Center of Mass of System of Particles

Q1: How does the center of mass (COM) of a tossed tire move?

A) In a straight line

B) In a chaotic path

C) In a parabolic trajectory

D) It remains stationary

Q2: Consider a rod of length 10 m with masses placed at 0 m (3 kg), 5 m (2 kg), and 10 m (1 kg). Where is the center of mass of this system?

A) 3.33 m

B) 3.67 m

C) 4 m

D) 5 m

Q3: How can the center of mass (COM) of a baseball bat be experimentally determined?

A) By measuring its length

B) By spinning it in the air

C) By balancing it on your finger

D) By weighing it

Q4: A car (m_1 = 1500 kg) and a motorcycle (m_2 = 300 kg) are positioned on a straight track at points x_1 = 0 m and x_2 = 100 m, respectively. Calculate the center of mass of this system.

A) 16 m

B) 25 m

C) 30 m

D) 35 m

Q5: What is the primary reason a baseball bat's motion is more erratic in the air compared to a ball?

A) It is lighter than the ball

B) Each particle follows a different path

C) It is heavier than the ball

D) It is symmetrical like the ball

Q6: How would the center of mass (CM) of a wrench  change if it is spun on a long table where net force is zero?

A) It would not move

B) It would move in a parabolic path

C) It would move in a straight line

D) It would move in a circular path

Q7: What simplification is made when describing the motion of a complex object like a bat or ball in terms of its center of mass (CM)?

A) The object is treated as if it has no mass

B) The object is treated as if it has variable mass

C) The object is treated as if all mass is concentrated at the CM

D) The object is treated as if it has infinite mass

Q8: A 4-meter-long uniform beam is suspended horizontally by a rope at each end. A cat, weighing 5 kg, walks from one end to the other. Initially, the cat starts at the 0-meter mark (left end of the beam). If the mass of the beam itself is 20 kg, at what position along the beam will the center of mass be located when the cat reaches the 3-meter mark?

A) 1.6 m

B) 1.8 m

C) 2.0 m

D) 2.2 m

Q9: If mass B is zero in a two-particle system, where is the center of mass located relative to mass A?

A) At the position of mass A

B) At the midpoint between mass A and mass B

C) At the origin

D) At an infinite distance

Q10: If mass A equals mass B in a two-particle system, where will the center of mass be located?

A) At the position of mass A

B) Midway between the two masses

C) Closer to mass B

D) Closer to mass A

Answers Uncubed

1. C) It moves in a parabolic trajectory.

Explanation: The center of mass of a symmetric object like a tire follows a simple parabolic trajectory when tossed, akin to a point mass under the influence of gravity.

2. A) 3.33 m

Explanation: The center of mass is calculated using the formula $x_{CM} = (m_1x_1 + m_2x_2 + m_3x_3) / (m_1 + m_2 + m_3)$:

x_{CM} = (3 kg * 0 m + 2 kg * 5 m + 1 kg * 10 m) / (3 kg + 2 kg + 1 kg) = 3.33 m.

Assumes, the rod is massless

3. C) By balancing it on your finger.

Explanation: The center of mass of a baseball bat can be determined by balancing it on your finger, where it will balance at the point directly above your finger *along the bat's central axis.*

4. A) 16 m

Explanation: The center of mass for the system is calculated as follows:

$x_{CM} = (m_1x_1 + m_2x_2) / (m_1 + m_2)$

x_{CM} = (1500 kg * 0 m + 300 kg * 100 m) / (1500 kg + 300 kg) = 16.67 m

5. B) Each particle follows a different path.

Explanation: The erratic motion of a baseball bat when tossed is due to the different paths followed by its particles, unlike a symmetrical ball where the mass distribution is uniform.

6. C) It would move in a straight line.

Explanation: On a frictionless table with no net force, the center of mass of the bat moves in a straight line, demonstrating that without external forces, the motion of the center of mass is unaltered.

7. C) The object is treated as if all mass is concentrated at the COM.

Explanation: Simplifying the motion of objects like bats and balls involves assuming all mass is concentrated at the center of mass, making it easier to predict and analyze their motion under external forces.

8. D) 2.2 m

Explanation: To find the center of mass of the system comprising the beam and the cat, we consider the masses and their respective positions. Since the beam is uniform, its center of mass is at the midpoint at 2 meters. When the cat walks to the 3-meter mark, we need to calculate the new center of mass considering the cat's position:

Calculate the center of mass with the formula:

x_{CM} = (mass of beam * position of beam's COM + mass of cat * position of cat) / (total mass)

x_{CM} = (20 kg * 2 m + 5 kg * 3 m) / (20 kg + 5 kg) = 2.2 m

Thus, when the cat is at the 3-meter mark, the center of mass of the system is located at 2.2 meters from the left end of the beam. This question demonstrates the shifting of the center of mass in a system due to the movement of mass within it, a fundamental concept in mechanics involving variable mass distribution.

9. A) At the position of mass A.

Explanation: If mass B is zero, the center of mass for the system is located at the position of mass A, as mass A is the only mass contributing to the system.

10. B) Midway between the two masses.

Explanation: When two masses are equal, the center of mass lies exactly midway between them, reflecting the symmetry of the mass distribution