

Chapter 9 – Center of mass and linear momentum

I. The center of mass

- System of particles / - Solid body

II. Newton's Second law for a system of particles

III. Linear Momentum

- System of particles / - Conservation

IV. Collision and impulse

- Single collision / - Series of collisions

V. Momentum and kinetic energy in collisions

VI. Inelastic collisions in 1D

-Completely inelastic collision/ Velocity of COM

VII. Elastic collisions in 1D

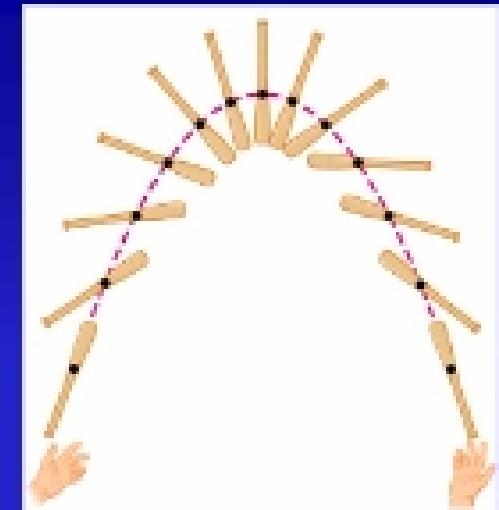
VIII. Collisions in 2D

IX. Systems with varying mass

X. External forces and internal energy changes

I. Center of mass

The center of mass of a body or a system of bodies is a point that moves as though all the mass were concentrated there and all external forces were applied there.

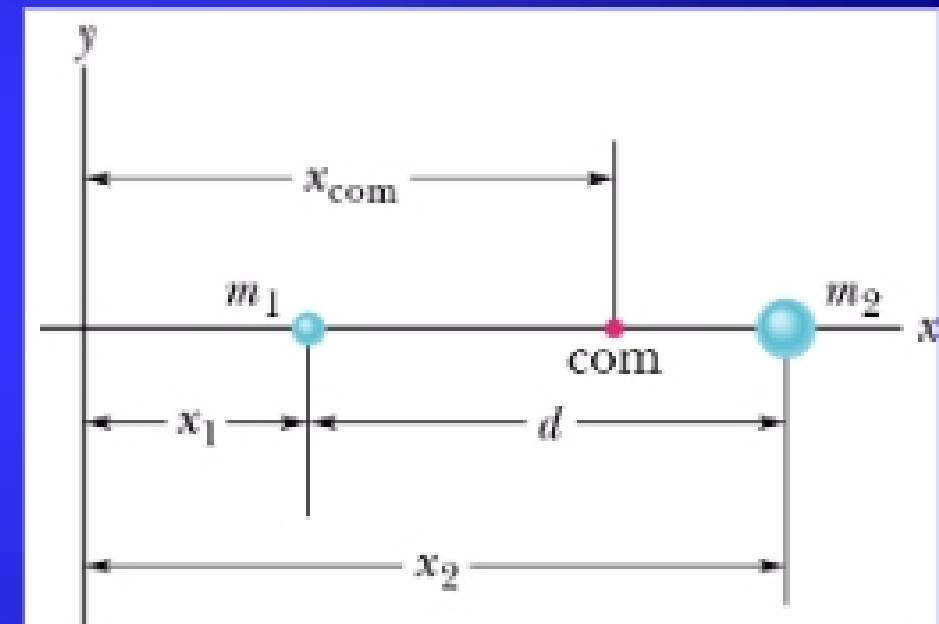


- System of particles:

General:

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

M = total mass of the system



- The center of mass lies somewhere between the two particles.

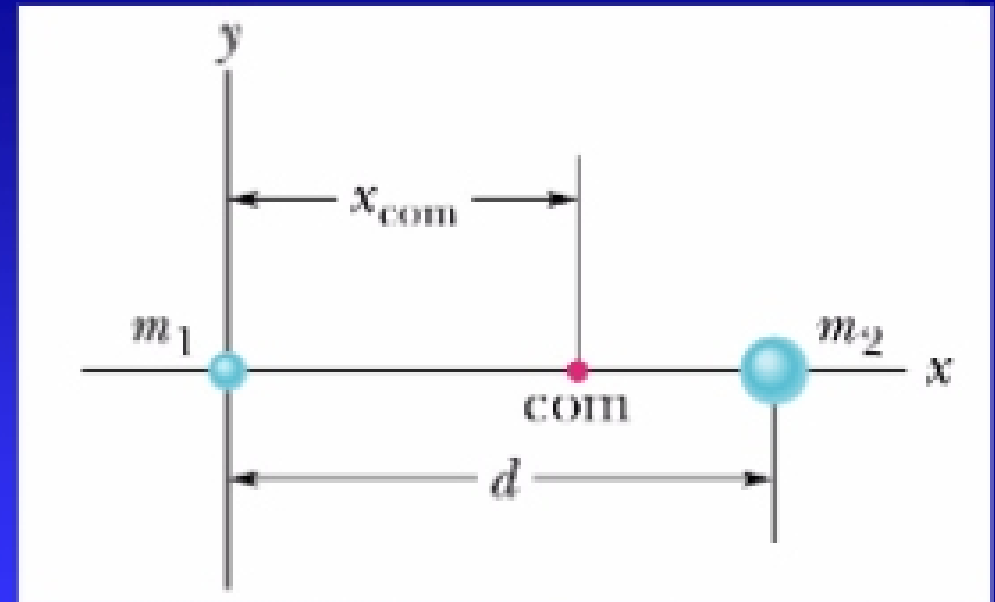
- Choice of the reference origin is arbitrary \rightarrow Shift of the coordinate system but center of mass is still at the same relative distance from each particle.

I. Center of mass

- System of particles:

$$x_{com} = \frac{m_2}{m_1 + m_2} d$$

Origin of reference system coincides with m_1



3D:

$$x_{com} = \frac{1}{M} \sum_{i=1}^n m_i x_i \quad y_{com} = \frac{1}{M} \sum_{i=1}^n m_i y_i \quad z_{com} = \frac{1}{M} \sum_{i=1}^n m_i z_i$$

$$\vec{v}_{com} = \frac{1}{M} \sum_{i=1}^n m_i \vec{v}_i$$