Laboratory Problem II: Battleship

In this laboratory you continue the study of accelerated motion in more situations. The carts you used in Laboratory I moved in only one dimension. However, as you know, objects don't *always* move in a straight line! However, motion in two and three dimensions can be decomposed into one-dimensional motions; what you learned in the first lab can be applied to this lab.

You will study the motions of an object in free fall and an object tossed into the air. In these labs, you will need to consider the effects of *air resistance* on the motion of the objects. Can it always be neglected? As always, if you have any questions, talk with your fellow students or Mr. Gorman.

Objectives:

After successfully completing this laboratory, you should be able to:

- Determine the motion of a projectile from its horizontal and vertical components by considering what quantities and initial conditions affect the motion.

Preparation:

Read Chapter 3 section 1 through 3. Review your results and procedures from Laboratory I. You should be able to:

- Determine instantaneous and average velocities and acceleration.
- Analyze a vector in terms of its components along a set of perpendicular axes.
- Add and subtract vectors.

Problem

Your friends are bored and want to play some game but cannot come up with one. Remembering that we are modeling motion in physics class you come up with playing a game of "battleship." However this game of battleship uses toy dart guns and plastic cups to represent the ships. You that if you measure the distance to the cups you can calculate the angle you need to fire the dart. First you need to know the muzzle velocity for the toy gun. So get to work win that game!

EQUIPMENT

For this problem you will have a toy dart gun, a meter stick, red and white cups to represent ships.

Warm-up

1. Make a large (about one-half page) rough sketch of the trajectory of the ball after it has been launched at an angle. Draw the ball being launched at 3 different angles. Label the horizontal and vertical axes of your coordinate system.
2. On your sketch, draw and label the expected acceleration vectors of the ball (relative sizes and directions) for the five different positions. Decompose each acceleration vector into its vertical and horizontal components.
3. On your sketch, draw and label the velocity vectors of the object at the same positions you chose to draw your acceleration vectors. Decomposes each velocity vector into its vertical and horizontal components. Check to see that the changes in the velocity vector are consistent with the acceleration vectors.
4. Looking at your sketch, how do you expect the ball's horizontal acceleration to change with time? Write an equation giving the ball's horizontal acceleration as a function of time. Graph this equation. If there

are constants in your equation, what kinematic quantities do they represent? How would you determine these constants from your graph?

5. Looking at your sketch, how do you expect the ball's horizontal velocity to change with time? Is it consistent with your statements about the ball's acceleration from the previous question? Write an equation for the ball's horizontal velocity as a function of time. Graph this equation. If there are constants in your equation, what kinematic quantities do they represent? How would you determine these constants from your graph?
6. Write an equation for the ball's horizontal position as a function of time. Graph this equation. If there are constants in your equation, what kinematic quantities do they represent? How would you determine these constants from your graph? Are any of these constants related to the equations for horizontal velocity or acceleration?
7. Repeat Warm-up questions 4-6 for the vertical component of the acceleration, velocity, and position. How are the constants for the acceleration, velocity and position equations related?

Prediction

8. Make a rough sketch of how you expect the graph of the horizontal velocity vs. time to look for the a ball launched at an angle.
   a) Do you think the horizontal component of the object's velocity changes during its flight?
   b) If so, how does it change? Or do you think it is constant? Explain your reasoning.
9. Make a rough sketch of how you expect the graph of the vertical velocity vs. time to look for the object.
   a) Do you think the vertical component of the object's velocity changes during its flight?
   b) If so, how does it change? Or do you think it is constant? Explain your reasoning.

Exploration

These are general steps be sure to detail EXACTLY what your group did.

1. Practice shooting the ball until you can get an idea of where the ball's motion will take it. Measure how far the ball went horizontally and determine the muzzle velocity of the ball. In your analysis of this lab think about how consistent the muzzle velocity is. How does that mimic real situations?
2. From the muzzle velocity, create a table relating the launch angle and the range (horizontal displacement) of the ball. Use angles 0-50 at 5º intervals.

The Game!

1. Set up your game board according to direction on the white board.
2. Measure your opponents battleship positions relative to your starting point. Be sure to only take the horizontal displacement.
3. Based on your trajectory table come up with the appropriate launch angle.
4. Have fun and keep track of what angle works for each ship.

Conclusion

1. Each team has three ships. Use Excel to create a graph (vertical position vs. time) of your trajectory of each ship. Be sure to label all graphs. Did your results agree with your initial predictions? Why or why not? If they do not agree, are there any assumptions that you have made, that might not be correct? What are the limitations on the accuracy of your measurements and analysis?
2. For each of the graphs above create a velocity (v_y) vs. time graph for the.
3. What is the impact velocity for each trajectory? How do these compare with each other. Comment as to why this would be.

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