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Class: 11
Subject: Physics
Topic: Rotational Motion
No. of Questions: 20
Duration: 60 Min
Maximum Marks: 60

1. Two bodies of different masses 2kg and 4kg are moving with velocities 2m/s and 10m/s towards each other due to mutual gravitational attraction. Then the velocity of the centre of mass is
   a. $5ms^{-1}$
   b. $6ms^{-1}$
   c. $8ms^{-1}$
   d. Zero

   Ans. D
   Solution:
   Mutual force of attraction is an Internal force

2. Two particles of masses 4kg and 6kg are at rest separated by 20m. If they move towards each other under mutual force of attraction, the position of the point where they meet is
   a. 12m from 4kg body
   b. 12m from 6kg body
   c. 8m from 4kg body
   d. 10m from 4kg body

   Ans. A
   Solution:
   $$X = \frac{m_2}{m_1 + m_2}.AB$$

3. Consider the following statements A and B and identify the correct answer
   A. Centre of mass lies inside or outside the body
   B. Mass must be present at centre of mass
   a. Both A & B are true
   b. A is true but B is false
   c. A is false but B is true
   d. Both A & B are false
   Ans. B
   Solution:
   Fact based. Eg. Centre of mass of a ring.

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4. Instructions for Assertion -Reason type Question
(A) If Both assertion and reason are true and reason is a correct explanation of the assertion.
(B) If Both assertion and reason are true and reason is not a correct explanation of the assertion.
(C) If assertion is true but reason is false.
(D) If assertion is false but reason is true.
(E) If both assertion and reason are false
Assertion: Position of centre of mass of a body depends on co-ordinate system
Reason: Internal forces effect the motion of centre of mass
   a. A
   b. B
   c. C
   d. D

   Ans. D
   Solution:
   Conceptual

5. Two skaters A and B, having masses 50 kg and 70 kg respectively stand facing each other 6 m apart on a horizontal smooth surface. They pull on a rope stretched between them. How far does each move before they meet?
   a. Both move 3 m
   b. A moves 2.5 m and B moves 3.5 m
   c. A moves 3.5 m and B moves 2.5 m
   d. Both come to rest

   Ans. C
   Solution:

$$X_{cm} = \frac{m_2 d}{m_1 + m_2}$$

6. A circular disc of radius 20cm is cut from one edge of a larger circular disc of radius 50cm. The shift of centre of mass is
   a. 5.7 cm
   b. (-5.7cm)
   c. 3.2 cm
   d. -3.2 cm

   Ans. B

   Solution:

Shift of centre of mass x $= \frac{-r^2 a}{R^2 - r^2}$
Where r is the radius of removed disc
R, radius of original disc

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a, distance between the centers

7. Four identical particles each of mass "m" are arranged at the corners of a square of side length "L". If one of the masses is doubled, the shift in the centre of mass of the system. w.r.t. diagonally opposite mass
   a. $\frac{L}{\sqrt{2}}$
   b. $\frac{3\sqrt{2}L}{5}$
   c. $\frac{L}{4\sqrt{2}}$
   d. $\frac{L}{5\sqrt{2}}$

   Ans. D
   Solution:

$$\text{Shift} = \frac{m \times \frac{L}{\sqrt{2}}}{5m}$$

8. A bomb shell of mass 3kg is moving with a velocity of 10m/s on the ground. Suddenly it explodes in to two pieces of masses 1kgand 2kg. The 2kg mass continues to move in the same direction with a velocity of 8 m/s. The velocity of the centre of mass of the bomb after the explosion?
   a. 8 m/s
   b. 16 m/s
   c. 10 m/s
   d. 2 m/s

   Ans. C
   Solution:
   Explosion of the bomb is due to internal force

9. The Na^+ and Cl^- ions which are initially at certain distance apart start moving towards each other due to mutual attraction. As they are moving nearer, their centre of mass
   a. shifts nearer to Na^+
   b. shifts nearer to Cl^-
   c. remains in the same position
   d. may shift towards Na^+ or Cl^-

   Ans. C
   Solution:
   Internal forces don't affect the COM of the system.

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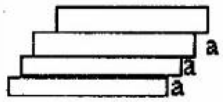
10. Four identical planks each of lengths 'L' are arranged one above the other over a table as shown. Each projects a distance 'a' beyond the edge of the one that is below it. What is the maximum possible value of 'a' for the system to be in equilibrium without tripping forward?



a. L/5
b. L/4
c. L/3
d. L

Ans. B

Solution:

COM of bricks, above each brick must not be beyond its edge. $X_{cm} = \frac{\sum m_i x_i}{\sum m_i}; x_{cm} = L$

$$x_1 = a + \frac{L}{2}, x_2 = 2a + \frac{L}{2}, x_3 = 3a + \frac{L}{2}$$

11. Three identical balls each of mass "m" are at the vertices of an equilateral triangle of side length "L". If the balls move under the influence of the mutual gravitational forces, the distance each ball moves before meeting the other two is

a. $\frac{L}{2}$
b. $\frac{L}{\sqrt{3}}$
c. $\frac{2L}{\sqrt{3}}$
d. L

Ans. B

Distance from vertex to Centre of Mass

12. A 2kg body and 3kg body are moving along the x-axis. At a particular instant the 2kg body is 1m from the origin and has a velocity of 3 ms^{-1} and 3kg body is 2m from the origin and has a velocity of -1 ms^{-1}. The position of the centre of mass of the system

a. 1m
b. 1.6m
c. 2.2 m
d. 0

Ans. B

Solution:

$$X_{cm} = \frac{\sum m_i x_i}{\sum m_i}$$

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13. Two balls are thrown at the same time in air, while they are in air, the acceleration of their centre of mass
    a. depends on masses of the balls
    b. depends on the direction of motion of the balls
    c. depends on speeds of the balls
    d. is equal to acceleration due to gravity

    Ans. D
    Conceptual

14. Three identical particles each of mass 0.1kg are arranged at three corners of a square of side √2m. The distance of the centre of mass from the fourth corner is
    a. 2/3 m
    b. 4/3 m
    c. 1m
    d. 8/3m

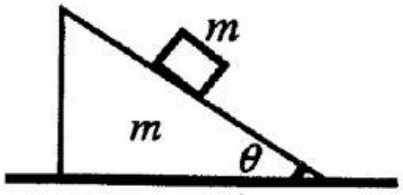
    Ans. B
    Solution:

$$X_{cm} = \frac{m\sqrt{2} + m\sqrt{2} + 0}{3m}$$

similarity Y_{cm}

$$r_{cm} = \sqrt{x_{cm}^{\ 2} + y_{cm}^{\ 2}}$$

15. A block of mass m slides down an inclined wedge of same mass m shown in figure. Friction is absent everywhere. Acceleration of centre of mass of the block and wedge is



    a. Zero
    b. $\frac{g\sin^2\theta}{(1+\sin^2\theta)}$
    c. $\frac{g\cos^2\theta}{(1+\sin^2\theta)}$
    d. $\frac{g\sin\theta}{(1+\cos\theta)}$

Ans. B

Solution:

Let, 'a' be the acceleration of wedge leftwards and 'a_r' be the relative acceleration of block down the plane.

$$a_r \text{Cos}\theta - a = a \Rightarrow 2a = a, \text{Cos}\theta \ldots\ldots(1)$$

For wedge, $N \text{Sin}\ \theta = ma \ldots\ldots(2)$

For bock, perpendicu lar to plane

$$N + m\, a \text{Sin}\ \theta = mg\ \text{Cos}\ \theta \ldots\ldots(3)$$

From eqs. (1), (2) and (3), we get,

$$a_r = \frac{2g\ \text{Sin}\ \theta}{1 + \text{Sin}^2\theta}$$

Accelerati on of block vert ically downwards.

$$a_y = a_r\ \text{Sin}\ \theta = \frac{2g\ \text{Sin}^2\theta}{1 + \text{Sin}^2\theta}$$

Accelerati on of COM is

$$a_{cm} = \frac{a_y}{2} = \frac{g\ \text{Sin}^2\theta}{1 + \text{Sin}^2\theta}$$

16. A uniform square sheet has a side length of 2R. A circular sheet of maximum possible area is removed from one of the quadrants of the square sheet. The centre of mass of the remaining portion from the centre of the original sheet is at a distance of

a. $\frac{\frac{\pi R}{\sqrt{2}(16-\pi)}}{\pi}$

b. $\frac{}{(16-\pi)}$

c. $\frac{\frac{R}{\pi(16-\pi)}}{}$

d. $\frac{R\pi}{(16-\pi)}$

Ans. A

Solution:

$$d = \frac{ax}{A - a}$$

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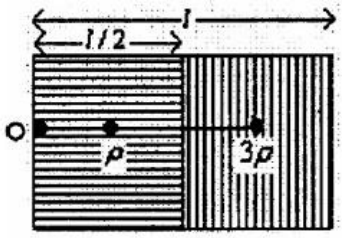
17. Half of the rectangular plates of length l as shown in the figure is made up on a material of density ρ and the other half of density 3ρ. The distance of centre of mass from O is



a. 0
b. $\frac{1}{2}$
c. $\frac{5}{8}l$
d. 1

Ans. C
Solution:

$$x = \frac{\rho_1 x_1 + \rho_2 x_2}{\rho_1 + \rho_2}$$

18. Two particles of equal mass have velocities $\bar{V}_1 = 4\bar{i}$ and $V_2 = 4\bar{j}$. First particle has an acceleration of $\bar{a}_1 = (5\bar{i} + 5\bar{j})ms^{-2}$ while the acceleration of the other particle is zero. The centre of mass of the two particles moves in a path of
    a. Straight line
    b. Parabola
    c. Circle
    d. Ellipse
    Ans. A
    Solution:
    $\overrightarrow{V}_{cm}$ Parallel $\overrightarrow{a}_{cm}$

19. If two particles of masses 3kg and 6kg which are at rest are separated by a distance of 15m. The two particles are moving towards each other under a mutual force of attraction. Then the ratio of distances travelled by the particles before collision is
    a. 2: 1
    b. 1: 2
    c. 1: 3
    d. 3: 1

    Ans. A
    Distance travelled = Distance from centre of mass;
    $m_1x = m_2(15-x)$

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20. To spheres of masses 4 kg and 8 kg are moving with velocities 2 ms^{-1} and 3 ms^{-1} away from each other along the same line. Find the velocity of centre of mass

a. $\frac{2}{3} ms^{-1}$ towards second sphere

b. $\frac{4}{3} ms^{-1}$ towards second sphere

c. $\frac{8}{3} ms^{-1}$ away from the second sphere

d. $\frac{2}{3} ms^{-1}$ away from the second sphere

Ans. B

Solution:

$$V_{cm} = \frac{\sum m_i v_i}{\sum m_i}$$