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• A rigid body is a body with a perfectly definite and unchanging shape. The distances between all pairs of particles of such a body do not change.

• Centre of Mass

For a system of particles, the centre of mass is defined as that point where the entire mass of the system is imagined to be concentrated, for consideration of its translational motion.

If all the external forces acting on the body/system of bodies were to be applied at the centre of mass, the state of rest/ motion of the body/system of bodies shall remain unaffected.

• The centre of mass of a body or a system is its balancing point. The centre of mass of a two- particle system always lies on the line joining the two particles and is somewhere in between the particles.

If there are two particles of masses m_1 and m_2 having position vectors \vec{r}_1 and \vec{r}_2 , then the position vector of the centre of mass is given by

$$\vec{r}_{cm} = \frac{m_1 \vec{r}_1 + m_2 \vec{r}_2}{m_1 + m_2}$$

Special Note: If the masses are of equal magnitude the centre of mass lies at the mid-point of the line joining them. If the masses are unequal, centre of mass is closer to the heavier body.

• For a system of n particles of masses $m_1, m_2, m_3, \dots, m_n$ and their respective position vectors $\vec{r}_1, \vec{r}_2, \vec{r}_3, \dots, \vec{r}_n$; the position

$$\vec{r}_{cm} = \frac{m_1 \vec{r}_1 + m_2 \vec{r}_2 + \dots + m_n \vec{r}_n}{m_1 + m_2 + \dots + m_n} = \frac{\sum_{i=1}^n m_i \vec{r}_i}{\sum_{i=1}^n m_i}$$

• The co-ordinates of the centre of mass of an n -particle system is given as:

$$X = \frac{m_1 x_1 + m_2 x_2 + \dots + m_n x_n}{m_1 + m_2 + \dots + m_n} = \frac{\sum_{i=1}^n m_i x_i}{\sum_{i=1}^n m_i} = \frac{1}{M} \sum_{i=1}^n m_i x_i$$

where $\sum_{i=1}^n m_i = M$, mass of system.

$$Y = \frac{m_1 y_1 + m_2 y_2 + \dots + m_n y_n}{m_1 + m_2 + \dots + m_n} = \frac{\sum_{i=1}^n m_i y_i}{\sum_{i=1}^n m_i} = \frac{1}{M} \sum_{i=1}^n m_i y_i$$

$$Z = \frac{m_1 z_1 + m_2 z_2 + \dots + m_n z_n}{m_1 + m_2 + \dots + m_n} = \frac{\sum_{i=1}^n m_i z_i}{\sum_{i=1}^n m_i} = \frac{1}{M} \sum_{i=1}^n m_i z_i$$

• Motion of centre of Mass

The centre of mass of a system of particles moves as if the entire mass of the system were concentrated at the centre of mass and all the external forces were applied at that point. Velocity of centre of mass of a system of two particles, m_1 and m_2 with velocity v_1 and v_2 is given by,

$$V_{cm} = \frac{m_1 \vec{v}_1 + m_2 \vec{v}_2}{m_1 + m_2}$$

Acceleration of centre of mass, a_{cm} of a two body system is given by

$$a_{cm} = \frac{m_1 \vec{a}_1 + m_2 \vec{a}_2}{m_1 + m_2}$$

• If no external force acts on the body, then the centre of mass will have constant

