Lab 3-2: **Relative Motion**

Purpose: 1. To be able to define a frame of reference.
2. To observe a tennis ball being tossed up and down from multiple frames of reference.
3. To develop notation for velocity addition between different frames of reference.

Volunteers: 1 Tosser 1 Filmer 2 Pushers

Procedure:
1. The volunteers should take a moment to practice moving at constant speed in a straight line. The *Tosser* needs to be able to toss a tennis ball straight up and down and the *Filmer* needs to be able to hold the camera steady while someone else pushes them at constant speed.
2. In the charts below, the velocities of the *Tosser* and the *Filmer* are given for the Room Reference Frame. This is what the class sees. Turn the camera on, and do each trial listed. The actual velocities don't matter, as long as they are reasonably constant.
3. Once all the trials are done, watch the video for each trial and determine the velocities in the Camera Reference Frame. This is conceptual only, so give answers in terms of "v". The video will be shown as a class.

Data:

Part 1: One Person Moving

	Room Reference Frame			*Camera Reference Frame*		
	Room	*Tosser*	*Camera*	*Room*	*Tosser*	*Camera*
Trial 1	0	+ v	0			
Trial 2	0	– v	0			
Trial 3	0	0	+ v			
Trial 4	0	0	– v			

Part 2: Both People Moving

	Room Reference Frame			*Camera Reference Frame*		
	Room	*Tosser*	*Camera*	*Room*	*Tosser*	*Camera*
Trial 5	0	+ v	+ v			
Trial 6	0	– v	– v			
Trial 7	0	– v	+ v			
Trial 8	0	+ v	– v			

Conclusions:
1. In the Room Reference Frame, what was always true about the velocity of the Room?

2. In the Camera Reference Frame, what was always true about the velocity of the Camera?

3. What was always true about the *Velocity of the Camera with respect to the Room* (V_{CR}) compared to the *Velocity of the Room with respect to the Camera* (V_{RC})?

Lab 3-2: **Relative Motion**

4. What had to be true for the Tosser to have a velocity of 0 in the Camera Reference Frame?

5. The Tosser always tried to toss the ball straight up and down in their reference frame. Between the two reference frames and eight trials, the resulting motion of the tennis was usually that of a projectile with a parabolic path.
   a. What had to be true for the tennis ball to be going simply up and down in a particular reference frame?

   b. Looking at Part 1, why was the path of the tennis ball always parabolic in the Camera Reference Frame?

   c. How was Part 2 different?

6. It turns out there is a neat, and quick, algebraic relationship between the velocities of objects in different reference frames. What is a simple rule that would tell someone how to fill out the entire Camera Reference Frame chart based on the given Room Reference Frame information?

7. The Room Reference Frame data shows the *Velocity of the Tosser with respect to the Room* and the *Velocity of the Camera with respect to the Room*, called V_{TR} and V_{CR}, respectively. Come up with an equation that would give us the *Velocity of the Tosser with respect to the Camera*, V_{TC}.

8. In general, if we have two reference frames, B and C and we are measuring the velocity of an object A, what is the relationship between the velocities?

9. In this lab, the video is kind of wobbly because of what we did. Imagine we did this with real smooth motions that were really constant velocities against an uniform background. Would there be any way to distinguish between the *Filmer* moving or the *Tosser* moving?