Projectile Motion: Predicting Landing Spots

Purpose

The intent of this activity is to allow students to use equations to predict the landing spot of a marble and test their hypothesis to see how close their predictions were to the actual results.

Overview

Students have a ramp, table, measuring device (ruler or meter stick), and a marble. The lab is composed of two parts. The first part is where students use equations listed in the “assessment” section to find how far from the table they expect the marble to drop.

When students have found this value, they will place paper (or aluminum foil if available) at the end of the table where the marble is expected to fall. They will mark a line with the predicted distance from the table that it will fall. Students will release the marble at the top of the ramp and see how close the landing prediction line and the actual landing spot are to each other when the marble flies off the table.

Student Outcomes

Students will learn how they can use physics and math to accurately predict real world occurrences, with the focus on projectile motion.

Time

Students should be allowed time to make predictions and complete the lab. This will likely take 20-25 minutes in total.

Level

The activity is intended for high school and secondary school students.

Materials and Tools

Students will need the following materials to complete this activity. They would also benefit from having paper to record data, predictions, and write out the calculations.

- Flat table
- Ramp (cardboard or bent ruler)
- Marbel
- Meter stick

- Timing device

Preparation

The ramp should be at the end of the table. Students should all have a meter stick, marble, and stopwatch.

Prerequisites/Prelab

Students should understand that the distance that an object falls can be measured by using velocity and the height of the table as well as the acceleration of gravity.

Procedure

Students should follow the following two procedures to both solve for the predicted distance that the marble will fall from the table and the actual value.

Prediction:

Students will be predicting how far from the table the marble will land. Depending on the angle of the ramp, they will find different values. There can be any angle, but it has to stay constant throughout the whole experiment.

1. Measure the height from the surface of the table to the floor.
2. Calculate the time it will take for the marble to fall using the following equation:
   $T_{fall} = (\frac{2h}{g})^{0.5}$
   The h value is replaced by the height value found in step one, and the g value is the acceleration of gravity, which is $9.8 m/s^2$.

This value should be recorded.

3. To find the velocity, measure the distance from the bottom of the ramp to the very end of the table. Do NOT include the length of the ramp at all.
4. Time how long it takes for the marble to travel across this distance. Again, do NOT include the time on the ramp. It may be helpful for this step to perform three time trials in order to have the most accurate data.
5. Take the average of the three time trials
6. Divide the distance found in step three by the average time found in step five. This is the velocity value.

To find how far the marble is expected to fall from the table, multiply the time value from the end of step two by the velocity value from step six. (x = v * t)

Lab:

Students should have recorded the predicted distance to check to see if their value is correct by using the following steps.

1. Do NOT move the ramp at all after the prediction has been made. Changing the distance of the ramp from the end of the table or the angle can lead to error in the experiment.
2. Place aluminum foil at the end of the table, so it covers where the marble is likely to land. If aluminum foil is not available, paper can also be used, but it will just be more difficult to see where the marble lands.
3. Measure from the end of the table the predicted distance found previously. Mark that distance with a line across the aluminum foil.
4. Release the marble from the top of the ramp. **Make sure not to push the marble down the ramp at all.**
5. Look to see how close to the line drawn in step three the marble lands. There will be a small dent/crater showing where the marble landed.
6. Students can measure the distance between where the marble landed and the line that they drew to see how accurate their prediction was.

Students should create a table to show the values that they found.

Ramp Height (m)	Table Height (m)	T_1 (sec)	T_2 (sec)	T_3 (sec)	Ave_{time} (sec)	Ave_{vel} (m/s)	T_{fall} (sec)	Predicted Distance (m)	Actual Distance (m)	Difference Between Distances (m)

Additional Information

Students should understand that even if the marble did not land right on the predicted line, it does not mean that their calculation was necessarily incorrect. There are other factors that can lead to the difference such as the ramp being moved slightly, if the marble does not travel in a completely straight line, and/or if the surface is not completely flat.

There is also air and surface friction working against the marble that the prediction does not account for, however, the friction force should not lead to any noticeable differences between the predicted and actual distance.