Projectile Simulation Lab Activity   Name:_____

A projectile is defined as any object that is launched into the air. Like any other object, the motion of a projectile is determined by Newton's Laws; the forces acting on the object determine the magnitude and direction of the object's acceleration. The two most common forces that act on projectiles are gravity and air resistance. Air resistance behaves like friction except that its value increases the faster you are going.   However, in most situations in this class we will treat air resistance as having a negligible influence on the motion of a projectile. If this is the case, then gravity is the only force acting on the projectile and it becomes very simple to calculate the trajectory, or path, a given projectile will take.

In this lab, we will first examine the effect air resistance has on a projectile and determine under what circumstances the air resistance can be ignored. We will then examine the conditions under which the motion of a projectile is affected. Click on this link to open the Projectile Firing Arena. Or, type in the following: http://phet.colorado.edu/simulations/sims.php?sim=Projectile_Motion

EXPERIMENT 1: Air Resistance

Under what circumstances can air resistance be ignored? There are several factors we can change in this simulation that can help us answer this question. We will focus on the physical attributes of our projectile. Namely, its mass, its size, and its launch speed. Whenever the trajectory of the projectile fired in the absence of air resistance is almost overlapping the trajectory when air resistance is present, we can claim that air resistance had little to no effect on the trajectory. Fill out Table 1 on your data sheet by entering the proper values as indicated in the table and determining the effect each has on the trajectory.

EXPERIMENT 2: The Motion of Simple Projectiles

EXERCISE 1:   If air resistance is negligible, a projectile experiences only one force: gravity. Since gravity acts vertically, we expect a projectile to accelerate vertically. However, since there is no force acting in the horizontal direction, the horizontal motion of a projectile should not change. We will test this idea by launching a pumpkin horizontally from a height in the air at different speeds and checking to see how the range and time spent in air are affected. Click and drag the wheel of the cannon to raise the cannon to be 19.62 m in the air. The tape measure on the ground should help you with this. Fill out Table 2-1 by entering the appropriate values for speed and checking the results at the top of the screen.

EXERCISE 2:   If a projectile is launched at some angle, it will start with both horizontal and vertical velocity. How does this affect the trajectory? We expect it to depend on how much horizontal velocity and how much vertical velocity the projectile has. Set the cannon back at ground level. Fill out Table 2-2 by entering the appropriate values for the launch angle and initial speed in the simulation and finding the range and

maximum height gained by the pumpkin. Except for the time, you won't be able to use the values at the top to fill out the table. Instead, use the tape measure to determine the maximum height of the trajectory and the range. Measure from and to the gray horizontal line, as this represents the level from which the pumpkin was launched. For the range, the tape measure should be set so its red crosshairs align with the red crosshairs of the cannon's wheel as this represents the starting point of the pumpkin's trajectory.

Now, use the tables you have created to answer the activity questions.

TABLE 1 – The Effect of Air Resistance

Firing #	Air Resistance	Initial Speed (m/s)	Mass (kg)	Diameter (m)	Paths different? (Y/N)
1	off	20	2	0.1	
2	on	20	2	0.1	
3	off	15	2	0.1	
4	on	15	2	0.1	
5	off	10	2	0.1	
6	on	10	2	0.1	
7	off	20	10	0.1	
8	on	20	10	0.1	
9	off	20	50	0.1	
10	on	20	50	0.1	
11	off	20	2	0.01	
12	on	20	2	0.01	
13	off	20	2	0.5	
14	on	20	2	0.5	

TABLE 2-1 – Horizontally Launched Projectiles

Firing #	Initial speed (m/s)	Angle (degrees)	Range (m)	Height (m)	Time (s)
1	0	0			
2	2	0			
3	5	0			
4	10	0			
5	15	0			

TABLE 2-2 – Projectiles Launched at a Positive Angle

Firing #	Initial speed (m/s)	Angle (degrees)	Range (m)	Height (m)	Time (s)
1	15	5			
2	15	10			
3	15	15			
4	15	20			
5	15	25			
6	15	30			
7	15	35			
8	15	40			
9	15	45			
10	15	50			
11	15	55			
12	15	60			
13	15	65			
14	15	70			
15	15	75			
16	15	80			
17	15	85			
18	15	90			

Activity Questions:

Exercise 1:
1. As the velocity of a projectile increases, does the trajectory with air resistance get closer to or further from the trajectory ignoring air resistance?

2. As the mass of a projectile increases, does the trajectory with air resistance get closer to or further from the trajectory ignoring air resistance?

3. As the size of a projectile increases, does the trajectory with air resistance get closer to or further from the trajectory ignoring air resistance?

4. Based on these questions, under what circumstances can air resistance be ignored?

Experiment 2-1:

5.   How does the initial speed of a projectile launched horizontally affect the
        range of the projectile?

6.   How does the initial speed of a projectile launched horizontally affect the
        height the projectile falls through?

7.   How does the initial speed of a projectile launched horizontally affect the time
        the projectile spends in air?

8.   Is there any mathematical relationship between the range and the horizontal
        launch speed? If so, what is it?

Experiment 2-2:

9.   How is the range of a projectile affected by the launch angle?

10.   How is the maximum height the projectile achieves affected by the launch
        angle?

11.   At what angle should an object be launched to get a maximum range?

12.   At what angle should an object be launched to achieve maximum height?

13.   In this table you may notice that certain launch angles result in the same
        range. Arrange these angles side by side. Is there any mathematical
        relationship between the angles? If so, what is it?

14.   How is the time spent in air affected by the launch angle?