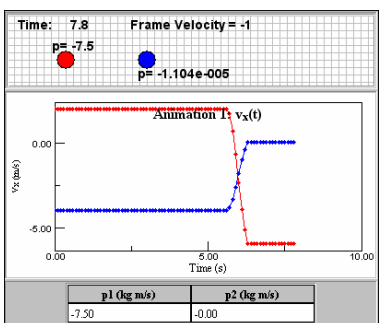


## Worksheet for Exploration 9.1: Compare Momentum in Different Frames



How does the momentum of a particle change when viewed from a different reference frame? The momentum of each ball in the animation is shown in the table (**position is given in meters and time is given in seconds**). The graph displays color-coded plots of the velocities of the two particles. [Restart](#).

You can view the collision in another inertial reference frame by entering a new value into the frame velocity text box,  $-10 \text{ m/s} < v < 10 \text{ m/s}$ , before you start the animation. Consider the two particles to be an isolated system and answer the following questions using at least two different inertial reference frames for each animation.

For parts a, b, c, complete the following table (you select several different reference velocities):

$V_{\text{ref}}$		Animation 1			Animation 2		
		$p_1$	$p_2$	$p_{\text{tot}}$	$p_1$	$p_2$	$p_{\text{tot}}$
	before						
	after						
	before						
	after						
	before						
	after						
	before						
	after						

- Does the total momentum depend on your choice of reference frame?
  - Animation 1
  - Animation 2
- Does the change in momentum depend on the reference frame? (the change here refers to changing  $v_{\text{ref}}$ )
  - Note what the change is when you change  $v_{\text{ref}}$ . Give a specific example.

- c. Is the total momentum conserved in different reference frames?  
i. For this consider the total momentum before and after the collision?

- d. Find the mass and the ratio of the masses of the two balls. Does this result depend on the reference frames?  
i. Consider the change in momentum 1 for a given change in reference frame.

$$\Delta p_1 = \underline{\hspace{2cm}} \qquad m_1 = \underline{\hspace{2cm}}$$

- ii. Likewise for momentum 2.

$$\Delta p_2 = \underline{\hspace{2cm}} \qquad m_2 = \underline{\hspace{2cm}}$$

- e. Is there a reference frame in which the total momentum is zero? If so, observe the change in velocity in this reference frame and explain why analysis of the collision is particularly simple in this reference frame.  
i. Find the velocity of the reference frame that gives total momentum of zero.

- ii. What is the change in velocity for each of the objects?

**Animation 1:**

**Animation 2:**

- iii. Why is this reference frame simple?