

We are given that the object m_1 collides with the rod with velocity v_0 , and the rod is floating in free space. Given m_1 , v_0 , m_2 , I_0 , and r , we are to figure out the final velocity of m_1 after collision v_f , the velocity of m_2 after collision v_{CM} , and of course the rotation of the rod after collision ω .

We are assuming that this collision is elastic.

We have, then, for conservation of linear momentum:

$$m_1 v_0 = m_1 v_f + m_2 v_{CM} \quad (1)$$

Furthermore, we understand that kinetic energy is also conserved here; therefore:

$$\frac{1}{2} m_1 v_0^2 = \left(\frac{1}{2} m_1 v_f^2 \right) + \left(\frac{1}{2} m_2 v_{CM}^2 \right) + \left(\frac{1}{2} I_0 \omega^2 \right) \quad (2)$$

$$\Rightarrow m_1 v_0^2 = (m_1 v_f^2) + (m_2 v_{CM}^2) + (I_0 \omega^2) \quad (3)$$

as the point mass does not have any rotational inertia, and the rod is not rotating at the start