**Projectile Motion - Video Analysis**

**Background**

So far, we have primarily studied things that move in only one dimension, either horizontal or vertical. In reality, though, many things move in two dimensions, that is, both horizontally and vertically at the same time. One of the simplest examples of two-dimensional motion is a moving ball.

One of the most important things to remember is that while each dimension is separate (don’t mix your horizontal and vertical variables), they can both be written with the same set of equations. The equations for motion are

  

**Goal:** To examine projectile motion two ways: through video analysis of a basketball in flight and also by using a projectile launcher to hit a target.

**Video Analysis**

In this part of the lab, you will watch a basketball shot and track the ball’s flight as it hits the floor and bounces upward. We will look at position vs. time, velocity vs. time, and acceleration vs. time graphs and try to analyze each graph to its corresponding kinematic equation of motion with a constant acceleration.

* Open Logger Pro 3.8.6.1 on your desktop. Go to File→Open…→Sample Movies→Basketball Shot→Basketball Shot. Click on the movie and expand the movie by grabbing the lower, right-hand corner and dragging the corner to the bottom of the screen.
* Click on the “red dot” icon (Add Point) from the column of buttons on the right-hand side and click on the same point on the basketball, frame by frame. Place the cursor crosshairs over the same point on the ball, click on it, and Logger Pro will advance to the next frame automatically.
* Set the scale by clicking on the ruler on the Set Scale button five buttons from the top in the right-hand column buttons. There is a 2-meter stick on the floor. Click on one end of the stick and drag the cursor to the other end. When you release the mouse, you will be asked the distance of your traced line. If you want, you can also set the origin of the coordinate system by clicking the Set Origin button (third from top) then clicking where you want the origin to be in the movie frame.
* Mark the position of the basketball until the movie ends. Be consistent with where you mark the ball. For example, always do the top or middle of the ball.

* Consider the forces on the ball when it is in the following positions: Draw a free-body diagram (including the direction of all forces on the ball) for each of the following circumstances:

|  |  |  |
| --- | --- | --- |
| Being shot by the person | In the air | Hitting the floor |
|  |  |  |

Next, you will create a series of graphs for the projectile. In LoggerPro, you can change what is being graphed by right clicking on a graph and choosing Graph Options→Axes Options. Or, you can left click on the label on the vertical or horizontal axis and choose from the options listed.

Make the graphs listed on the next page, analyze them, and include reasons or explanations with your answers. Remember that graphs are labeled in the form of *vertical vs. horizontal*.

* Create a graph of ***y vs. x***
  + Is this graph a good representation of the trajectory?
  + What is the shape of the curve of the ball’s trajectory **while it is in the air**, not touching the floor or the person’s hands?
* Create a graph of ***x vs. t***
  + Highlight the portion of the data where the ball is in the air after leaving the shooter’s hands. Fit the line with a linear fit (Analyze>Linear Fit). What does this slope signify?
  + Linear relationships are often described as “y = mx + b”, where m is the slope and b is the y-intersect. Using this idea, what is the slope of the best fit line?

* + One of our kinematic equations states that , where . If , (so  at any time) then

, or .

The position can be described as a function of time as Rewrite this equation using the slope of the line and the y-intercept:

x(t) = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* Shade the data where the ball is in the air after it hits the floor. Fit the line with a linear fit (Analyze→Linear Fit). Compare the velocity in the x-direction of the ball  before and after the bounce. What caused the ball to slow down after it touched the floor?

* Create a graph of ***y vs. t***
  + Shade the data where the ball is in the air after leaving the shooter’s hands. Fit the line with a linear fit (Analyze→Linear Fit). Then, fit the line with a quadratic fit (Analyze→Curve Fit→Quadratic→Try Fit→OK). Which fit best describes the vertical position?

* The vertical position can be described as . Rewrite the equation for vertical motion using the coefficients A, B, and C from your quadratic fit:

y(t) = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* Determine the acceleration, ay, from your coefficient A.

ay = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* One would expect the acceleration to be . What is your percent error?

* Repeat the instructions for after the ball hits the floor to the end of the movie.

y(t) = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

ay = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

percent error = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* Create a graph of ***vx vs. t***
* Shade the data that shows after the ball leaves the hand but before the ball hits the floor. (You may need to “trim” some data at the start and the finish.) Go to Analyze>Statistics. What is the mean x-velocity?

* Do the same for the time after the ball strikes the floor to the end of the movie. What is the mean x-velocity?

* Create a graph of ***vy vs. t***
* Use the Linear fit to find the y-acceleration:

While the ball is in the air before the bounce?

During the bounce?

After the bounce?

* Save the LoggerPro file as “yourname basketball” and email it to your instructor and your lab partner..

**Summary Questions**

1. Why did the ball change its x-velocity when it hit the floor?
2. What is the cause (or source) of the y-acceleration while the ball is in the air?
3. What are the causes of the acceleration the ball feels when it is hitting the floor?
4. Gravity is affecting the ball always, even while it is touching the floor. When the ball is touching the floor, which is imparting a larger force on the ball, the floor or gravity? Give reasons behind your answer.