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 to 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 elastic.

We have, then, for conservation of linear momentum:

$$m_1 v_0 = m_1 v_f + m_2 v_{CM} \tag{1}$$

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

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

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

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

Lastly, we understand that the angular momentum is conserved through a collision; letting the origin as the center of mass of the rod:

$$m_1 r^2 \left(\frac{v_0}{r}\right) = m_1 r^2 \left(\frac{v_f}{r}\right) + I_0 \omega \tag{4}$$

$$\Rightarrow m_1 r v_0 = m_1 r v_f + I_0 \omega \tag{5}$$

We now have a system of three equations that can be combined to solve for three unknowns v_f, v_{CM}, and ω.

```
var("I m1 v0 m2 r vf vcm w")

expand(solve([m1*v0 == m1*vf+m2*vcm, m1*v0^2==m1*vf^2+m2*vcm^2+I*w^2, m1*r^2*(v0/r)==m1*r^2*(vf/r)+I*w]
```