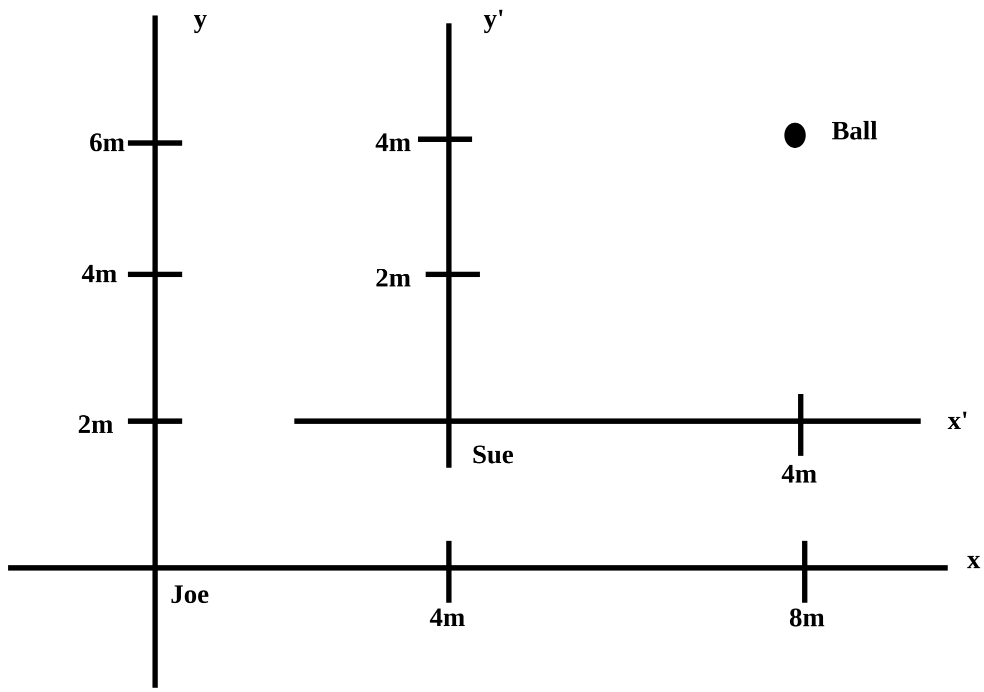
Kinematics III

I. Comparing Measurements By Different Observers

A. Position

As we noted earlier, the **position vector** is **NOT UNIQUE** as it depends on the **arbitrary choice** of the **observer's coordinate axis**.

Example: Joe and Sue determine the location pf a baseball using their own coordinate axis shown below:



a) Draw the baseball's position vector as seen by Joe

b) Draw the baseball's position vector as seen by Sue

c) Write the baseball's position vector seen by Joe in Cartesian form.

d) Write the baseball's position vector as seen by Sue in Cartesian form.

How can a baseball have **two** different **position vectors** when it only has **one physical location**?

Answer: The **position vector** is a mathematical concept for describing a particle and **Not A Real** (physical) **Quantity**! What is required to correctly describe the particle is a **formula relating** position vectors measured by two **different** observers (Joe and Sue).

We can obtain the equation by realizing that the measurements are related by vector addition!!!

Position Transformation Equation

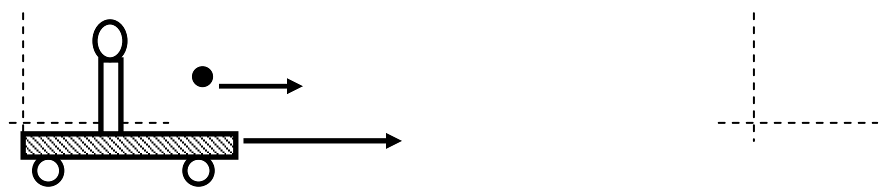
Equations like the one above that relate the measurements of two observers are called **TRANSFORMATION EQUATIONS**. They are very important in the field of physics.

Problem: Use the transformation equation above to find the location of the ball as seen by Joe if you were told Joe and Sue's location and the location of the ball as seen by Sue. (You better get the answer in part b!!)

Velocity Transformation

Because velocity is <u>defined</u> in terms of the <u>**position vector**</u>, it <u>depends</u> on the **observer's frame** of **reference** (<u>coordinate axis</u>) as well and is not unique.

Example: Nolan Ryan throws his 100mph fast ball while traveling on a train moving toward the batter at 50mph. (Use your everyday intuition!)



a) What is the velocity of the fast ball according to Nolan Ryan?

b) What is the velocity of the ball according to the batter?

Question: How can we prove this?

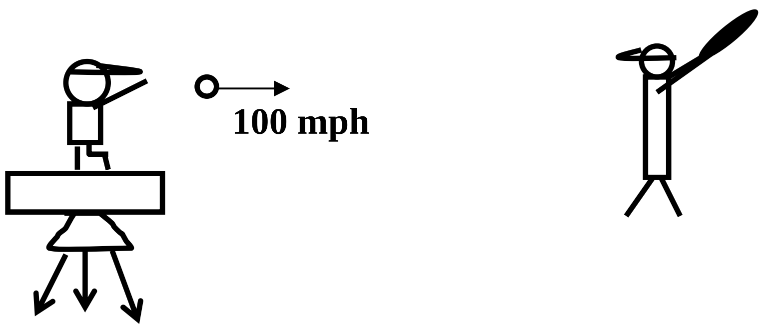
Answer: Using our definition of velocity and our <u>**position transformation equation**</u> to derive a velocity transformation equation.

Velocity Transformation Equation

Derivation:

Problem: Use the velocity transformation equation to show that our previous work was correct?

Problem 2: If Nolan Ryan is blasting off on a rocket traveling upward at 50 mph when he throws the ball.



a) What is the velocity of the ball as seen by the batter?

b) What is the speed of the ball as seen by the batter (neglect gravity)?

******* **Important:** You **can't measure absolute motion** of a body! You can only **measure** its motion **relative** to your axis! (Relative Velocity)

This is called Galilean Relativity after Galileo Galilee. It was the study of this motion and E&M that led Albert Einstein to determine the equations which produced the atomic bomb, lasers, and computers!

Finally, it is the observer's coordinate axis that is relative and not the answer to the measurement! Using your measurements and the transformation equations, you can exactly predict what any other observer would see.

Acceleration Transformations

1. Two observer's will also not agree upon a body's acceleration if they are accelerating with respect to each other.

Transformation Equation:

Example: Observer 1 is riding in a car accelerating at 10 m/s^2 in the +x-direction as seen by observer 2. If observer 2 sees a plane accelerating at 20 m/s^2 in the +x-direction, what is the plane's acceleration as measure by observer 1?

2. Special Case: Inertial Frames

A frame of reference where **Newton's laws hold** (a **non-accelerating** reference frame)!

If two frames are NOT accelerating with respect to each other then both observer's will **agree** on the **acceleration** of the object.

This concept will become **extremely important** for our discussions on fictitious forces starting in Chapter 4 (Centrifugal, Coriolis forces, etc.)