Two Dimensional Motion

By Robert McGee

Introduction

Two dimensional motion is described as the motion of an object that has both x and y coordinates. When you shoot a basketball, you are shooting it at an angle. This allows the ball to travel to the basket, and high enough, so that it will go through the basket. The motion in the y-direction is due to gravity; gravity will accelerate the ball towards the floor. There is no acceleration in the x-direction, so the motion will be described by the velocity and the time.

Background

When dealing with these problems, the most important thing to know is that gravity is what is pulling the object towards the earth. One can use the following equation:

$$y_f = y_i + v_{yi}t - \frac{1}{2}gt^2$$

To obtain the time it takes for an object to fall to the ground. When you get this value of time, you can use it to figure out the motion of the x-direction with the following equation:

$$x_f = x_i + v_{xi}t$$

Now you can get how far the object has traveled in the x-direction. Another important thing to note is that projectile motion deals with objects that may be fired at angles. For this case, you must break down the velocity into its x and y components. This is done using the trigonometric identities:

Vectors

$$v_{xi} = v_i \cos(\theta)$$
$$v_{yi} = v_i \sin(\theta)$$

Please pay very close attention to this fact, if you use the wrong velocity, you will get the wrong answer!

Ex:

A cannonball is fired at 400mph, 30 degrees from the horizontal. What is its initial velocity in the x and y direction?

$$v_{ix} = v\cos\theta = 400\cos 30 = 346.4mph$$
$$v_{iy} = v\sin\theta = 400\sin 30 = 200mph$$

As you can see, the cannonball has velocities in the x and y direction. By using trigonometry, we can find those velocities like we did in the above example.

IV. Equipment List

-Car   -Vernier Motion Sensor
-Ruler   -Carbon paper
-Hot Wheels Booster   -Hot-Wheels Track
-Tape   -Photogate
-PC   -Logger *Pro* interface

V. Experimental Procedure:
Getting the initial velocity

1) Place the hot wheels booster on the table, and make sure that the batteries are charged.

2) Connect the hot wheels track to the designated part of the booster and place a Photogate at the end of the track and position it so that the car is detected by the Photogate as it passes underneath. Check figure 2 below.
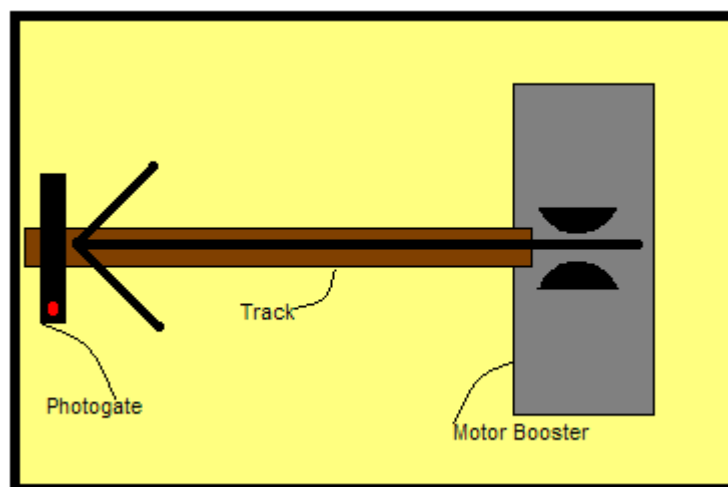

Figure 2 (top view)

3) Connect the Logger *Pro* interface to the computer and make sure that it is able to collect data. Then measure the length of the car, so you can calculate the velocity after it passes the

Photogate (use $v = \dfrac{length\_of\_car}{distance,\ meaning\_how\_far} = l$) and record it. Also measure and record the value of the distance, meaning how far from the table the car fell.

4) Click collect [▶ Collect], turn on the booster so that the rubber wheels begin to spin, then take the hot wheels car and place it in the booster.

5) When ready gently push the car into the booster wheels and allow it to be launched from the booster passing through the Photogate; let the car fall from the table and record the distance from the table to the exact dropping spot of the car. Also record the height of the table (y-direction).

6) Repeat this procedure three times. Collect and record the data.

Photogate Sensor Measurement				
Trial (θ=90 degrees)	Velocity (Vi) (m/s)	Time t (s)	x-direction (m)	y-direction (m)
1				
2				
3				
4				
5				

Analysis

1. What would happen if you used a car that was heavier? What would be most affected by using a heavier car?

2. Calculate how far the car would go if it jumped off a 20 degree ramp off the table using the initial velocity of your last run?

3. On the moon, gravity is 1/6 here on Earth. How far would the car in problem 2 go on the moon?