**Please do all of this in your lab notebook.** [**https://phet.colorado.edu/en/simulations/category/physics**](https://phet.colorado.edu/en/simulations/category/physics)

 **Projectile Motion (You may have to go through PUFFIN to access this simulation.)**

Title: Projectile Motion Simulations

Purpose: Apply what was learned about kinematic equations in two dimensions, by using simulations to analyze data and observe patterns.

**[You do not have to write the procedure in your lab notebook]**

**Procedure:**

 **(1) Make a table (with lines!) (Table 1) for these objects:**

 **mass in kg diameter in meters drag coefficient (turn on air resistance for this value)**

 **golf ball**

 **baseball**

 **bowling ball**

 **piano**

 **Buick**

**All simulations at initial velocity of 18 m/s.**

 **(2) Erase everything. No air resistance. Bring cannon to the far left of the screen. Make sure it’s not “on a platform”. The evidence of this is that firing results in a height of -1.2 m. Sound effects are optional ☺.**

 **(3) For each object, change only the angle, then fire and record the range and time. DO NOT ERASE between each angle change so the trajectories for a given object can be shown on one screen.**

 **(4) Either DRAW the trajectories for each object as accurately as possible OR print the screen and cut and paste it into the lab notebook. This is Figure 1. Label all parabolas !**

 **(5) Draw these two tables (with lines !) (Table 2) of the ranges in meters and (Table 3) time in seconds as shown below.**

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 **Table 2: The initial velocity is 18 m/s. The ranges are in meters.**

 **\_\_23⁰ 39⁰ 45⁰ 51⁰ 55⁰ 67⁰\_\_\_\_\_**

 **Range Range Range Range Range Range\_\_\_\_**

 **golf ball**

 **baseball**

 **bowling ball**

 **piano**

 **Buick**

 **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

 **Table 3: The initial velocity is 18 m/s. The times are in seconds.**

 **\_\_23⁰ 39⁰ 45⁰ 51⁰ 55⁰ 67⁰\_\_\_\_\_**

 **Time Time Time Time Time Time\_\_\_\_\_**

 **golf ball**

 **baseball**

 **bowling ball**

 **piano**

 **Buick**

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

 **(6) Still with an initial velocity of 18 m/s, set the angle to 45 degrees. DO NOT ERASE between firings. Fire all five objects on the same screen. Note what happens. One of the questions will refer to this observation.**

 **(7) Keep the initial velocity at 18 m/s and the angle at 45 degrees. DO NOT ERASE between firings. Fire the BOWLING BALL without air resistance, then with air resistance. Then fire the PIANO without air resistance then with air resistance. Then fire the BUICK without then with air resistance. Observe the pattern.**

 **(8) DRAW THE SCREEN OR PRINT IT OUT then cut and paste. This is Figure 2. Label all parabolas !**

 **(9) Choose the bowling ball. No air resistance. DO NOT ERASE between firing. Fire the ball at 35 degrees at these three velocities: 10 m/s, 15 m/s, and 18 m/s. Repeat for 45 degrees. Then repeat again for 55 degrees Draw and label these 9 parabolas. This is Figure 3.**

 **Questions: This is the last part of the lab report. So, the lab report consists of a title, purpose, three tables, three figures, and questions. Write the questions then answer them.**

 (A) Why is the height always -1.2 meters? What does this say about the symmetry of the trajectories of these objects?

 (B) Referring to TABLE 1, what seem to be the factors associated with an increase in the drag coefficient?

 (C) Referring to TABLE 2, for which pairs of angles would you expect the range to be the same? (Refer to Figure 1)

 (D) Referring to question (C), what is the variable that might account for the differences in those ranges. (Refer to question (A).)

 (E) What is the angle of the maximum range? Does this hold true for all objects?

 (F) How do the ranges for each object compare for the same angle? Why is this true?

 (G) Referring to TABLE 3, what variable seems to make the greatest impact on the time? Be specific.

 (H) Referring to Figure 2, what can be observed about an object’s path without air resistance compared to its path with air resistance?

 (I) Referring to Figure 3, what can be observed about an object’s path when the angles AND the initial velocities change?