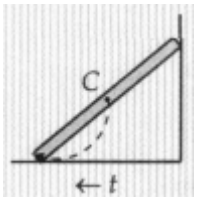
CBSE

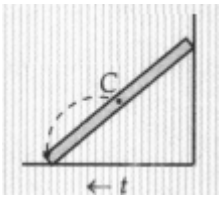
SYSTEM OF PARTICLES AND ROTATIONAL MOTION WS 1

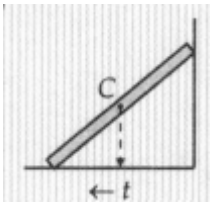
Class 11 - Physics

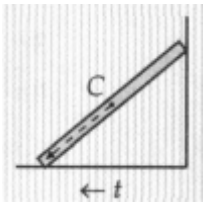
Section A

1. A ladder is leaned against a smooth wall and it is allowed to slip on a frictionless floor. Which figure represents trace of its centre of mass? **[1]**

a) 

b) 

c) 

d) 

2. Four particles of mass 2 kg, 3 kg, 4 kg and 8 kg are situated at the corners of a square of side length 2m. The centre of mass may be given as **[1]**

a) $\left(\frac{14}{17}, \frac{24}{17}\right)$

b) $\left(\frac{34}{18}, \frac{34}{18}\right)$

c) $\left(\frac{20\sqrt{2}}{18}, \frac{24\sqrt{2}}{18}\right)$

d) $\left(\frac{30}{18}, \frac{28}{18}\right)$

3. Let r_i be the position vector of the i^{th} particle having mass m_i and R be the position vector of the centre of mass. **[1]**

The formula for R is:

a) $\mathbf{R} = \frac{\sum^{m_1} \mathbf{r_i}}{\sum^{m_1}}$

b) $\mathbf{R} = \frac{\sum^{m_1} \mathbf{r_i}}{\sum^{m_3}}$

c) $\mathbf{R} = \frac{\sum^{m_1} \mathbf{r_i}}{\sum^{m_2}}$

d) $R = \frac{\sum m_1 \cdot r_i}{\sum m_1}$

4. The centre of mass of a solid cone along the line from the centre of the base to the vertex is at **[1]**

a) one-fifth of the height

b) one-fourth of the height

c) one-eight of the height

d) one-third of the height

5. 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 **[1]**

a) line joining centres of any two balls

b) point of intersection of the medians

c) centre of one of the balls

d) horizontal surface

6. Two bodies of different masses of 2 kg and 4 kg moving with velocities 2 m/s and 10 m/s towards each other due to mutual gravitational attraction. What is the velocity of their centre of mass? **[1]**

a) 6 m/s

b) 8 m/s

c) 5 m/s

d) zero

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

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

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

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

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

8. If a body moves through a distance greater than $2\pi R$ in one full rotation, then **[1]**

a) $v_{cm} \leq R\omega$

b) $v_{\text{cm}} > R\omega$

c) $v_{cm} < R\omega$

d) $v_{cm} \geq R\omega$

9. Three masses are placed on the x-axis: 300 g at origin, 500 g at x = 40 cm and 400 g at x = 70 cm. The distance of the centre of mass from the origin is **[1]**

a) 30 cm

b) 40 cm

c) 45 cm

d) 50 cm

10. A solid sphere is rotating freely about its symmetry axis in free space. The radius of the sphere is increased keeping its mass the same. Which of the following physical quantities would remain constant for the sphere? **[1]**

a) Angular velocity

b) Angular momentum

c) Rotational kinetic energy

d) Moment of inertia

11. Three masses of 2 kg, 4 kg and 4 kg are placed at the three points (1, 0, 0), (1, 1, 0) and (0, 1, 0) respectively. The position vector of its centre of mass is **[1]**

a) $\frac{2}{5}\hat{i} + \frac{4}{5}\hat{j}$

b) $\frac{1}{5}\hat{i} + \frac{3}{5}\hat{j}$

c) $\frac{3}{5}\hat{i} + \frac{4}{5}\hat{j}$

d) $(3\hat{i} + \hat{j})$

12. Two bodies, A and B initially, at rest, move towards each other under mutual force of attraction. At the instant when the speed of A is v and that of B is 2v, the speed of the centre of mass of the bodies is **[1]**

a) 2v

b) 3v

c) zero

d) 1.5v

13. **Assertion:** If all particles of a system lie in a cube, the centre of mass would necessarily be in the cube. **[1]**
Reason: For a uniform, symmetric body, the center of mass is necessarily within the matter of the body.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement.

14. **Assertion (A):** A shell at rest, explodes. The centre of mass of fragments moves along a straight path. **[1]**
Reason (R): In explosion the linear momentum of the system remains always conserved.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

15. **Assertion (A):** The centre of mass of a proton and an electron, related from their respective positions remains at rest. **[1]**

Reason (R): The centre of mass remain at rest, if no external force is applied.

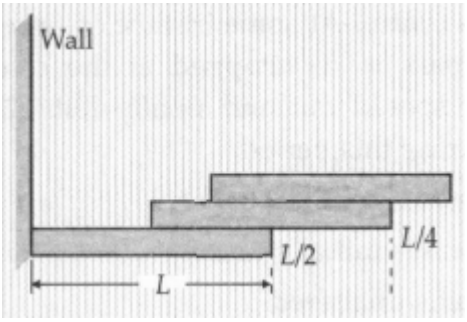
a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

16. Three bricks each of length L and mass M are arranged as shown from the wall. The distance of the centre of mass of the system from the wall is **[1]**



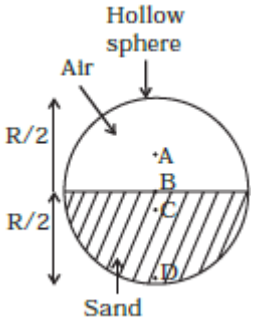
a) $\frac{3}{2}$L

b) $\frac{L}{4}$

c) $\frac{11}{12}$L

d) $\frac{L}{2}$

17. Which of the following points is the likely position of the centre of mass of the system shown in Figure ? **[1]**



a) C

b) B

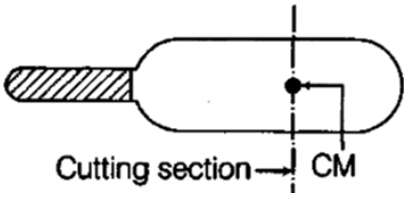
c) A

d) D

18. Can the mass of body be taken to be concentrated at its centre of mass for the purpose of calculating its rotational inertia? **[1]**

19. Where does the centre of mass of uniform triangular lamina lie? **[1]**

20. A cricket bat is cut through its centre of mass into two parts as shown **[1]**



Then, state whether both parts are of same mass or not. Also, give reason.

21. Why is centre of mass of a body often called its centre of gravity? **[1]**

22. How much is the torque due to gravity on a body about its centre of mass? **[1]**

23. Give an example each for a body, where the centre of mass lies inside the body and outside the body. **[1]**

24. On what factors, does the position of centre of mass of a rigid body depend? **[1]**

25. Write two factors on which centre of mass of a body does not depend. **[1]**

26. Should there necessarily be any mass at centre of mass of system? **[1]**

27. A labourer standing near the top of an old wooden step ladder feels unstable. Why? **[1]**

28. Define centre of mass of a system. **[1]**

29. Does the centre of mass of a solid necessarily lie within the body? If not, give an example. **[1]**

30. If two particles of masses m_1 and m_2 move with velocities v_1 and v_2 towards each other on a smooth horizontal table, what is the velocity of their centre of mass? **[1]**

31. A man climbs a tall, old step ladder that has a tendency to sway. He feels much more unstable when standing near the top than when near the bottom. Why? **[1]**

32. Should the center of mass of a body necessarily lie inside the body? **[1]**

Section B

33. Find the moment of inertia of the hydrogen molecule about an axis passing through its centre of mass and perpendicular to the internuclear axis. Given mass of H-atom = 1.7×10^{-27} kg, interatomic distance = 4×10^{10} m. **[2]**

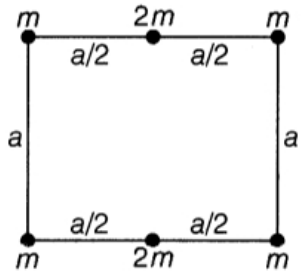
34. Two particles of masses 100 g and 300 g at a given time have positions $2\hat{i} + 5\hat{j} + 13\hat{k}$ and $-6\hat{i} + 4\hat{j} - 2\hat{k}$ respectively and velocities $10\hat{i} - 7\hat{j} - 3\hat{k}$ and $7\hat{i} - 9\hat{j} + 6\hat{k} ms^{-1}$ respectively. Determine the instantaneous position and velocity of CM. **[2]**

35. Prove that the centre of mass of two particles divides the line joining the particles in the inverse ratio of their masses. **[2]**

36. In which case centre of mass of a body lie outside it? Give one example. **[2]**

37. How is it possible to describe the motion of a big system when Newton's laws of motion are applicable for individual particles of the system? **[2]**

38. Six particles are placed at different points of a square as shown in the figure. Find the centre of mass for the system of six particles. **[2]**



39. What is the advantage of the concept of centre of mass? **[2]**

40. Two men stand facing each other on two boats floating on still water at a distance apart. A rope is held at its ends by both. The two boats are found to meet always at the same point, whether each man pulls separately or both pull together, why? Will the time taken be different in the two cases? Neglect friction. **[2]**

41. What is meant by a particle, a system and internal and external forces? **[2]**

42. Three point masses of 1 kg, 2 kg and 3 kg lie at (1, 2), (0, -1) and (2, -3) respectively. Calculate the coordinates of the centre of mass of the system. **[2]**

43. Find the centre of mass of a triangular lamina. **[2]**

44. What is the importance of the study of centre of mass of a system in mechanics? **[2]**

Section C

45. **State True or False:** **[3]**

    (a) Centre of the mass of body lies toward the region of heavier mass. **[1]**

    (b) The centre of mass of a solid necessarily lie within the body . **[1]**

(c) A boat is likely to capsize if the persons in the boat stand up. **[1]**

46. **Fill in the blanks:** **[3]**

(a) The centre of mass of triangular lamina lies at its _____ **[1]**

(b) Centre of the mass of a body is a point where its whole _____ acts whereas its center of gravity is a point where its whole _____ acts. **[1]**

(c) The position vector of the centre of mass of a system of particles is the _____ of the position vectors of the particles, each particle making a contribution proportional to its _____. **[1]**

47. Define centre of mass of a n-particle system. State the coordinates of centre of mass of a n-particle system. **[3]**

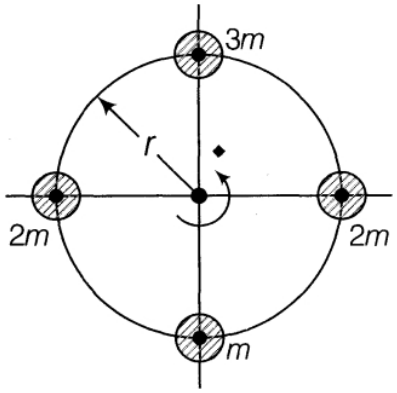
48. Find the centre of mass of three particles at the vertices of an equilateral triangle. The masses of the particles are 100g, 150g, and 200g respectively. Each side of the equilateral triangle is 0.5m long. **[3]**

49. From a uniform circular disc of diameter D, a circular disc or hole of diameter $\frac{D}{6}$ and having its centre at a distance of from the centre of the disc is scooped out. Determine the centre of mass of the remaining portion. **[3]**

50. A carpet of mass M made of inextensible material is rolled along its length in the form of a cylinder of radius R and is kept on a rough floor. The carpet starts unrolling without sliding on the floor when a negligibly small push is given to it. Calculate the horizontal velocity of the axis of the cylindrical part of the carpet when its radius reduces to $\frac{R}{2}$. **[3]**

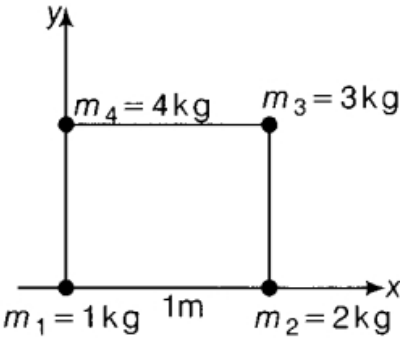
51. Find the centre of mass of a uniform L-shaped lamina (a thin flat plate) with dimensions as shown. The mass of the lamina is 3 kg. **[3]**

52. Four masses are rotated about an axis as shown. Find radius of gyration of the system. **[3]**



53. A boat of 90 kg is floating in still water. A boy of mass 30 kg walks from the stern to the bow. The Length of the boat is 3 m. Calculate the distance through which the boat will move. **[3]**

54. Four particles of mass 1 kg, 2 kg, 3 kg and 4 kg are placed at the four vertices A, B, C and D of square of side 1m. Find the position of centre of mass of the particle. **[3]**



55. If three point masses m_1, m_2 and m_3 are situated at the vertices of an equilateral triangle of side a, then what will be the co-ordinates of the centre of mass of this system? **[3]**

56. Show that the centre of mass of a Uniform rod of mass M and length L lies at the middle point of the rod. **[3]**

57. A rod of weight W is supported by two parallel knife edges A and B and is in equilibrium in a horizontal **[3]**

position. The distance between the knife edges is d and the centre of mass of the rod is at a distance x from A. Find the value of normal reactions at the knife edges A and B.

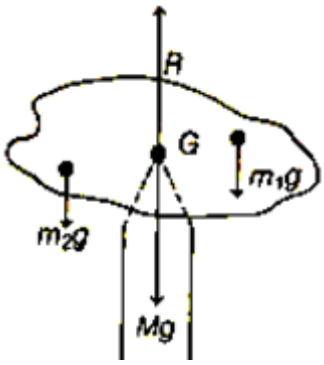
58. Determine the coordinates of the centre of mass of a uniform semicircular plate of radius R. **[3]**

Section D

Question No. 59 to 63 are based on the given text. Read the text carefully and answer the questions: **[5]**

The centre of gravity of a rigid body is a point through which the total weight of the body act. Centre of gravity can lie within the body or not. For small objects, centre of mass always coincides with centre of gravity. But in case of large bodies whose dimensions are comparable to the size of earth, centre of mass and centre of gravity will be at different locations.

In the given figure, balancing of a cardboard on the tip of a pencil is done. The point of support, G is the centre of gravity.



59. If the $F_{net, ext}$ is zero on the cardboard, it means

a) $m_1g = Mg$ b) $R = \frac{m_1}{g}$

c) $m_2g = M_g$ d) $R = Mg$

60. Choose the correct option.

a) Net τ due to m_1g, m_2g ... m_ng about CG = 0 b) All of these

c) τ_{M_0} about CG = 0 d) τ_R about CG = 0

61. The centre of gravity and the centre of mass of a body coincide when

a) g is negligible b) g is variable

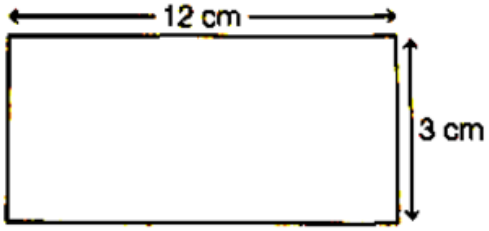
c) g is constant d) g is zero

62. If value of g varies, the centre of gravity and the centre of mass will

a) become same physical quantities b) not coincide

c) become different physical quantities d) coincide

63. Where will be the centre of gravity of the following rigid body?



a) (6, 1.5) b) (6, 6)

c) (1.5, 3) d) (6, 3)

64. Find the centre of mass of a uniform **[5]**

i. half-disc,

ii. quarter-disc.

65. Determine the coordinates of the centre of mass of a right circular solid cone of base radius R and height h. **[5]**

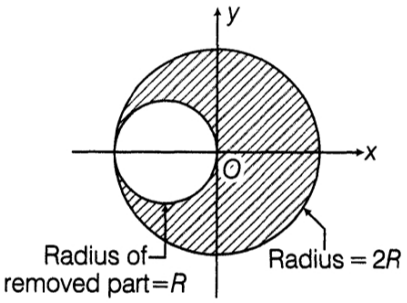
66. Determine the position of the centre of mass of a hemisphere of radius R. **[5]**

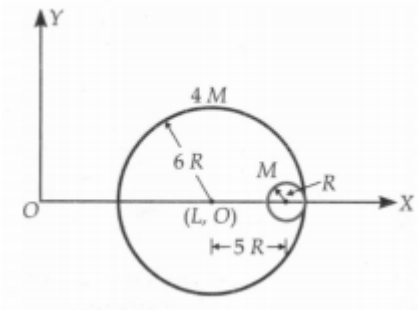
67. Determine the position of centre of mass of a uniform semicircular wire of radius R. **[5]**

68. Find position of centre of mass of a semicircular disc of radius r. **[5]**

69. A tube of length L is filled completely with an incompressible liquid of mass M and closed at both the ends. The tube is then rotated in a horizontal plane about one of its ends with a uniform angular velocity ω. Determine the force exerted by the liquid at the other end. **[5]**

70. A disc of radius R is removed from a disc of radius 2R as shown. **[5]**



Find centre of mass of above disc with hole.

71. A small sphere of radius R is held against the inner surface of a larger sphere of radius 6R (Fig.). The masses of large and small spheres are 4M and M, respectively. This arrangement is placed on a horizontal table. There is no friction between any surfaces of contact. The small sphere is now released. Find the co-ordinates of the centre of the larger sphere when the smaller sphere reaches the other extreme position. **[5]**