Suppose I have two masses with masses m_i and initial velocities u_i. They collide with a coefficient of restitution e. What are the final velocities?

First we have to switch to the center of mass frame, where

$$v_{com} = \frac{m_1 u_1 + m_2 u_2}{m_1 + m_2}$$

In the COM frame, we have

$$u_1' = u_1 - \left[\frac{m_1}{m_1+m_2}u_1 + \frac{m_2}{m_1+m_2}u_2\right] = \frac{m_2}{m_1+m_2}u_1 - \frac{m_2}{m_1+m_2}u_2 = \frac{\mu}{m_1}(u_1 - u_2)$$

and

$$u_2' = \frac{\mu}{m_2}(u_2 - u_1)$$

The kinetic energy is

$$KE_i = \frac{1}{2}m_1\frac{\mu^2}{m_1^2}(u_1-u_2)^2 + \frac{1}{2}m_2\frac{\mu^2}{m_2^2}(u_1-u_2)^2 = \frac{1}{2}\mu^2(u_1-u_2)^2\left[\frac{1}{m_1}+\frac{1}{m_2}\right] = \frac{1}{2}\mu(u_1-u_2)^2$$

The final velocities in this frame are $v_1' = \frac{\mu}{m_1}(v_1 - v_2)$ and $v_2' = \frac{\mu}{m_2}(v_2 - v_1)$, and the kinetic energy is $KE_f = \frac{1}{2}\mu(v_1 - v_2)^2$. Given the coefficient of restitution e,

$$\frac{1}{2}\mu(v_1-v_2)^2 = e^2\frac{1}{2}\mu(u_1-u_2)^2 \implies (v_1-v_2)^2 = e^2(u_1-u_2)^2 \implies v_1 - v_2 = \pm e(u_1-u_2)$$

We must also have

$$m_1 v_1 + m_2 v_2 = m_1 u_1 + m_2 u_2$$

Solving the first equation for v_1 and substituting:

$$\begin{aligned}
m_1(v_2 \pm e(u_1-u_2)) + m_2 v_2 &= m_1 u_1 + m_2 u_2 \\
(m_1+m_2)v_2 &= u_1(m_1 \mp e m_1) + u_2(m_2 \pm e m_1) \\
\implies v_2 &= u_1\frac{m_1}{m_1+m_2}(1 \mp e) + u_2\frac{m_2 \pm e m_1}{m_1+m_2} \\
&= \frac{m_1 u_1 + m_2 u_2 \pm e m_1(u_2-u_1)}{m_1+m_2} \\
&= v_{com} \pm e\frac{m_1}{m_1+m_2}(u_2-u_1)
\end{aligned}$$

and similarly

$$v_1 = v_{com} \pm e\frac{m_2}{m_1+m_2}(u_1-u_2)$$

although I'm not sure if the $\pm$ in the two equations are connected; I'd need to investigate.

If $e = 1$, then

$$v_2 = u_2\frac{m_2+m_1}{m_1+m_2} = u_2 \quad \text{or} \quad v_2 = u_1\frac{2m_1}{m_1+m_2} + u_2\frac{m_2-m_1}{m_2+m_1}$$

If $e = 0$, then