Centre of Mass

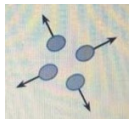
Definitions

The conservation law: The centre of mass remains at rest, or continues to travel at a constant velocity, unless an **external force** acts on the system.

Any external force applied to the body in line with the centre of mass will move the entire system.
Any external force applied to the body which is not in line with the centre of mass will result in a rotation of the system.

Centre of mass during collisions

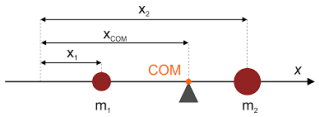
The centre of mass of an explosion remains approximately at the point of the explosion (because no ***external force*** *acts on the system).*



Equations

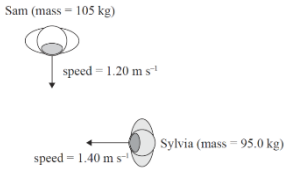
$$x_{COM} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$$

Position of centre of mass	x_{com}	m
mass	m_1, m_2	kg
Position of masses	x_1, x_2	m



Questions

QUESTION ONE (2017;1)



Two astronauts, Sylvia and Sam, are on a mission to another planet. During their journey they are doing a "spacewalk" outside their spaceship. At one time they are moving freely as shown in the diagram below. They collide and stick together.

(a) Calculate the distance between Sam and the centre of mass of the system when he and Sylvia are 4.80 m apart.

(b) Describe what happens to the centre of mass of the system as the astronauts move closer together and then collide.

CENTRE OF MASS (2008;2)

(c) Many ski resorts provide chairlifts to carry skiers to the top of the mountain. The chairs hang from a single suspension point on a steel cable. The whole chair is rigid. It hangs freely from a pivot point on the cable. A heavy skier sits in the chair at X. Explain why the chair moves and why it hangs in this new equilibrium position.

Terms

Centre of mass: When an external force acts upon a system, the system reacts as though all the matter were concentrated at the centre of mass. The centre of mass can be thought of as a pivot point around which the system can revolve.

Pivot: Point upon which an object turns or rotates

Collision: Objects hitting each other

Tips

- Memorise the definition for the conservation of the state of the centre of mass

Answers

(a)

$$x_{com} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$$

$$x_{com} = \frac{105 \times 0 + 95.0 \times 4.80}{105 + 95.0}$$

$$x_{com} = 2.28\ \text{m}$$

(b) The centre of mass keeps moving at constant velocity.

(c) The chair moves because of unbalanced torque. Due to the centre of mass now being to the right of the suspension cable / weight of skier causes torque. The torque causes angular acceleration until it hangs in new position where new centre of mass is below suspension point, so there is no net torque and no angular acceleration.