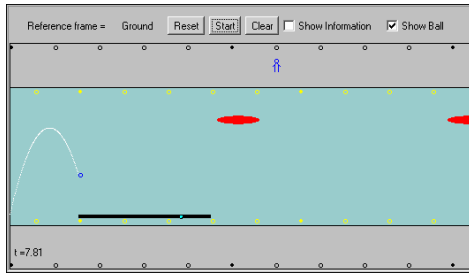


Worksheet for Exploration 9.3: Compare Relative Motion in Different Frames



An object may appear to have one motion to one observer and a different motion to a second observer, depending on how the two observers are moving relative to one another. This Exploration lets you view objects from different frames of reference.

There is a river (shown in **green**) in the center of the screen (the yellow dots are stationary with respect to the water) and two **red** boats are moving with respect to the river. There is a rectangular barge that is stationary with respect to the river and changes color based on your reference frame. There is also a person (shown in **blue**) walking on the ground (shown in gray with black dots stationary relative to the ground) near the river.

You can easily change your frame of reference by moving the mouse to different regions and to different objects. For example, if you move the mouse within the river, YOU will become an observer moving with the water. The long thin rectangle (the barge) in the water moves with the water and changes color to represent the reference frame you are in. In addition,

- If you click the "Show Information" check box, velocity vectors for your frame of reference will be shown with numbers (**position is given in meters and speed is given in m/s**). Each vector's color corresponds to the color of the object whose reference frame you are in.
 - If you click the "show ball" check box, a blue ball is thrown upward from the barge on the river. When you change reference frames you can see how the projectile motion of the ball looks different in different reference frames. Deselect the "show ball" check box to clear the ball's trajectory.
 - You can press the mouse button to suspend the animation. If you press with **left** mouse button, the animation will resume when you release it. If you press with **right** mouse button, you need to click it again to resume the animation.
 - To change the velocity vectors, it is easier to first suspend the animation. Then click anywhere in the animation to bring up the vectors. Now click near the tip of the arrow and drag it to the left or right.
 - There are two numbers near the person. Those are the vertical and horizontal speeds of that person in your frame of reference.
 - While the animation is suspended, click near the left leg of the person and drag the mouse up and down. You are changing her vertical speed. Click with the right mouse button to resume the animation. The person will now move toward the river, and then swim across it. (The horizontal speed with respect to the ground will increase due to river current).
- a. Suspend the animation and then turn on "show information." Change the horizontal and vertical speeds of the person so that she swims straight across the river (as seen from the ground). Once you are satisfied with your choice of velocity, deselect the "show information" check box, click in the animation (things are easier to see this way), and resume the animation.
 - b. What ground velocity do you have to give her to accomplish this task?
 - i. Note that the horizontal velocity you give to the person on the ground is maintained once the person reaches water. Just like they can walk on water with the speed you give them.
 - ii. Consider the velocities of the person in the water for the conditions you have set in part a. The subscripts mean for example, measure the velocity of the person with respect to the ground ...etc.

$V_{x \text{ person, ground}} = \underline{\hspace{2cm}}$ (measured while on the ground)

$V_{x \text{ person, ground}} = \underline{\hspace{2cm}}$ (measured while in the water)

$V_{x \text{ person, water}} = \underline{\hspace{2cm}}$ (measured while in the water)

$V_{x \text{ water, ground}} = \underline{\hspace{2cm}}$ (measured while in the water)

- c. Now move the mouse around to change reference frames. Does the person still swim straight across the river in other reference frames? If not, what velocity must you give her (relative to the ground) to accomplish this as seen from the boats? What velocity must you give her (relative to the ground) to accomplish this as seen from the river?

i. Specifically, as you left things in part b, does the person swim straight across with respect to an observer placed on the barge (river), or boats?

ii. For an observer on the boat set the conditions to make the person cross "straight".

$V_{x \text{ person, ground}} = \underline{\hspace{2cm}}$ (measured while on the ground)

$V_{x \text{ person, boat}} = \underline{\hspace{2cm}}$ (measured while in the water)

$V_{x \text{ person, water}} = \underline{\hspace{2cm}}$ (measured while in the water)

$V_{x \text{ water, boat}} = \underline{\hspace{2cm}}$ (measured while in the water)