Physics Standard level

Internal Assessment

Research question:

What launch angle of the Nerf gun gives the dart furthest distance?

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Introduction:

Due to my curiosity and interests in physics, I would like to contribute many aspects in different area of physics. In this investigation, I would like to make experiment related to parabola. Parabola (according to dictionary.com) is a plane curve formed by the intersection of a right circular cone with a plane parallel to a generator of the cone. In simple word, a curve of an object that appears when throwing it into the air and dropped back down due to gravity. I would like to take a closer look in to the angle of particular object that can create the greatest distance from the same point. Which angle that the person throw will maximize the distance the most, and create the perfect and longest parabola. The entire lab will be based on the following research question:

What launch angle of the Nerf gun gives the dart furthest distance?

Nerf Gun

What is Nerf gun? Nerf is a toy brand that sells different types of toy of foam-based weaponry, the Nerf guns is one type of Nerf toys that shoot ammunition made from Nerf foam. It might be very strange to use a toy in an experiment, but I believe in this situation, Nerf gun is the best cannon for shooting objects. In this experiment, it required a person or thing to apply the same force for all of the tries. It is impossible for people to manage and control their strength precisely to make each tries in a fair state. Where the Nerf gun apply the same force to all darts each time, which makes the Nerf gun suitable for this experiment.

How Nerf Gun works

There is a piston inside the Nerf gun, the piston has been pulled back against the force of the spring and it locked with a latch that links to the trigger. At the tip of the spring connects a plunger. The Nerf gun now stored potential energy, and the chamber's value is now large. When the trigger is pulled, the piston has been released from the latch and the spring forced the plunger to move forward, causing the volume of the

chamber to decrease and increase in air pressure. The air pressure applies force that cause the only move able object (dart) to blast off. Since the length of spring, volume of chamber, length of Nerf gun, and weight of dart does not change, it gives the perfect condition for fair experiment.

Apparatus:

- Meter ruler and rope
- Pen, Marker and Paper
- Nerf Gun model: Nerf N-strike Elite strong-arm blaster slam fire.
- Nerf Gun Dart
- Table
- Tape and scissor
- Protractor

Photo of the Nerf gun: Nerf N-strike Elite strong-arm blaster slam fire

Instruction

Step 1: Place Meter ruler and rope on the ground and put a table at the end of the Meter ruler.

Step 2: Create a giant protector by using paper and pen, and protractor. (Bigger size than the gun)

Step 3: Place the gun and created protractor on the table, mark the gun position and place the created protractor next to Nerf gun.

Step 4: Use the created protractor to determine the angle of recording experiment, and launch the dart of Nerf gun.

Step 5: Wait until the dart stopped completely before measuring the distance from the table to the location where dart contact with surface of the floor.

Step 6: Record down the distance on piece of paper.

Step 7: Reload the Nerf gun dart.

* Repeat step 4 to step 7 with different angles in the experiment.

* Location will be held in a large area of indoor, without any wind or disturbance.

* Location used: School Gym

Theoretical Background

In the area physics named Kinematics has related formula to calculate the maximum distance an object can reach in certain angle. By seeing this experiment, there are two opponents needs to be consider in - X(t) and Y(t). X(t) represents the dart traveling in horizontal position in an ideal situation, with no accelerations, wind, or air-resistance. Where Y(t) is the vertical changes due to the gravitational force. We can use these two elements to calculate the maximum angle for the furthest distance travel.

$$X(t) = X_0 + V_0 \times t + \frac{1}{2} \times a \times x \times t^2$$

$$= V_0 \times \cos\theta \times t$$

$$Y(t) = Y_0 + V_0 \times g \times t + \frac{1}{2} \times a \times y \times t^2$$

$$= V_0 \times \sin\theta \times t - \frac{g}{2} \times t^2$$

$$= (V_0 \times \sin\theta - \frac{g}{2} \times t) \times t$$

When $Y(t) = 0$, $t = 0$ and/or $V_0 \times \sin\theta - \frac{g}{2} \times t = 0$

By rearranging $V_0 \times \sin\theta - \frac{g}{2} \times t = 0$

$$V_0 \times \sin\theta = \frac{g}{2} \times t$$

$$V_0 \times \sin\theta \times 2 = g \times t$$

$$t = \frac{2 \times V_0 \times \sin\theta}{g}$$

Using substitution of $t = \frac{2 \times V_0 \times \sin\theta}{g}$ to X(t):

$$X_{max} = \frac{V_0 \times \cos\theta \times 2 \times V_0 \times \sin\theta}{g}$$

$$= \frac{V_0^2}{g} \times 2 \times \sin\theta \times \cos\theta = \frac{V_0^2}{g} \times \sin 2\theta$$

The maximum of sin in graph can get is $90°$, $2\theta = 90°$, $\theta = 45°$

Therefore, by using the formula can proof the best angle is $45°$ in scientific way.

Hypothesis

Based on the calculations shown in the section - theoretical background, i will follow the scientific method to state my Hypothesis. The best angle that the dart will launch the furthest would be at $45°$. In other word, any angle that is less than or more than $45°$ will have lesser distance comparatively. The data will be fully analysis with tables and graphs to support or against my theory.

Data

Angles (Degree)	Distance (cm)			
	Tries 1	Tries 2	Tries 3	Average
90	119	49	-3	55
80	220	277	214	237
70	639	627	702	656
60	1270	1341	1280	1297
50	2020	1569	1697	1762
45	2265	2264	2290	2273
40	2110	2290	2377	2259
30	2135	2228	2318	2227
20	2105	2176	2164	2148
10	1602	1635	1657	1631
0	847	1023	505	792

Weight of Dart (oz)	Height of Nerf gun placed (cm)
0.05	64

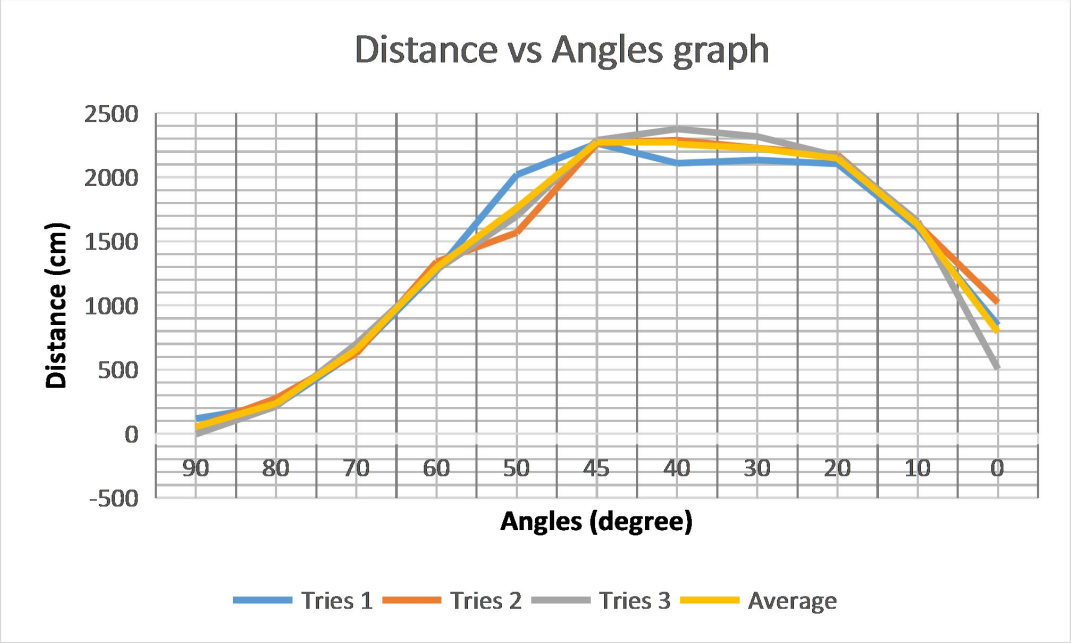
Dimensions of Nerf gun in centimeter (cm)

Height (cm)	Length (cm)	Width (cm)
16.4	29.5	3.9

Dimensions of Nerf gun dart in centimeter (cm)

Radius (cm)	Length (cm)	Volume (cm^3)
0.6	7.1	8.03

Graph



Analysis

The recordings of numbers are all calculated in average, in this way it is much easier to find the most accurate results. 3 tries is a reasonable amount of times to test the experiment, the more tries means the more reliable the result it is.

(Try 1 + Try 2+ Try 3) / 3 = Average Tries Distance

Based on the recording above, we can clearly sees the curve of the graph and the changes in the table number. The records had proofed that my hypothesis is correct. By the point of 45 degree, it is the maximum distance the Nerf gun can travel. The curve of the graph shows the change of the distance while changing in angles.

Although, the experiment contain different situation compare to the theoretical background. The Y(t) should be starting on 0 ground level and landed on 0 ground level, but this experiment place the Nerf gun in 64 cm above ground. There are possibilities of the chances will make the table of data and result graph wrong, however, it came out successfully in a nice curvy line that indicates the 45° is the best angle for launching greatest distance.

Counter difficulties

- Darts hitting roof

- Even though the experiment is held in the gym, the height should be enough to do the experiment. However, the force that the gun can apply on the dart is larger than i expected, it constantly hit the roof top while firing the dart. The experiment became much more complicated and difficult to get the absolute correct result, I only record the result that did not have any contact with the roof top or building structures. I had considered another location for the experiment, but the place we have is not considerable. Outside is too windy for the researcher, the result will be hugely effected by outside factor, in other indoor building contain much lower height to even do the experiments. Therefore gym is the only suitable options to run the tests, much more effort and time had involved by doing the experiment. Because I will have to restart one specific test angle if one dart had hit any objects.

Error and Future Changes

There are many possible areas that contain errors can effect the result significantly, here are few things that I recognized and spotted during the experiment that needed to improved and edit.

- The dart bounces

- The dart is made by soft foam, so when it make contact with the ground, it won't stay in the same place, it bounces. The record will always be on the spot where it first hit the ground, so i have to record it by using visual to provide the values. For the future reference, it would be better to have two people in this experiment, one launch the Nerf gun and other one stay next to the meter ruler and do the recording. It will minimized the error in recording of the dart position.

- The protractor is not accurate enough

- Although the protractor is very large that can put the Nerf gun next to it reading and placing the Nerf gun as stable and exact the angle as it can, the accuracy is not

enough human reading and placing the Nerf gun cannot be very precise, it can shakes in between angles and cost the ending result significantly. However, imagining if there is a stand that can hold the gun in place and project the Nerf gun in different angle, the result will be far more accurate and reliable.

Conclusion:

Based on the experiment above, it have successfully answers the research question: In what angle of the Nerf gun does it launch the dart furthest distance? The tables of results and plotted diagrams had successfully provide enough evidence to support my hypotheses. It is a great experiment for understanding the physics behind the research, it is important to test out things by one-self than listen to others believes. This research had proofed me that at the point of 45 degrees, the object can be launched in the furthest distance.

Bibliography:

"How Do Nerf Guns Work?" - *Quora*. N.p., n.d. Web. 17 Feb. 2016.