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Projectile Motion Lab

AP Physics C – Mechanics

https://phet.colorado.edu/sims/html/projectile-motion/latest/projectile-motion_en.html

Objective: I will calculate kinematic quantities of an object in projectile motion given initial conditions of various launch speeds.

You will be working on a virtual lab (above) under the "Lab" setting to find an expression for the range of a projectile fired from the ground. To be successful in AP Physics C, you need to be able to collect data and linearize graphs to determine relationships between variables. Your goal is to do just that and analyze the slope and y-intercept of your graphs to extract meaning from data.

The required parts of the procedure are below:

1. Collect data. Leave air resistance off for today and hold *g* constant at 9.81 m/s/s.
2. Graph quantities according to what you collect. Make sure your graphs have units and axes labels. Also, ***caption any graphs you create like so, under the graphs: "*****Figure x.** Caption here.". Your captions should tell the reader what the graph is showing and for which system.
3. Linearize the graphs.
4. Explain what the slope and intercept mean, from your best fit line.
5. Conclude with "[vertical axis variable name] is related to [horizontal variable] and the expression relating the two is as follows: [expression here]."

Outside of this, you will determine which values to hold constant, which values to measure, and which values to vary. As you fill out the sections below, please delete the italicized text.

Set the initial height for the cannon to 0 m and, using data, find an expression for the range of the projectile. Your expression must be independent of time and should depend on initial speed v_0, launch angle θ, and physical constants as needed! However, keep the launch angle constant in this experiment for ease.

Procedure

Constant:

H = 0

θ = *80*

Varied:

V_0 = *Initial velocity*

Measured:

Δx= *Ground distance from cannon*

Data

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Put your data table here. Make sure to include units.

Initial Velocity Squared (m^2/s^2)	*Speed (m/s)*	*Distance (m)*
25	5	0.87
100	10	3.49
225	15	7.84
400	20	13.95
625	25	21.79

Results and Discussion

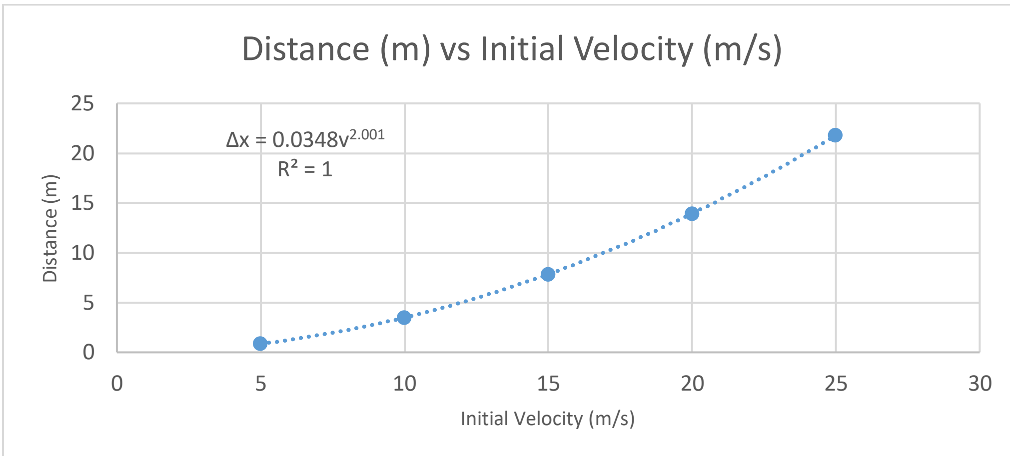

Figure 1. Distance (m) vs Initial Velocity (m/s) for an object.

Distance traveled is quadratically related to initial velocity, and the expression relating the two is as follows: $\Delta x = 0.0348v^{2.001}$.

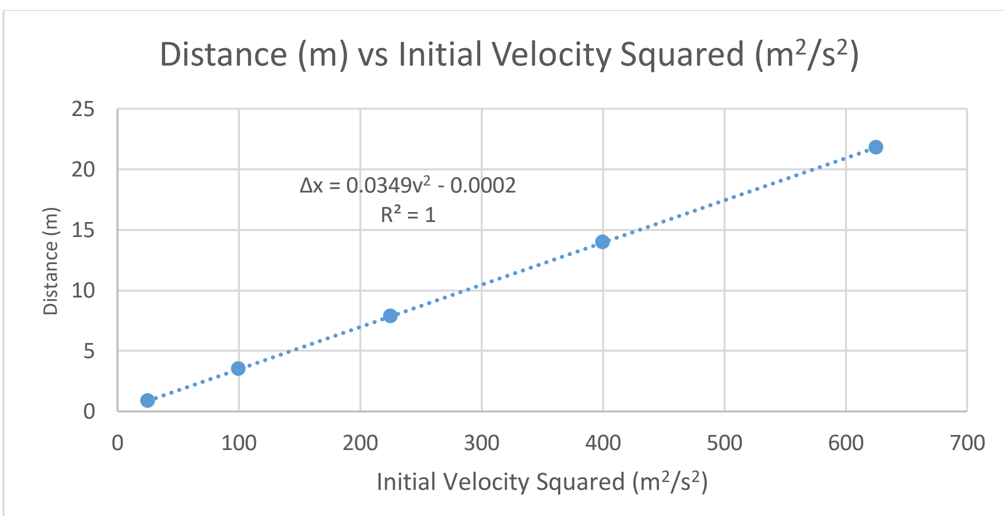

Figure 2. Distance (m) vs Initial Velocity Squared (m^2/s^2) for an object.

Distance traveled is linearly related to initial velocity squared, and the expression relating the two is as follows: $\Delta x = 0.0349v^2$.

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Post-Lab Questions

1. Derive an expression for the range of an object using the constraints above. How does it compare to what you found using data?
   a. The objects height is at a max when the y velocity is zero, and since the path is symmetric the time of flight is twice this time. Multiplying this time by the constant x velocity we get the range.

$$v_i + at = v_f$$
$$v_i - gt = 0$$
$$\frac{2v_{iy}}{g} = 2t$$
$$\frac{2v_{iy}}{g} * v_{ix} = R$$

$$\frac{2v^2 * \sin(\theta) * \cos(\theta)}{g} = R$$
$$\frac{v^2 * \sin(2\theta)}{g} = R$$

This lines up almost perfectly with our data, as the .0349 factor multiplying the v^2 term is nearly equal to the $\sin(2\theta)/g$ for our chosen g and θ (.0348644386672…).

2. Using kinematics equations, derive an expression for the maximum height of the projectile from the ground. Your expression must be independent of time and should depend on initial speed v_0, launch angle θ, and physical constants as needed! How does it compare to the expression for the range? If you wish, support your expression with data. However, because it is a similar process to what you did for the range, I am not requiring you to collect data for this.

$$2a\Delta h = {v_{fy}}^2 - {v_{iy}}^2$$
$$-2g\Delta h = 0 - {v_{iy}}^2$$
$$2g\Delta h = {v_{iy}}^2$$
$$\Delta h = \frac{{v_i}^2 sin^2(\theta)}{2g}$$

This is the very similar to the range expression except it has an extra sine instead of a cosine on the top and the 2 factor is on the bottom.

3. For an object that starts at a height above 0, might the angle needed for maximum range be less than, equal to, or greater than 45 degrees? Justify your answer using words.

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Less than 45 degrees, as the object would not need to gain as much height in order to ensure it does not hit the ground too early.

Conclusion: Certain real-world factors may cause the values in such an experiment to be thrown off, a phenomenon that does not occur in a simulation like the one that was used in this lab. Factors like air resistance may cause the range to fall short of what is predicted, which can be rectified by using denser objects or objects shaped more aerodynamically. Other factors, such as the object sliding when first contacting the ground may cause actual values to exceed predicted ones. This can be rectified by measuring where the object first lands, which can be achieved by either careful observation or by making sure it lands on a material like floral foam where it can make an indentation. The slope is nearly equal to $\sin(2\theta)/g$ for our chosen g and θ . The y intercept of this line should be 0 given an ideal set of data, showing that the object will not move if it starts with no initial velocity. The value of our y intercept reflects either an error in our data or an error in the regression.

(Sorry for typing this in word)