

A Projectile Simulation

- Purpose:**
1. To gain a better understanding of motion in two dimensions by working a projectile problem
 2. To gain experience using a computer simulation of a physical problem

Equipment Needed: windows based computer with Interactive Physics software

Introduction: The computer will be used to create a simulation of a rubber ball being thrown through a window on the side of a building. The computer, of course, uses the laws of physics (previously programmed into the computer) to simulate the motion. In a similar way, we can use the laws of physics to do the calculations ourselves and predict the correct initial velocity needed and thus check the accuracy of our simulation. The only other means of verifying any simulation (and the best!) is doing the actual experiment, but depending on the situation this may be difficult and/or costly.

By adjusting the initial velocity of the ball we can use the computer to repeat the experiment over and over again until we achieve the desired result (getting the ball through the window). The ball's initial velocity is controlled by using the slider bars for V_x and V_y or by simply typing in values in the boxes below each slider. Be sure that the simulation has been reset before making any changes. The components, V_x and V_y , of the ball's velocity are displayed by digital meters. Vectors attached to the ball indicate the ball's velocity as well as the x and y components of the velocity.

Procedure:

1. Turn on the computer and load the **Interactive Physics** software by double clicking on its icon located within the **Physics Apps** folder. A file named **flyball** will be used to set up the simulation of the ball heading toward the window. To open this file first select **FILE/OPEN** (with the mouse) and then open the **motion** folder by double clicking on its icon. When this folder opens, double click on **flyball** to open the file.
2. Set the initial velocity of the ball by adjusting the sliders for V_x and V_y and observe the initial velocity vector attached to the ball change as you adjust the sliders. Run the simulation by clicking on the **Run** button and observe the motion of the ball. Note how the velocity and time are displayed at each point along the motion. Also watch the velocity vector and its components as they change throughout the motion. Push the reset button and repeat the simulation with a different initial velocity until the ball goes through the center of the window. Record V_{0x} , V_{0y} , and the elapsed time. (You can find the total time by stepping through the motion with the player controls at the bottom of the screen.) Also locate the initial position of the ball by moving the mouse until the cursor on the center of the ball. Read the values for x and y in the coordinate boxes in the lower left portion of the screen. In a similar manner, determine the coordinates of the center of the window. Using your motion equations, calculate what the time of flight should be and compare with the simulation time.
3. Using the player controls, step the motion back to where your projectile is at the very top of its path. Record the values for V_x , V_y , and t at this point. From your initial velocity, calculate what the time should be at the top. How does your calculated time compare with the simulation's time?

4. Run the simulation using a ball speed of $V_{0x} = 6.00$ m/s and $V_{0y} = 8.02$ m/s. Record the horizontal and vertical components of the velocity at various times (using the player controls), completing a table like the one shown below in your lab book. Be careful to record the sign (positive or negative) in all cases.

Time (s)	V_x (m/s)	V_y (m/s)
0.0	6.0	8.02
0.2		
0.4		
0.6		
0.8		
1.0		
1.2		
1.4		

5. Using the data from the table, plot the horizontal and vertical components of the velocity, V_x and V_y , versus time on a single graph in your lab book. Use a different symbol (e.g. \square and \triangle) to mark the data points for the two velocity components. You should observe that one component of velocity changes while the other is constant. Explain.
6. From your graph, find the slope of the line for the vertical component of the velocity by finding the rise over the run. Show your calculation and explain the physical meaning of the result.
7. The horizontal and vertical positions of a projectile in free fall are given by

$$x = x_0 + V_{0x}t + \frac{1}{2}a_x t^2$$

$$y = y_0 + V_{0y}t + \frac{1}{2}a_y t^2$$

Solve each of these equations algebraically for V_{0x} and V_{0y} .

8. Using the results from part 7, calculate V_{0x} and V_{0y} for a time of flight (to the window) of 1.6 s and then run the simulation. Verify that the ball does go through the center of the window for your calculated values of V_{0x} and V_{0y} . Repeat for a time of flight of 1.33 s and 0.5 s. Sketch the shape of each trajectory and discuss the differences in the trajectories. Can you generalize your results?
9. Calculate the initial speed (magnitude of the velocity) and direction (angle above the horizontal) for each of the three simulations discussed in part 8. Put the results from parts 8 and 9 in a table.