Center of Mass Reference Frame

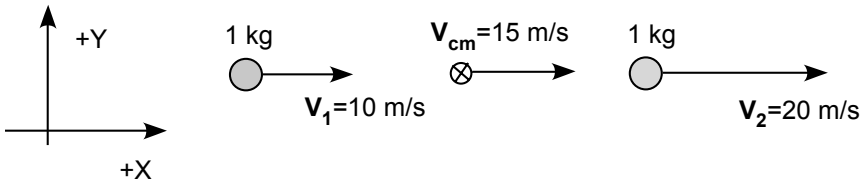
It is often more convenient to analyze a problem in the CM reference frame because the math involved is often simplified.

Ex. a) Find V_{cm} of two particles, each mass of 1 kg, moving in same direction. One particle is moving at 10 m/s and the other at 20 m/s.

$$V_{cm} = \frac{m_1 v_1 + m_2 v_2}{m_1 + m_2}$$

$$V_{cm} = \frac{(1kg)(10m/s) + (1kg)(20m/s)}{1kg + 1kg}$$

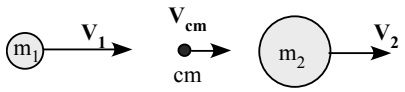
$$V_{cm} = 15m/s$$



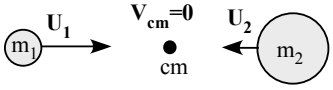
b) What is the velocity of the center of mass in the center of mass reference frame? ZERO!!

1. In the CM reference frame the velocity of the CM is zero. (That is, the velocity of the CM is zero relative to the CM.) Since $\mathbf{P_{sys}} = M\mathbf{V_{cm}}$, then $\mathbf{P_{sys} = 0}$ since $\mathbf{V_{cm}} = 0$ in the CM reference frame. This is sometimes referred to as the zero-momentum RF.

2. Two particles, before a collision in the CM reference frame, must have equal and opposite momenta.



Original RF



CM RF

A. After a perfectly inelastic collision the objects remain at rest.

B. After a 1D elastic collision, the velocity of the particles are equal and opposite to their initial velocities.