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MTH 229

12-5-2016

Project: Toy Cannon

I have a toy cannon sitting atop a table and manage to hit a mark on the floor that is 10ft from the table. Using a 4ft table and a Nerf N-Strike Maverick, I was able to calculate the angle and time it would take to hit the mark. Some things that were not taken into account or assumed would be the gravity of the earth, the cannon being fired straight at the mark to where a third dimension wouldn't be necessary, and that air resistance wouldn't play a factor in the darts path and velocity. Using excel and free fall equations to explore possibilities, two real answers were finally reached.

Equations Used:

$$y(t) = \left(-\frac{1}{2}g\right)t^2 + v_y t + y_0$$

$$x = v_x t + b$$

$$v_y = V_o \sin(\emptyset)$$

$$v_x = V_0 \cos(\emptyset)$$

$$Degree = radian(\frac{\pi}{180})$$

Subscripts:

V_y= velocity in the y-direction (vertical)

V_x= Velocity in the x-direction (horizontal)

V_0= Initial Velocity

Information Found:

Table Height= 4ft

Initial Velocity of Nerf N-Strike Maverick= 44.6ft/s

Gravity= 32 ft/s^2

Based on this information I was able to find two answers that satisfied my original statement of firing a toy cannon atop a table and manage to hit a mark on the floor that is 10ft from the table. Using the nerf gun which has an initial muzzle velocity of 44.6 I found that it could be shot at two angles and still hit the same spot. Shooting at an angle of 85.1^o it took approximately 2.864 seconds to land while shooting the cannon at an angle of -17.31^o the projectile would hit the same spot in approximately 0.235 seconds. This information can be found on the excel sheet labeled "path 1" and "path 2" accordingly.

I found the angles by using excel to calculate time using $x=V_x+b$ and $V_x=V_o\cos(\emptyset)$. Using the second equation and given information of V_0= 44.6 ft/s and subbing in a list of angles I produced a list of velocities in the x direction which was subbed into the first equation to find the time it took to travel 10ft. This time was then subbed into the y(t) equation to find the height at that given time. This was carried out until I found a time, which corresponded with an angle, where the height was 0 ft. This information can be found on the excel sheet labeled "Angle".

Once angles and corresponding time of flight was found, I could then calculate the height of the projectile depending on time. Using the equations $v_y=V_o \sin(\emptyset)$ and $y(t) = \left(-\frac{1}{2}g\right)t^2 + v_y t + y_0$ I could find the height and velocity at any given time. Using the first equation, the angle and time from the previous calculations which yielded angle and time for the impacts. I found the missing component of equation two which was then used to map out the height of the projectile depending on time where each piece of information was then plugged into the formula and then carried out by excel for each angle.

Then I found the horizontal distance depending on time which is graphed using the equations $x=v_x t + b$ and $v_x=V_0(\cos(\emptyset))$. This was done to show the correlation between height and distance at each given point in time and that the projectile did in fact reach the distance of 10ft. This information combined with the information found from $y(t) = \left(-\frac{1}{2}g\right)t^2 + v_y t + y_0$ was graphed to show the actual flight of the ball depending on its horizontal and vertical position. This was used to graph in excel for each angle found.

Data

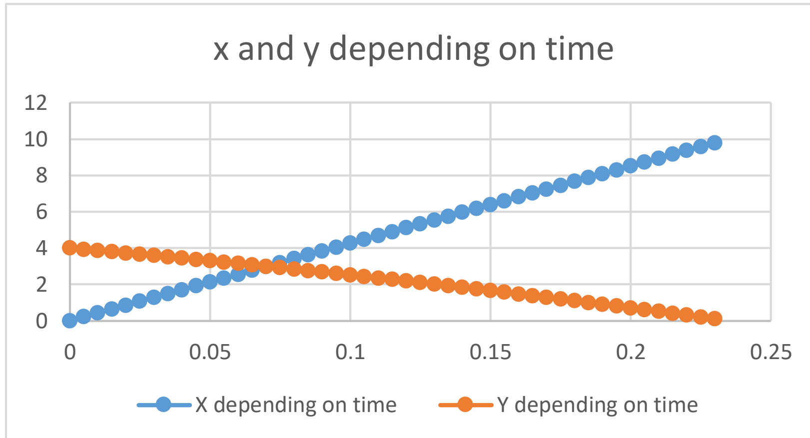
Each table shows last 4 calculations before impact and 1 after.

Cannon Angle -17.31^0

$x(t)=4.46(t)$

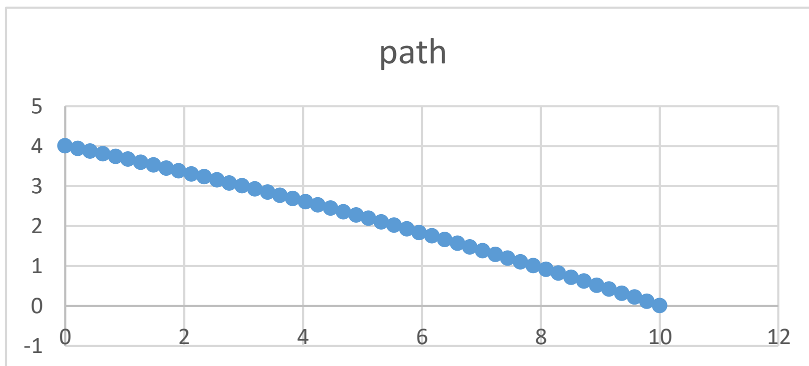
Time	Depth(x)	Height(y)
0.215	9.1547	0.407264
0.22	9.3676	0.306112
0.225	9.5805	0.20416
0.23	9.7934	0.101408
0.235	10.0063	-0.00214

$y(t)=-16t^2-13.2704t+4$

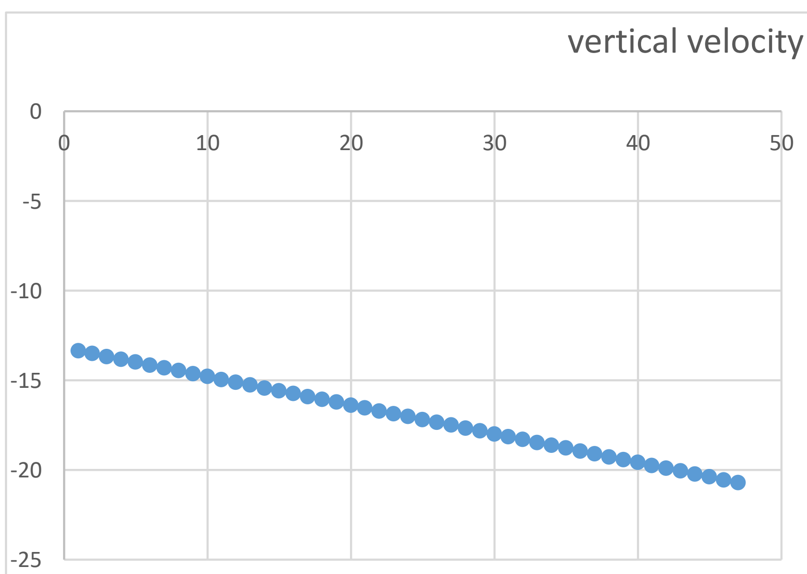


$y(x)=-16x^2-13.2704x+4$

Distance(x)	Height(y)
9.1547	0.407264
9.3676	0.306112
9.5805	0.20416
9.7934	0.101408
10.0063	-0.00214



Time	Vertical Velocity
0.215	-20.0704
0.22	-20.2304
0.225	-20.3904
0.23	-20.5504
0.235	-20.7104

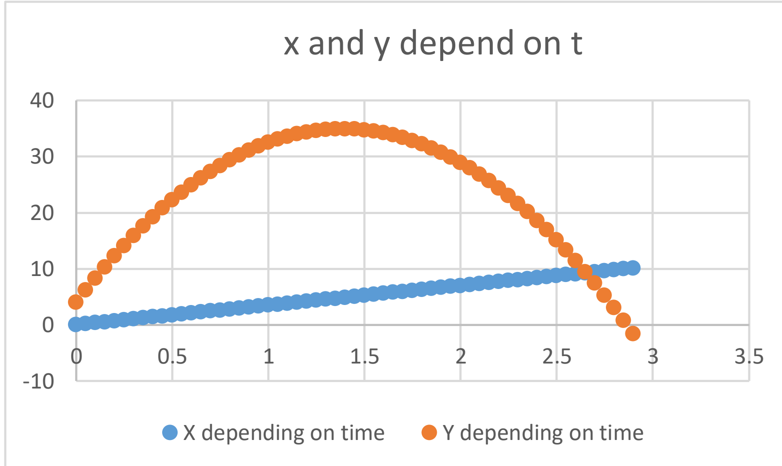


Cannon Angle 85.51^0

$x(t)=3.49152(t)$

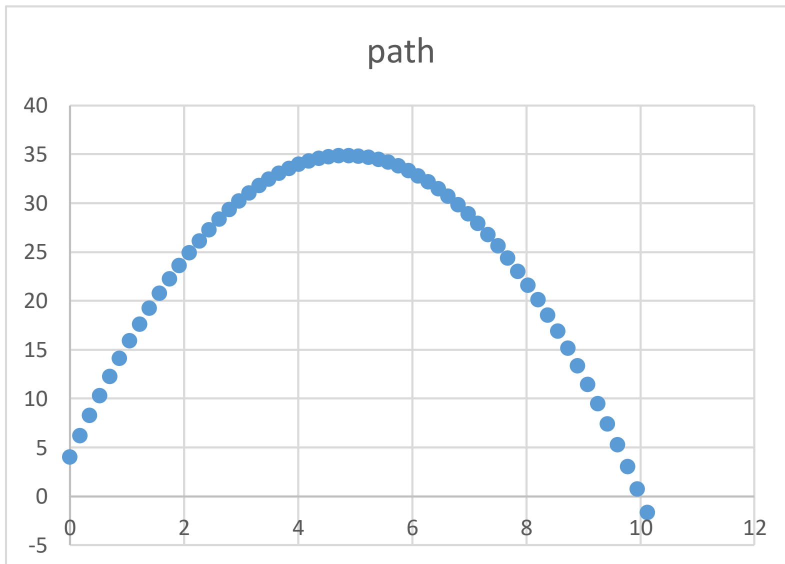
Time	Depth(x)	Height(y)
2.7	9.427104	7.402
2.75	9.60168	5.265
2.8	9.776256	3.048
2.85	9.950832	0.751
2.9	10.12541	-1.626

$y(t)=-16t^2+44.46(t)+4$

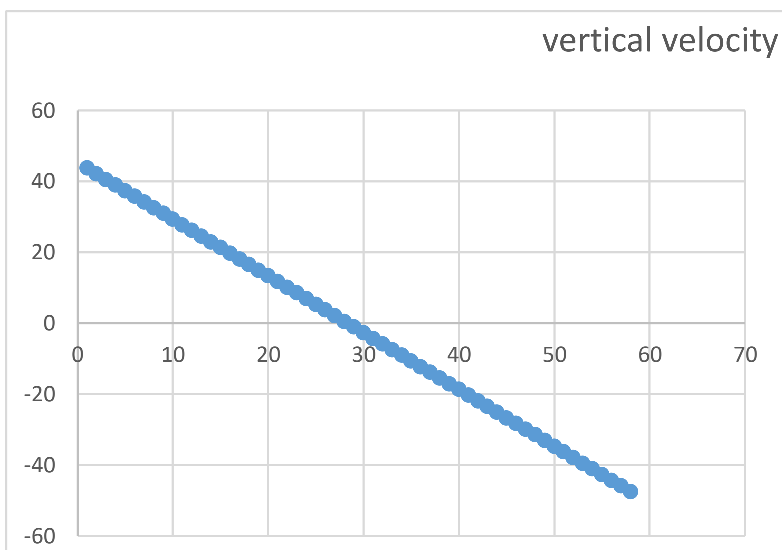


$y(x)=-16x^2+44.46(x)+4$

Distance(x)	Height(y)
9.427104	7.402
9.60168	5.265
9.776256	3.048
9.950832	0.751
10.12541	-1.626



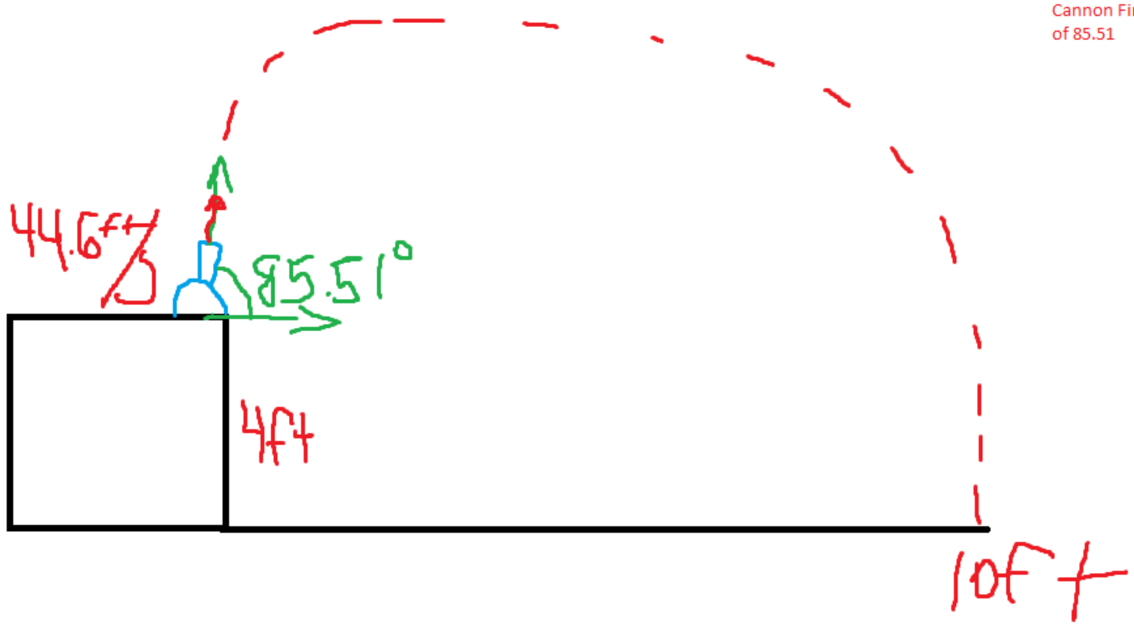
Time	Velocity
2.7	-41.14
2.75	-42.74
2.8	-44.34
2.85	-45.94
2.9	-47.54



Illustrations:

Cannon Angle of -17.31

Cannon Fired at Angle of 85.51



References

- Nerf Gun Velocity:
    - Stoker, C. (2014, November 8). Nerf Gun Dart Speed-part 2 - Stoked About Science. Retrieved December 04, 2016, from http://stokedaboutscience.com/episodes/nerf-guns2/
- Table Height:
    - Measurement of a table in my house.
- Equations: Found at time 9:36
    - (2013, June 08). Retrieved December 04, 2016, from https://www.youtube.com/watch?v=M8xCj2VPHas