionless pulley. Calculate the magnitude of acceleration of

centre of mass of the system when the blocks are allowed to accelerate, given $g = 10\ \mathrm{m/s^2}$

(A) $5\ \mathrm{m/s^2}$

(B) $2.5\ \mathrm{m/s^2}$

(C) $2\ \mathrm{m/s^2}$

(D) Zero

Q25 A boat of mass $40\ \mathrm{kg}$ is at rest A dog of mass $4\ \mathrm{kg}$ moves in the boat with velocity of $10\ \mathrm{m/s}$. What is the velocity of boat (nearly)?

(A) $4\ \mathrm{m/s}$

(B) $2\ \mathrm{m/s}$

(C) $8\ \mathrm{m/s}$

(D) $1\ \mathrm{m/s}$

Q26 A shell is fired from a cannon with a velocity v at the angle θ with the horizontal direction. At the highest point of its path, it explodes into two pieces of equal mass. One of the pieces retraces its path to the cannon and the speed of the other piece immediately after explosion is

(A) $3v\cos\theta$

(B) $2v\cos\theta$

(C) $\frac{3}{2}v\cos\theta$

(D) $\frac{\sqrt{3}}{2}v\cos\theta$

Q27 A gun (mass = M) fires a bullet (mass = m) with speed v relative to barrel of the gun which is inclined at an angle of 60° with horizontal. The gun is placed over a smooth horizontal surface. Find the recoil speed of gun.

(A) $\frac{Mv_r}{2(M+m)}$

(B) $\frac{mv_r}{2(M+m)}$

(C) $\frac{Mv_r}{2M}$

(D) $\frac{mv_r}{2m}$

Q28 Mr. Verma $(50\ \mathrm{kg})$ and Mr. Mathur $(60\ \mathrm{kg})$ are sitting at the two extremes of a $4\ \mathrm{m}$ long boat ($40\ \mathrm{kg}$) standing still in water. To discuss a mechanics problem, they come to the middle of the boat. Neglecting friction with water, how far does the boat move on the water during the process?

(A) $13\ \mathrm{cm}$ (Right)

(B) $13\ \mathrm{cm}$(Left)

(C) $10\ \mathrm{cm}$ (Right)

(D) $10\ \mathrm{cm}$(Left)

Q29 A projectile is fired at a speed of $100\ \mathrm{m/s}$ at an angle of 37° above the horizontal. At the highest point, the projectile breaks into two parts of mass ratio $1:3$, the lighter piece comes to rest. Find the distance from the launching point to the point where the heavier piece lands.

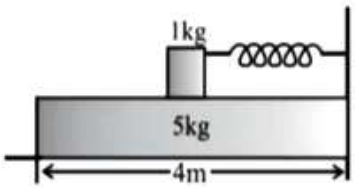
(A) $1100\ \mathrm{m}$

(B) $1110\ \mathrm{m}$

(C) $1120\ \mathrm{m}$

(D) $1105\ \mathrm{m}$

Q30 A plank of mass $5\ \mathrm{kg}$ placed on a frictionless horizontal plane. Further a block of mass $1\ \mathrm{kg}$ is placed over the plank. A massless spring of natural length $2\ \mathrm{m}$ is fixed to the plank by its one end. The other end of spring is compressed by the block by half of springs natural length. The system is now released from the rest. What is the velocity of the plank when block leaves the plank? (The stiffness content of spring is $100\ \mathrm{N/m}$)



(A) $\sqrt{\frac{5}{3}}\ \mathrm{m/s}$

(B) $\sqrt{\frac{10}{3}}\ \mathrm{m/s}$

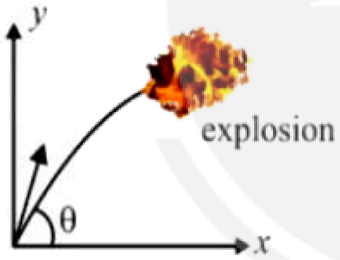
(C) $\sqrt{\frac{7}{3}}\ \mathrm{m/s}$

(D) $\sqrt{\frac{2}{3}}\ \mathrm{m/s}$

Q31 Three interacting particles of masses $100\ \text{g}, 200\ \text{g}$ and $400\ \text{g}$ each have a velocity of $20\ \text{m/s}$ magnitude along the positive direction of x-axis, y-axis and z-axis. Due to force of interaction the third particle stops moving. The velocity of the second particle is $(10\hat{j} + 5\hat{k})$. What is the velocity of the first particle?

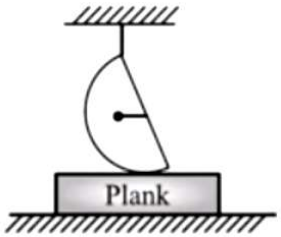
(A) $20\hat{i} + 20\hat{j} + 70\hat{k}$
(B) $10\hat{i} + 20\hat{j} + 8\hat{k}$
(C) $30\hat{i} + 10\hat{j} + 7\hat{k}$
(D) $15\hat{i} + 5\hat{j} + 60\hat{k}$

Q32 A projectile is projected in $x - y$ plane with velocity vo. At top most point of its trajectory projectile explodes into two identical fragments. Both the fragments land simultaneously on ground and stick there. Taking point of projection as origin and R as range of projectile if explosion had not taken place. Which of the following cannot be position vectors of two pieces, when they land on ground?



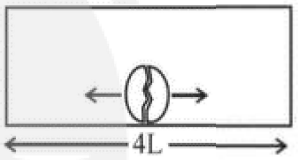
(A) $\frac{R}{2}\hat{i}, \frac{3R}{2}\hat{i}$
(B) $0\hat{i}, 2R\hat{i}$
(C) $R\hat{i} - R\hat{k}, R\hat{i} + R\hat{k}$
(D) $2R\hat{i} + \frac{R}{2}\hat{k}, R\hat{i} - \frac{R}{2}\hat{k}$

Q33 Lower surface of a plank is rough and lying at rest on a rough horizontal surface. Upper surf ace of the plank is smooth and has a smooth hemisphere placed over it through a light string as shown in the figure. After the string is burnt, trajectory of center of mass of the sphere is



(A) a circle
(B) an ellipse
(C) a straight line
(D) a parabola

Q34 A bomb of mass $3\ \text{m}$ is kept inside a closed box of mass $3\ \text{m}$ and length $4\ \text{L}$ at its centre. It explodes in, two parts of mass $m\&2\ \text{m}$. The two parts move in opposite direction and stick to the opposite side of the walls of box. Box is kept on a smooth horizontal surface. What is the distance moved by the box during this time interval?



(A) $\frac{L}{3}$ (Right direction)
(B) $\frac{L}{3}$ (Left direction)
(C) $\frac{L}{2}$ (Right direction)
(D) $\frac{L}{2}$ (Left direction)

Q35 Two particles of masses $2\ \text{kg}$ and $4\ \text{kg}$ are projected from the top of a tower simultaneously such that $2\ \text{kg}$ is with speed $20\ \text{m/s}$ at an angle 30° above horizontal and $4\ \text{kg}$ is with $40\ \text{m/s}$ horizontally. Acceleration of the centre of mass of the system of two particles is;

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

Answer Key

Q1	(A)
Q2	(B)
Q3	(B)
Q4	(C)
Q5	(C)
Q6	(C)
Q7	(D)
Q8	(B)
Q9	(D)
Q10	(A)
Q11	(C)
Q12	(D)
Q13	(A)
Q14	(C)
Q15	(B)
Q16	(D)
Q17	(D)
Q18	(D)
Q19	(A)
Q20	(C)
Q21	(A)
Q22	(B)
Q23	(B)
Q24	(B)
Q25	(D)
Q26	(A)
Q27	(B)
Q28	(A)
Q29	(C)
Q30	(B)
Q31	(A)
Q32	(D)
Q33	(C)
Q34	(B)
Q35	(C)