Name __________KEY____________________________ Date __________________________ Section ______

Acceleration

Procedure I:

1. Tear off two pieces of masking tape that are about 12 inches long.

2. Place the two pieces on a table or uncarpeted floor. One piece of tape will be the start line and one will be the finish line.

3. Start a ball rolling about a foot before the start line, and allow it to roll about a foot past the finish line.

4. Make a video of the whole ball roll. You can trim the parts that are before and after the start and finish lines in the next step. The video camera should be overhead and perpendicular to the path of the ball roll. It should also be far enough above the path to capture the entire ball roll without moving the camera during the recording of the roll.

5. If Tracker cannot open your video (see next step to try it), open the video file in a video editor such as Windows Live Movie Maker or iMovie. For Windows Live Movie Maker, save the movie as "Burn to a DVD" to get a little higher definition video. Use your name or initials and something like "Floor Ball Run" to name the file. The movie file will have a ".wmv" extension.

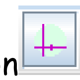
6. Open Tracker and click  in the tool bar at the top of the screen to open your movie file. Prepare the movie for tracking as follows:

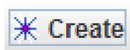
    a. Play the movie in Tracker by clicking the green Play triangle  at the bottom of the screen.

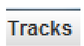
    b. Trim the movie to capture only the section from the start to the finish line. Do this by dragging the left black slider triangle  at the bottom of the screen to the frame showing the ball at the start line. This is the Start Frame.

    c. Drag the right black slider triangle  at the bottom of the screen to the frame showing the ball at the finish line. This is the End Frame.

d. Calibrate by clicking the calibration icon  in the toolbar at the top of the screen. Select the calibration stick from the drop down menu. Drag the ends of the calibration stick to the start and the finish lines. Enter "2" for 2 feet to replace the numbers  already on the calibration stick. After typing "2" hit Enter on the keyboard.

e. Click the coordinate axes button . Drag the origin of the coordinate axes to the start line. Drag the horizontal axis to make it parallel to the direction of motion of the ball roll.

f. Click the  button and select Point Mass from the drop down menu to create a point mass track.

g. Click Tracks  in the toolbar, then New and Point Mass from the drop down menus.

7. Mark the track of the ball rolling down the board by clicking the mouse while holding down the Shift key. (Note that when you Shift+Click, data are added to the data table on the right hand side of the screen, and Tracker automatically moves to the next video frame.)

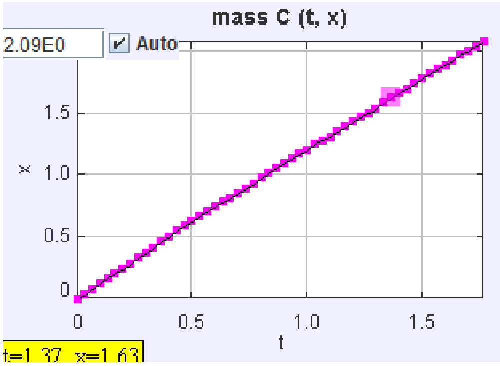
8. From the drop down File menu "Save Tab As" Flat Ball Run with your initials.

Materials:

24" square piece of wall board
Two to four textbooks
Video camera
Balls (or small balls with different masses)
Laptop or desktop computer
Tracker video analysis software (free download)
Quick Time
Possibly Windows Live Movie Maker (or another movie editor like iMovie); depends on video camera save format

Analysis:

Sketch the graph and include the labels for the axes. The "x" on this graph is the position of the ball or the distance it has moved. So this is a position vs. time graph, also called a distance vs. time graph.



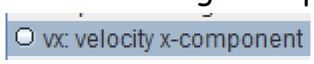
Compare the graph (plot) on the right hand side of the video track screen to the graph you made for the "Slow" part of the graph in the Robot Motion lab.

Both are straight lines, but with different slopes. The slope of the ball roll is steeper than the robot motion, since the velocity of the robot was so much slower.

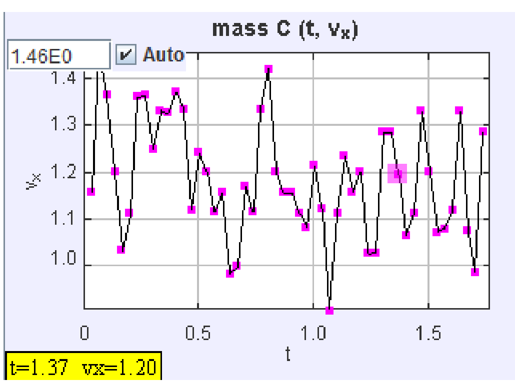
What does the slope of the line on a distance vs. time graph represent? (Hint: It shows change in distance with change in time and has units like feet per second.)

The slope shows the speed or velocity of the moving object.

Click the vertical axis **label**

to change the plot view (graph) from position x to velocity vx in the drop down menu 

. The velocity of the ball in the x direction is shown in this view. Sketch the graph and include labels for the axes. Notice that there is some scatter in the data. On your sketch, draw a "best fit" line through the data to show the velocity of the ball.



The best fit line is a horizontal line drawn along the velocity of 1.2 feet/sec.

What is the velocity of the ball and 0.5 seconds and at 1 second?

The velocity is the same at both times. It is about 1.2 feetl/second.

As time increases along the horizontal scale, does the velocity remain constant, increase, or decrease? Remember to average for the scatter in the data.

Velocity is constant as shown by the straight, horizontal line of the slope.

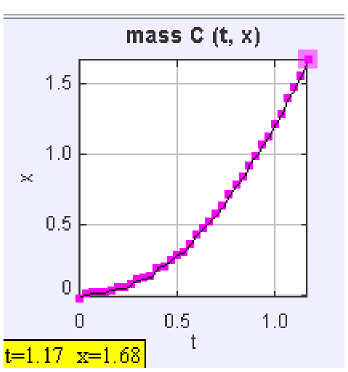
Procedure II:

1. Prop up a 24" piece of gypsum board on the edge of books on the floor. The books should be about 2 inches high.
2. Release the ball from the top edge of the board and allow it to roll down the board onto the floor.
3. Record the rolling ball from the side as you did in the flat ball roll. You can also record the rolling ball from the side with the camera perpendicular to the path of motion. Do not record the ball rolling straight at the camera. This perspective is not helpful for video analysis.
4. Download the video into Windows Live Movie Maker if necessary to change the format. See step 5 in Procedure I. Otherwise open the movie in Tracker. Follow steps 6, 7 and 8 in Procedure I. Trim the video to capture the ball just at its release at the upper end of the slanted gypsum board and until it reaches the lower end of the slanted board.
5. From the drop down File menu "Save Tab As" Ramp Ball Run with your initials.

Analysis II:

Click on the verical axis label to change the plot view from position x to velocity vx (in the drop down menu).

Sketch the graph and include labels for the axes.



How is the velocity (vx) graph for the ball rolling down the ramp different from the velocity (vx) graph for the ball rolling across the floor?

When the ball was rolling across the floor, *the distance vs. time graph gave a straight line. When the ball was rolling down the ramp, the line of the graph is curved. increasing slope)*

Look back at the graph of the moving robot. Compare the steepness of the slope of the line when the robot moved slowly and when it moved quickly.

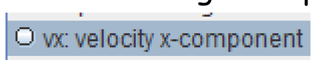
For the slower velocity, the slope of the line was less steep.

Sketch the robot graph again but leave out the "Stopped" and "Backwards" part of the graphs. That means, connect the "Slow" part of the graph with the "Fast" part of the graph.

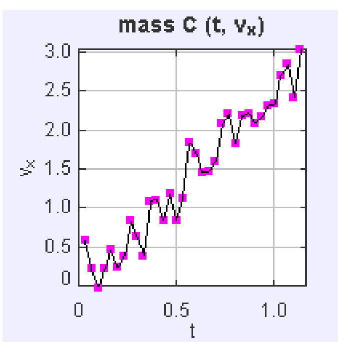
The graph will have a shallow slope starting at time = 0. It will then switch to a steeper slope. The result will be similar to the graph above for the ball rolling down the ramp.

Does this graph show the velocity of the robot remaining the same, increasing (speeding up), or decreasing (slowing down)?

The graph shows the robot speeding up, which is an increase in velocity.

Click the vertical axis **label** to change the plot view (graph) from position x to velocity vx in the drop down menu 

. Place the cursor at the origin and click the checked box to turn off "Auto" for auto scaling and type "0" to set the origin to zero. The velocity of the ball in the x direction is shown in this view. Sketch the graph and include labels for the axes. Notice that there is some scatter in the data. On your sketch, draw a "best fit" line through the data to show the velocity of the ball.



What is the velocity or the ball at 0.5 seconds and at 1 second?

In the above example, the velocity at 0.5 seconds is about 1 foot/second. The velocity of the ball at 1 second is about 2.4 feet/second.

How is the velocity of the ball rolling down the ramp changing with time? (Increasing, decreasing, staying the same?)

The velocity is increasing. It starts out with a slow velocity and speeds up toward the bottom of the ramp.

This change in velocity is called **acceleration**. Did the ball accelerate when it rolled across the floor?

No, the velocity stayed the same, so it did not accelerate.

Did the ball accelerate when it rolled down the ramp? How did you know?

The ball accelerated. The velocity increased as shown by the increasing slope in the velocity graph. The graph shows the ball speeding up with time.

Conclusion:

Explain acceleration in your own words.

Acceleration is change in velocity.

Try this! Increase the upper edge of the ramp by adding more books. Start with two more under the gypsum board. Use Procedure II, and measure a different acceleration.