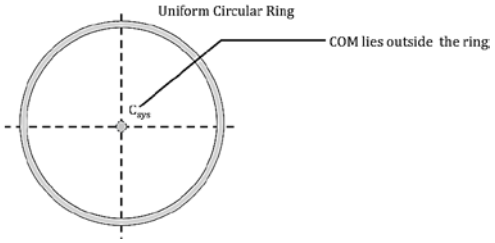
Chapter 10

Center of Mass Exercise

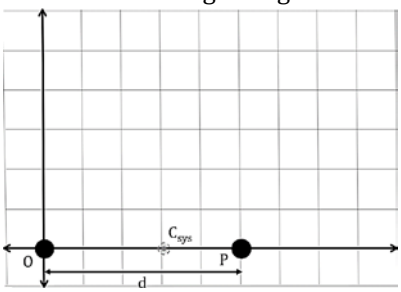
Position of CM

Q.1 Which of the following statements is incorrect?



(A) Centre of mass of the body can lie within the body
(B) Centre of mass of a two-particle system of equal masses lies at the midpoint joining the two masses
(C) Centre of mass of a body must not lie outside the body.
(D) Centre of mass of a symmetric body lies at the geometric centre

Q.2 Which of the following statements is correct regarding the COM of a two-mass system?



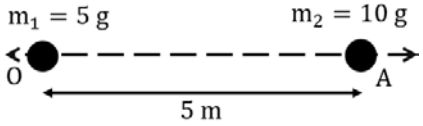
(A) If masses are real, centre of mass always lies at the midpoint joining the two masses
(B) Centre of mass divides internally the line joining the two masses in the ratio of their masses
(C) Centre of mass divides externally the line joining the two masses in the ratio of their masses
(D) Centre of mass divides internally the line joining the two masses in the inverse ratio of their masses

Q.3 The position vector of four particles of masses $m_1 = 2$ kg, $m_2 = 4$ kg, $m_3 = 6$ kg, $m_4 = 8$ kgare $\overrightarrow{r_1} = 2\hat{i} + 3\hat{j} + 0\hat{k}$, $\overrightarrow{r_2} = 0\hat{i} + 2\hat{j} + 3\hat{k}$, $\overrightarrow{r_3} = 2\hat{i} + 0\hat{j} + 3\hat{k}$, $\overrightarrow{r4} = 2\hat{i} + 3\hat{j} + 3\hat{k}$. The position vector of their centre of mass is given by

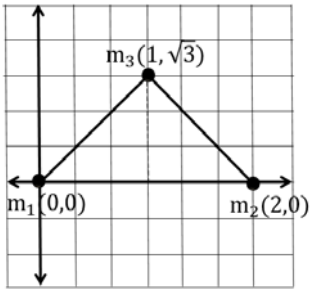
(A) $\frac{16\hat{i}+19\hat{j}+27\hat{k}}{11}$ **(B)** $1.6\hat{i} + 1.9\hat{j} + 2.7\hat{k}$ **(C)** $8\hat{i} + 9\hat{j} + 13\hat{k}$ **(D)**$\frac{32\hat{i}+38\hat{j}+54\hat{k}}{11}$

Q.4 Two masses 5 g and 10 g are placed along x − axis as shown in figure. Then, the distance of the COM of the two-particle system from the 5 g mass is

(A) $\frac{5}{3}$m **(B)** $\frac{10}{3}$m **(C)** 5 m **(D)**2.5



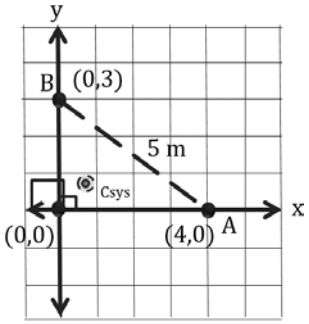
Q.5 Three particles of masses 50 g, 100 g and 150 g are placed at the vertices of an equilateral triangle of side 2 m as shown in figure. The (x, y) co-ordinates of the centre of mass (in m) will be



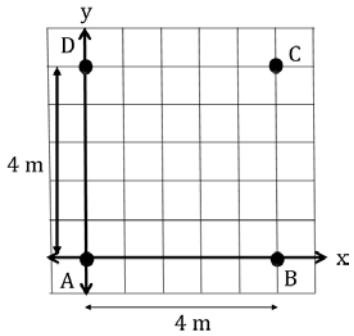
(A) $(\frac{7}{6},\frac{\sqrt{3}}{2})$ **(B)** $(\frac{7}{12},\frac{\sqrt{3}}{4})$ **(C)** $(\frac{7}{3},\sqrt{3})$ **(D)** $(\frac{7}{12},\frac{\sqrt{3}}{2})$

Q.6 Three particles A, B and C of masses 2 kg, 3 kg and 5 kg are placed at the vertices of a scalene triangle as shown in figure. Find the location of COM of the three particle system

(A) $(\frac{4}{5},\frac{9}{10})$m **(B)** $(\frac{9}{10},\frac{4}{5})$m **(C)** $(\frac{4}{5},\frac{4}{5})$m **(D)** $(\frac{9}{10},\frac{9}{10})$m



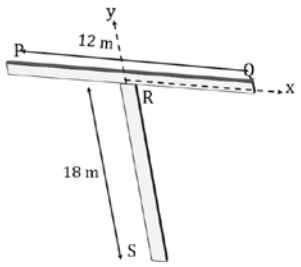
Q.7 Four point masses 2 kg, 3 kg, 5 kg and 7 kg respectively are placed at the four corners A, B, C and D of a square of side 4 m. The position of COM will be



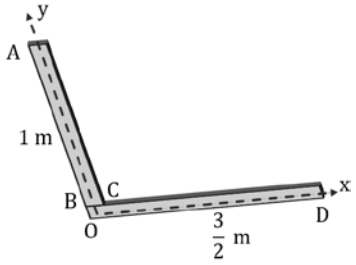
(A) $(\frac{48}{17},\frac{32}{17})$m **(B)** $(\frac{32}{17},\frac{48}{17})$m **(C)** (2,4)m **(D)** (2,2)m

Q.8 Two rods PQ and RS of identical mass and lengths 12 cm and 18 cm are joined to form a T −shaped frame as shown in figure. If the centre of mass of a rod is at the mid point of the rod, the location of centre of mass of the T −shape frame (w.r.t pointR) is

(A) $(0,-9)$cm **(B)** $(0,-4.5)$cm **(C)** $(-4.5,0)$cm **(D)** $(4.5,-4.5)$cm

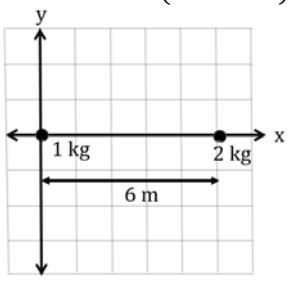


Q.9 Two rods AB and CD of the same mass and lengths 1 m and $\frac{3}{2}$ m are joined at 'O' to form anL −shaped frame AOD as shown in figure. Assuming COM of a rod is at the mid point of the rod, the location of centre of mass of the L −shaped frame from the point of intersection 'O' is



(A) $(\frac{3}{8},\frac{3}{8})$m **(B)** $(\frac{1}{4},\frac{1}{4})$m **(C)** $(\frac{1}{4},\frac{3}{8})$m **(D)** $(\frac{3}{8},\frac{1}{4})$m

Q.10 Two point particles of masses 1 kg and 2 kg are placed on an axis as shown in figure. The distance of COM of the system from the 1 kg mass would be (in meters)



WORK SHEET

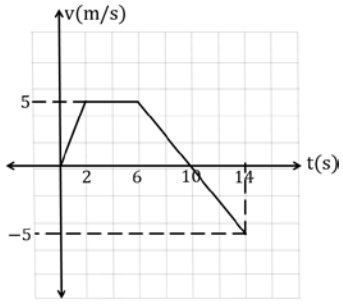
VECTOR

Q.1 Given that $\vec{A}+\vec{B}=\vec{C}$. If $|\vec{A}|=4$, $|\vec{B}|=5$ and $|\vec{C}|=\sqrt{61}$, then angle between $\vec{A}$ and $\vec{B}$ is:

(A) 30° **(B)** 60° **(C)** 90° **(D)**120°

V –t – Graph

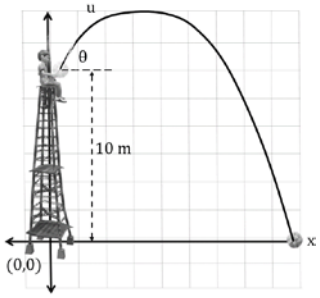
Q.2 The variation in velocity of a particle moving along a straight line is shown in the figure. If the particle is moving along x –axis with initial position x = 10 m, find the final position of particle.



(A) 35 m **(B)** 25 m **(C)** 45 m **(D)**55 m

Equation of Trajectory

Q.3 A particle is projected upwards at an angle $\theta=45°$ with horizontal from the top of a tower 10 m high. Assume the origin is situated at the bottom of the tower and the speed at which the particle is projected is $40\sqrt{2}$ m/s. Find the equation trajectory of the particle.



(A) $y=x-\frac{x^2}{320}$ **(B)** $y=x-\frac{x^2}{320}-10$ **(C)** $y=x-\frac{x^2}{320}+10$ **(D)**$y=x+\frac{x^2}{320}-10$

River-Boat Problem

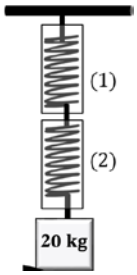
Q.4 A boat running upstream takes 7 hr to cover a certain distance, while it takes 4 hr to cover the same distance running downstream. What is ratio of the speed of boat is still water to the speed of water current?

(A) 11: 3 **(B)** 3: 2 **(C)** 7: 3 **(D)**Can't be determined

Spring Balance

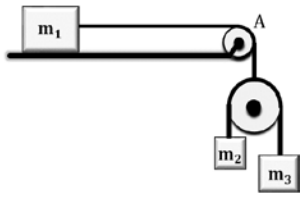
Q.5 A block of mass 20 kg is suspended through two light spring balances as shown in figure. Calculate the reading of spring balance (1) and (2) respectively.

(A) 200 N, 400 N **(B)** 400 N, 200 N **(C)** 0 N, 200 N **(D)**200 N, 200 N



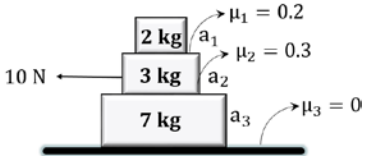
Acceleration

Q.6 An arrangement of pulley, string and blocks is shown in figure. Given $m_1 = 4$ kg, $m_2 = 2$ kg and $m_3 = 4$ kg. All surfaces are frictionless, string and pulleys are massless. Find the acceleration of block m_1. Assume $g = 10\ m/s^2$.



(A) $\frac{36}{11}\ m/s^2$ **(B)** $\frac{40}{11}\ m/s^2$ **(C)** $\frac{36}{7}\ m/s^2$ **(D)** $\frac{40}{7}\ m/s^2$

Q.7 Find the accelerations a_1, a_2 and a_3 of the three blocks as shown in figure, if a horizontal force of 10 N is applied on the 3 kg block. The coefficient of static friction (μ) for all contact surfaces are shown in the figure. Take $g = 10\ m/s^2$.



(A) $a_1 = a_2 = a_3 = \frac{5}{6}\ m/s^2$ **(B)** $a_1 = \frac{10}{3}\ m/s^2, a_2 = \frac{5}{6}\ m/s^2, a_3 = \frac{10}{3}\ m/s^2$

(C) $a_1 = \frac{10}{3}\ m/s^2, a_2 = \frac{10}{3}\ m/s^2, a_3 = \frac{5}{6}\ m/s^2$ **(D)** $a_1 = \frac{5}{6}\ m/s^2, a_2 = \frac{5}{6}\ m/s^2, a_3 = \frac{10}{3}\ m/s^2$

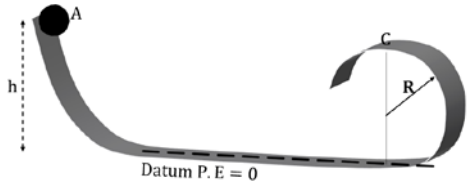
Work Done

Q.8 Three Constant forces $\vec{F}_1 = (2\hat{i} - 3\hat{j} + 2\hat{k})$ N, $\vec{F}_2 = (\hat{i} + \hat{j} - \hat{k})$ N and $\vec{F}_3 = (3\hat{i} - \hat{j} - 2\hat{k})$ N displaces a particle from $(1, -1, 2)$ m to $(-1, -1, 3)$ m and then to $(2, 3, 4)$ m ,displacement being measured in meters. Find the total work done by the forces

(A) $\sqrt{40}$J **(B)** 0J **(C)** $\sqrt{50}$ J **(D)** 24J

Energy Conservation

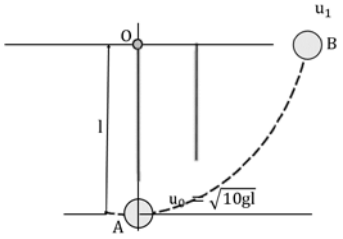
Q.9 A ball of mass m is released from rest at A as shown in the figure. Find the minimum height h, so that ball will just complete the circular motion on the track (all surfaces are smooth).



(A) $h = 2R$ **(B)** $h = 4R$ **(C)** $h = R$ **(D)** $h = \frac{5}{2}R$

Velocity

Q.10 A body of certain mass is tied to one end of a light string of length l, whose other end is fixed at point O. The body is given a speed of $\sqrt{10gl}$ from the lowermost position A. Find the magnitude of change in velocity of body, while moving from position A to B as shown in figure.



(A) $\sqrt{gl}$ m/s **(B)** $\sqrt{7gl}$ m/s **(C)** $\sqrt{18gl}$ m/s **(D)** $\sqrt{9gl}$ m/s

Position of COM

Q.11 A rigid body consists of a 3 kg mass connected to 4 kg mass by a massless rod. The 3 kg mass is located at $\overrightarrow{r_1} = (3\hat{i} + 2\hat{j})$ m and the 4 kg mass at $\overrightarrow{r_2} = (8\hat{i} + 7\hat{j})$ m. Find he length of the rod and the co-ordinates of the center of mass

(A) 5m, $(\frac{41}{7}, \frac{34}{7})$m **(B)** $5\sqrt{2}$m, $(\frac{41}{7}, \frac{34}{7})$m **(C)** 5m, (6.5,0)m **(D)** $5\sqrt{2}$m, (5,0)m

Q.12 Three particles of masses 2 kg, 3 kg and 5 kg are placed at the three vertices A, B, C of a right-angled triangle, respectively. Co-ordinates of the particles are A(0, 3), B(0, 0) and C(3, 0). Find the position of center of mass of particles.

(A) (1,1) **(B)** (2,1) **(C)** (1.5,0.6) **(D)** (1.5,1.6)

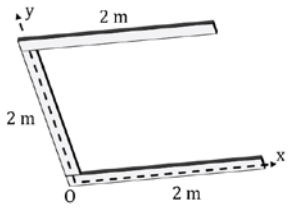
Q.13 Two particles of masses m_1 and m_2 are located at x = 0 m and x = 6 m.If the position of their center of mass is at x = 4 m, then the ratio of their masses $\frac{m_2}{m_1}$ is

(A) 2 **(B)** 1 **(C)** 4 **(D)** 3

Q.14 The position vector of four identical masses of mass 1 kg each are $\vec{r}_1 = (\hat{i} + 2\hat{j} + 7\hat{k})$, $\vec{r}_2 = (3\hat{i} + 5\hat{j} + \hat{k})$, $\vec{r}_3 = (6\hat{i} + 2\hat{j} + 3\hat{k})$ and $\vec{r}_4 = (2\hat{i} - \hat{j} + 5\hat{k})$. Find the position vector of their center of mass.

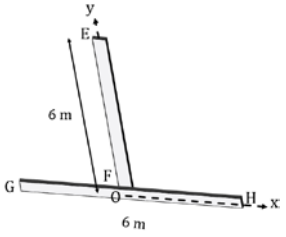
(A) $(2\hat{i} + 3\hat{j} + 4\hat{k})$ **(B)** $(4\hat{i} + 3\hat{j} + 2\hat{k})$ **(C)** $(3\hat{i} + 4\hat{j} + 2\hat{k})$ **(D)** $(3\hat{i} + 2\hat{j} + 4\hat{k})$

Q.15 The position vector $(\vec{r})$ of the center of mass of a uniform bar made up of three rods each having length 2 m and negligible area of cross-section as shown in figure is (Assuming masses of the rods are equal)



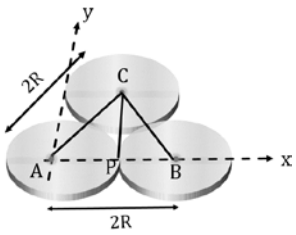
(A) (2m, 2m) **(B)** $(\frac{2}{3}$m, 2m) **(C)** (1m, 1m) **(D)** $(\frac{2}{3}$m, 1m)

Q.16 Two identical uniform rods EFand GH, each of length L = 6 cm are joined as shown in figure. Locate the center of mass of the frame. [Point O, which is the point where the axes of the rods meet is the origin]



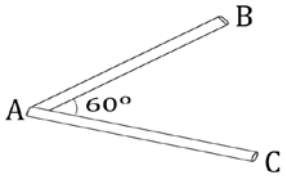
(A) $(0\text{ m}, 0\text{ m})$ **(B)** $(0\text{ m}, 1\text{ m})$ **(C)** $(0\text{ m}, 1.5\text{ m})$ **(D)** $(0\text{ m}, 2\text{ m})$

Q.17 Three identical circular plates of radius R each are placed on a horizontal surface touching one another as shown in the figure. If the circle with the center C is removed, the y coordinate of the center of mass of the system is [Consider A to be at the origin]



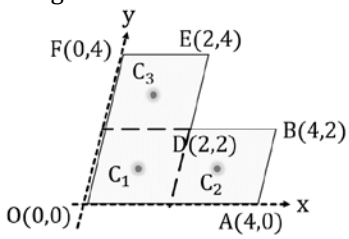
(A) $\frac{R}{3}$ **(B)** $\frac{R}{\sqrt{3}}$ **(C)** $\sqrt{3R}$ **(D)** R

Q.18 A uniform wire of length $L = 1$ m is bent into the shape V as shown in figure. The distance of its center of mass from the vertex A is.



(A) $\frac{\sqrt{3}}{8}$ m **(B)** $\frac{\sqrt{3}}{4}$ m **(C)** $\frac{\sqrt{3}}{2}$ m **(D)** $\frac{\sqrt{3}}{18}$ m

Q.19 Find the center of mass of a uniform L shaped lamina (a thin flat plate with dimensions as shown in figure. The mass of the lamina is 6 kg.



(A) $(\frac{5}{6}, \frac{5}{6})$m **(B)** $(\frac{5}{2}, \frac{5}{2})$m **(C)** $(\frac{5}{3}, \frac{5}{3})$m **(D)** $(\frac{5}{4}, \frac{5}{4})$m

Q.20 The centre of mass of a system of three particles of masses 2 g, 3 g and 5 g is taken as the origin of a coordinate system. The position vector of a fourth particle of mass8 g, such that the centre of mass of the four-particle system lies at the point (3,4,7) m, is $\lambda(3\hat{i} + 4\hat{j} + 7\hat{k})$ m where λ a constant is. Then the value of $\lambda =$ _____ (Answer up to two decimal places)

ANSWER KEY

Q.	1	2	3	4	5	6	7	8	9	10
Sol.	(C)	(D)	(B)	(B)	(A)	(A)	(B)	(B)	(D)	4 m
WORK SHEET										
Q.	1	2	3	4	5	6	7	8	9	10
Sol.	(B)	(A)	(C)	(A)	(D)	(D)	(A)	(B)	(D)	(C)
Q.	11	12	13	14	15	16	17	18	19	20
Sol.	(B)	(C)	(A)	(D)	(D)	(C)	(B)	(A)	(C)	2.25