Will It Make It?

Blaise Waligun, Colby Karnes, Emily Miller, Greg Bronsberg, and Kathryn Waclawski
Professor Mager, Physics 211
PennState Wilkes-Barre

Synopsis:

A toy car longs to smash and crash, but sometimes to achieve its "demolishing derby" dream, it must overcome obstacles in its path. This experiment is a 2-D, Physics-based, experimental-investigation on which path is the best to maneuver over a wall that is in the toy car's path, and how different angles will affect the trajectory of the toy car as it is launched off a ramp and over a wall. With repeated launch trials by means of a constructed device, off a ramp, with changing angular values, an optimal ramp angle is hoped to be found to maximize distance whilst clearing the wall. Will it make it?!

Methodology:

The fact of whether or not the car makes it over the obstacle is dependent on the car's trajectory, initial velocity, and the length of the desired jump-obstacle.

Velocity is a vector which is defined by a change in distance over time. In order to calculate it, distance must be divided by time. A time needed for the car to travel 5 cm just before becoming airborne was recorded. In order to find a more constant number for time, the times recorded from the 5 trials were averaged.

$$v = (5\text{ cm})/(\sum t/5)$$

The setup used recorded times in milliseconds, but velocity was then converted into meters per second rather than centimeters per millisecond.

$$\text{cm/ms} \times (1\text{ m})/(100\text{ cm}) \times (1000\text{ ms})/(1\text{ s}) = \text{m/s}$$

Since velocity was recorded at an angle, it had to be further broken down into its x and y components.

$$v_y = v_i \sin\theta$$
$$v_x = v_i \cos\theta$$

To see if the car will achieve the required height to clear the obstruction, the amount of time the car is airborne, before hitting the obstruction, must be found. This can be easily done by manipulating the definition of velocity.

$$d/t = v$$
$$d/v = t$$

With an equation for time, distance in the x direction (.45m) and the velocity in the x-direction can be used to see the time allocated per jump.

$$(0.45\text{ m})/v_x = t_{airborne}$$

To find the height achieved in the y-direction before the car crashes into the obstacle, a kinematics equation can be used.

$$d_f = d_i + v_{iy} t + 1/2\, a_y\, t^2$$

Initial velocity in the y-direction, acceleration in the y-direction, and time are all known and calculated variables, making the equation for displacement a simple calculation. Since there was an initial displacement of 0.06 m, it was added to the value. There is a negative acceleration in the y-direction due to gravity of -9.8 m/s².

$$d_f = (0.06\text{ m}) + v_{iy}\, t + 1/2\,(-9.8\text{ m/s}^2)\, t^2$$

Timing:

The timing system works through the use of two photo sensors. Each photo sensor is made up of a laser and a CDS cell.

The laser is pointed into the receiving CDS cell, and when the laser is interrupted by any object, the resistance of the CDS cell lowers and turns on a transistor. This triggers a timer to start or stop because there is not enough light hitting the CDS cell to keep the transistor off. The circuit used is much like the circuit used in a light sensitive night light.

When no light shines on the sensor (CDS cell), the light turns on, and when it is daytime and bright in the room, the light is off. Simply, the circuit sends a signal from the first sensor to start a timer; the next sensor sends the same signal telling the timer to stop.

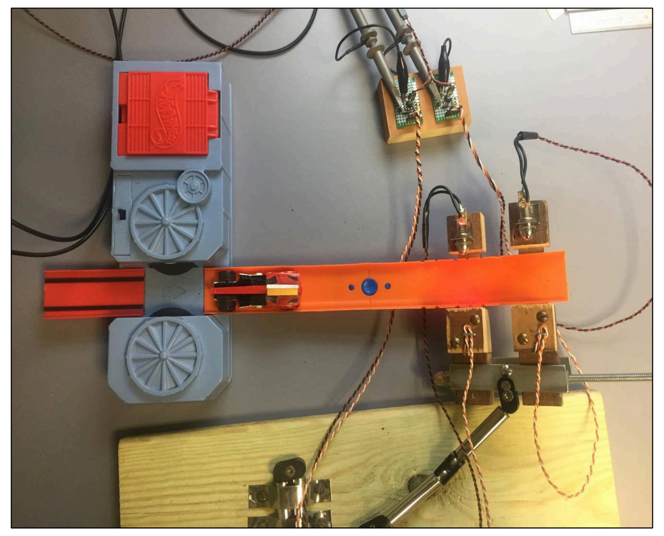
The timer used with the two sensors gives a precise and accurate measurement of time. By use of a universal counter to measure the time, the only error in the time measurement is equipment related.

Because the time measuring system uses two identical sensors, any error is repeated between them and thus negated. This leaves the accuracy of the universal counter, deemed accurate enough due to recent calibration by a certified calibration lab. All of these factors give the most precise and accurate time measurement possible.

Angle	T1	T2	T3	T4
20	10.09	11.54	11.52	11.27
25	10.54	11.41	10.78	11.28
30	10.84	10.97	11.12	12.17
35	11.3	10.4	13.05	12.66
40	12.65	12.37	11.21	15.49
45	10.53	18.06	19.73	18.19
50	17.59	18.14	18.14	17.6
55	17.3	16.89	17.39	17.63
60	21.48	20.01	19.73	20.41
65	20.43	15.52	24.85	20.39
70	17.96	23.07	26.92	21.3

"To see if the car will achieve the required height to clear the obstruction, the amount of time the car is airborne, before hitting the obstruction, is necessary. This is easily found my manipulating the definition of velocity," (see "Methodology".)

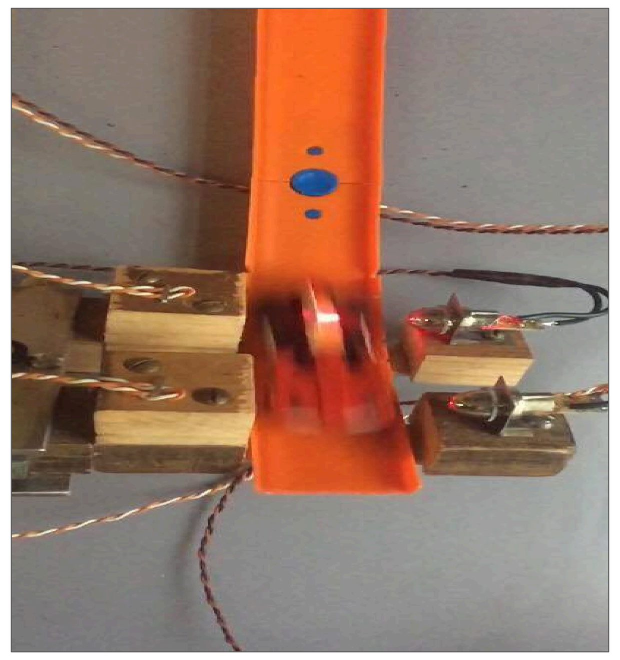
Actual Height Achieved	Adjusted for beginning height
0.107622643	0.167622643
0.149635101	0.209635101
0.192715829	0.252715829
0.237616236	0.297616236
0.248334056	0.308334056
0.21825364	0.27825364
0.221434343	0.281434343
0.28059912	0.34059912
0.134539456	0.194539456
-0.016049333	0.043950667
-0.542060974	-0.482060974

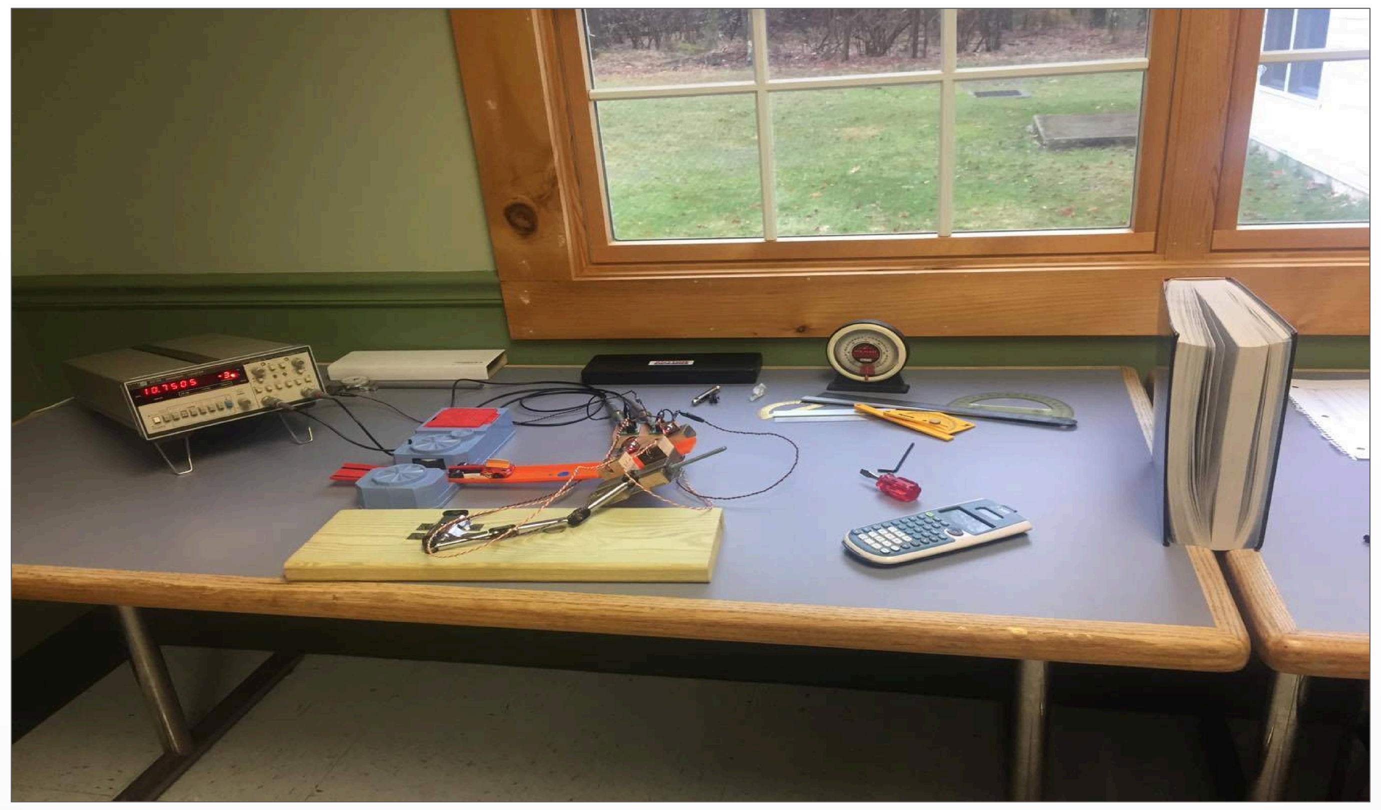


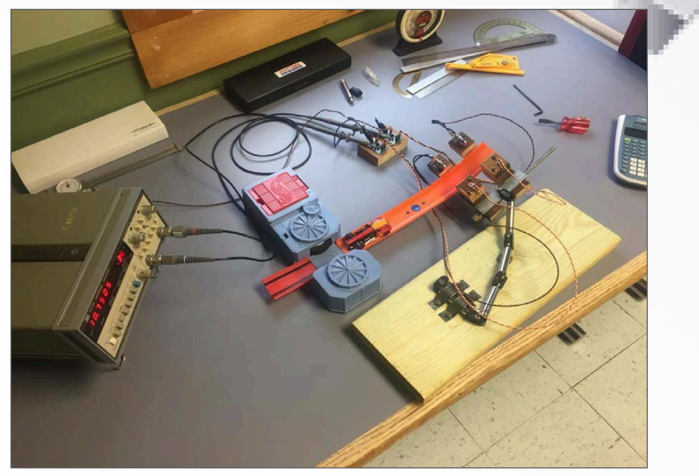
This experiment requires the test to be repeated at least five times for the upmost accuracy. After the date for each trial is recorded (in milliseconds), they are averaged, varying in angle size, to calculate the average times.

Velocity (m/s)	Vx	Vy
4.476275739	4.206594138	1.530232088
4.483500717	4.063850649	1.893910395
4.445234708	3.850276024	2.221595406
4.373687894	3.583492091	2.507534691
3.619516433	2.773533707	2.325598844
2.927400468	2.07080875	2.069160366
2.762430939	1.776592397	2.115359106
2.886836028	1.65697172	2.363951558
2.480404802	1.241342616	2.147434863
2.37846066	1.006420493	2.155038957
2.181691247	0.747451982	2.049656613

As the angle increases, it becomes more and more difficult for the car to maneuver over its obstacle, hence the eventual and inevitable failures. These failures can be seen as decreased or negated variables shown on the chart above.







Angle	Trail 1	Trail 2	Trail 3	Trail 4	Trail 5	Calculated Success	Will it make it?
20	F	F	F	F	F	No	No
25	F	F	F	F	F	No	No
30	F	F	F	F	F	Yes	No
35	F	F	F	F	F	Yes	No
40	S	S	S	S	S	Yes	Yes
45	S	S	S	S	S	Yes	Yes
50	S	S	S	S	S	Yes	Yes
55	S	S	S	S	S	Yes	Yes
60	S	F	S	F	S	No	No; Error in Data
65	F	F	F	F	F	No	No
70	F	F	F	F	F	No	No

Reasons for Error:

There are various gaping holes for errors to manifest themselves within this project..

1. Due to constants, such as drag, the experiment eventually proceeds to decrease, making it harder and harder to maintain successful trials.

2. The setup also complicated the experiment; for instance, the wooden blocks withholding the lasers would often get in the way of the toy car, stopping the trial completely. Because of this, the trial would have to be redone..

3. Human error can always be a reason as to why something doesn't go as planned. For instance, there is a possibility the experimenters misuse or even use the wrong formula to determine the calculated velocities and heights, or the setup could have been built incorrectly.

Conclusion:

The test was deemed successful only if the angles were precise for the toy car to successfully jump over the book whilst in mid air. Drag, whilst the toy car was airborne, complicated the toy car from making said jump, which caused ending results to all be deemed failures.

References

1. Fitzpatrick, Richard. "Projectile Motion with Air Resistance." Projectile Motion with Air Resistance. Richard Fitzpatrick, March & April 2011. Web. 02 Apr. 2017.

2. Ohanian, Hans C., and John T. Markert. Physics for Engineers and Scientists. 3rd ed. London, U.K.: W.W. Norton & Company Inc. , 2007. Print.