Equations of Motion Workshop

Academic Resource Center

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Presentation Outline

- Understanding Concepts
  - Displacement
  - Time
  - Velocity
  - Acceleration
  - Equations of Motion
- Example Problems

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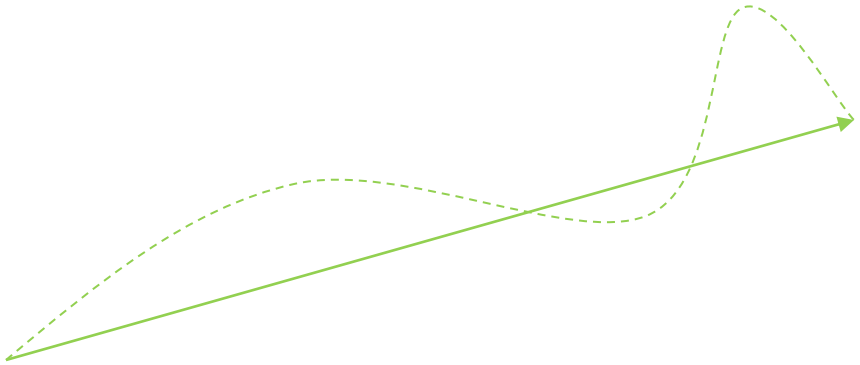
Understanding Concepts

- Displacement:
  - Definition: the vector distance between the initial and final point.



  - Displacement (arrow) vs. distance traveled (dashed line)

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Velocity

- Definition: the rate of change of displacement.
- Average Speed: the distance traveled over time
- Average Velocity: the displacement over time

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Acceleration

- Definition: the rate of change of velocity, i.e, change of velocity over time.
- Average Acceleration: the change in velocity over time.
- If the average acceleration is constant, then the equations of motion can be applied.

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Equations of Motion

- 4 Equations:

$$x = x_o + \frac{v_o + v}{2} t$$

$$x = x_o + v_o t + \frac{1}{2} a t^2$$

$$v = v_o + at$$

$$v^2 = v_o^2 + 2a(x - x_o)$$

- Note: the subscript "$_o$" denotes the initial/starting point. These equations are written for the x direction of motion but they can also be applied to the y direction.

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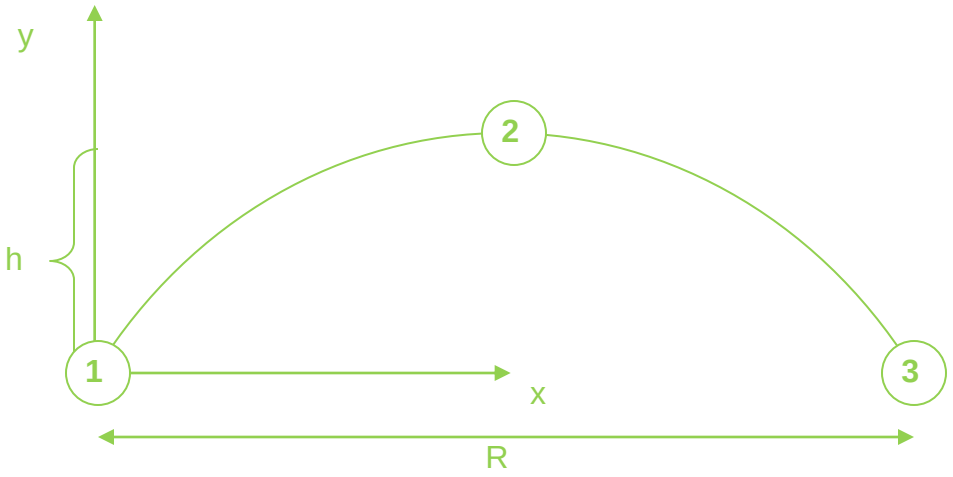
Concept Check

- Consider a ball thrown which follows the path shown, h is the height and R is the horizontal distance traveled

- What is the displacement (horizontal &vertical) of the ball at each of the points (1, 2 & 3)?



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Example Problem 1

- A bullet is moving at a speed of 350 m/s when it embeds into a lump of moist clay. The bullet penetrates for a distance of 0.05 m. Determine the acceleration of the bullet while moving into the clay. (Assume a uniform acceleration.)

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Solution Strategy

1. Understand the Problem
   - What is being asked? Make a sketch.
2. Translate into “Physics Language”
   - List the given quantities with their units.
3. Find equation/s to help you solve for the unknown.
4. Solve
5. Check and report your answers
   - A good practice is to check the units of all the calculations that have been done.

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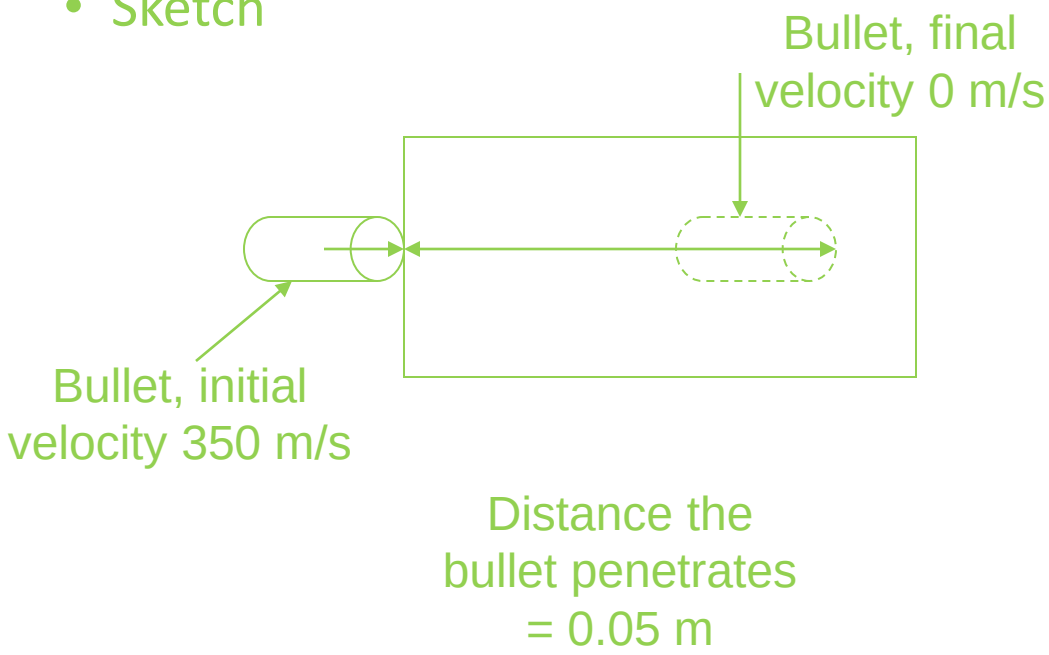
Solution

- Sketch



Solution (cont'd)

Given:

vi = 350 m/s, vf = 0 m/s, d = 0.05 m

Find:

a = ??

Which equation should we use to solve?

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Solution Cont'd

vf^2 = vi^2 + 2*a*d

(0 m/s)^2 = (350 m/s)^2 + 2*(a)*(0.05 m)

-{(350^2) m^2/s^2}/0.05 m = a

a = -1.225*10^6 m /s^2

(The - sign indicates that the bullet slowed down.)

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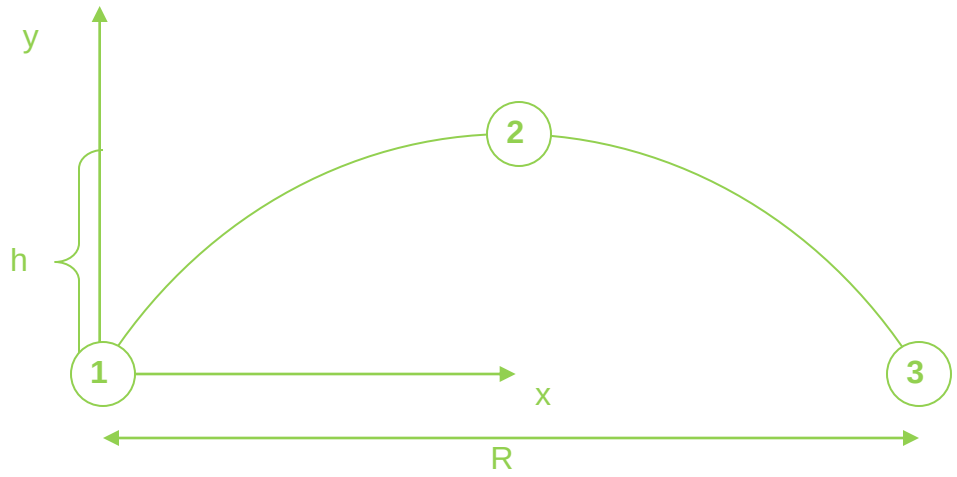
Example Problem 2

- Consider the ball problem from before; knowing the height (h) of the ball and the horizontal distance traveled, what more can we learn about the ball's motion?



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Solution Problem 2

- Answer: Everything!
- Solution Strategy:
  - By knowing the height that the ball travels, we can solve for the y component of the velocity (velocity in the y or vertical direction).
  - Then, we can solve for the time it takes for the ball to reach its maximum height which will be half the time it takes to cover the horizontal distance R.
  - Finally, we can solve for the horizontal component of velocity.
  - Furthermore, we can deduce the angle that the ball was launched at from knowing the initial components of the velocity in the x and y direction.

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