Relative Motion

Unit: Special Relativity

MA Curriculum Frameworks (2016): N/A

AP® Physics 2 Learning Objectives: N/A

Mastery Objective(s): (Students will be able to…)

- Describe how a situation appears differently in different reference frames.

Success Criteria:

- Explanations account for observed behavior.

Language Objectives:

- Describe a situation when you thought you were moving but you weren't (or *vice versa*).

Tier 2 Vocabulary: relative, reference frame

Vocabulary:

relativity: the concept that motion can be described only with respect to an observer, who may be moving or not moving relative to the object under consideration.

reference frame: the position and velocity of an observer watching an object that is moving relative to himself/herself.

Use this space for summary and/or additional notes:

Notes:

Consider the following picture, taken from a moving streetcar in New Orleans:

"New Orleans Streetcar." Photo by Don Chamblee.

If the streetcar is moving at a constant velocity and the track is smooth, the passengers may not notice that they are moving until they look out of the window.

In the reference frame of a person standing on the ground, the trolley and the passengers on it are moving at approximately 30 miles per hour.

In the reference frame of the trolley, the passengers sitting in the seats are stationary (not moving), and the ground is moving past the trolley at approximately 30 miles per hour.

Of course, you might want to say that the person on the ground has the "correct" reference frame. However, despite what you might prefer, neither answer is more correct than the other. Either reference frame is valid, which means either description of what is moving and what is stationary is equally valid.

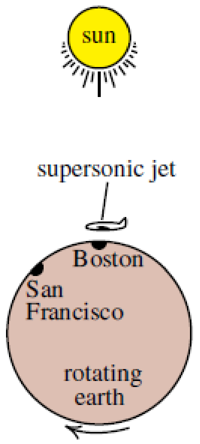
Use this space for summary and/or additional notes:

Principle of Relativity

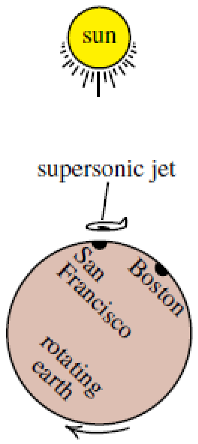
There is no experiment you can do that would allow you to determine conclusively whether or not you are moving uniformly.

Recall that "uniform motion" means moving with constant velocity, which means with a constant speed and direction. If velocity is constant, there is no acceleration, which means there is no net force.

Consider a fast airplane (such as a supersonic jet) flying from Boston to San Francisco. Imagine that the plane takes exactly three hours to fly to San Francisco, which is the same as the time difference between the two locations. Seen from outside the Earth, the situation might look like this:



Supersonic jet over Boston just after takeoff.



Supersonic jet three hours later over San Francisco.

You could argue that either:

1. The jet was moving from the airspace over Boston to the airspace over San Francisco.
2. The jet was stationary and the Earth rotated underneath it. (The jet needed to burn fuel to overcome the drag from the Earth's atmosphere as the Earth rotated, pulling its atmosphere and the jet with it.)

Use this space for summary and/or additional notes:

Of course, there are other reference frames you might consider as well.

3. Both the supersonic jet and the Earth are moving, because the Earth is revolving around the Sun with a speed of about $30\,000\,\frac{m}{s}$.
4. The jet, the Earth and the Sun are all moving, because the sun is revolving around the Milky Way galaxy with a speed of about $220\,000\,\frac{m}{s}$.
5. The jet, the Earth, the Sun, and the entire Milky Way galaxy are all moving through space toward the Great Attractor (a massive region of visible and dark matter about 150 million light-years away from us) with a speed of approximately $1\,000\,000\,\frac{m}{s}$.
6. It is not clear whether there might be multiple Great Attractors, and what their motion might be relative to each other, or relative to some yet-to-be-discovered entity.

Regardless of which objects are moving with which velocities, if you are on the airplane and you drop a ball, you would observe that it falls straight down. In relativistic terms, we would say “In the reference frame of the moving airplane, the ball has no initial velocity, so it falls straight down.”

Use this space for summary and/or additional notes: