PH 221 Week 2

Benjamin Bauml

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The first activity is Problem 22 of Chapter 2 from the *Student Workbook* for *Physics for Scientists and Engineers.*

R2-1: Toy Rocket Launch

A toy rocket is launched straight up with constant acceleration a. It runs out of fuel at time t.

(a) Is the rocket at its maximum height the instant it runs out of fuel? Explain briefly.

(b) What assumptions would you make in order to solve this problem?

(c) What is the name of motion under the influence of only gravity? How would you write the vector for acceleration due to gravity?

(d) Draw a motion diagram for this problem. You should have three identified points in the motion: launch, out of fuel, maximum height. We'll call these points 1, 2, and 3 to have consistent definitions.

- Using subscripts, define quantities: y, v_y, and t at each of the three points,
- Describe the acceleration a_1 during the interval from point 1 to point 2, and acceleration a_2 during the interval from point 2 to point 3.
- Identify each quantity as Unknown or Known:
  - Was it given numerically?
  - Was it given symbolically?
  - Can we reason that it must be zero?
  - Be careful with signs!

(e) Draw qualitatively accurate graphs of the acceleration vs. time and the velocity vs. time.

Suppose we want to know the maximum height of the rocket.

(f) This is a two-part problem. Use your knowledge of calculus and motion to write *kinematic equations* for the first part of the motion. Use the given (symbolic) values for a_1 and t_2 to determine—again symbolically—the two unknown quantities at point 2.

(g) Use your knowledge of calculus and motion to write similar *kinematic equations* for the second interval of the motion. Just write the equations; don't solve it yet.

(h) Now, substitute the known information from previous parts of the question into your equations from part (g). Find y_3 in terms of quantities given in the problem and the constant g.

R2-2: Two Window Toss

You are standing in a large building, and there is a single window right up by the ceiling. This window opens on an alleyway, and the building on the other side has an open window below the level of your building's window. You want to launch something from your building into the other, right through the center of each window. You know the heights of the windows and the width of the alley, so what do you need to do to throw it correctly?

(1) Draw a physical representation of the situation. On this drawing, indicate the height of the center of the first window h_1, the height of center of the second window h_2, the width of the alley w, the initial velocity $\vec{v}_0$, the launch angle θ, and your distance to the wall of the first window d. Add a coordinate system (indicate the directions of $+x$ and $+y$), and indicate the direction of gravitational acceleration $\vec{g}$. What are your unknowns?

(2) Since the window is right by the ceiling, you cannot arc your projectile too high. Suppose for simplicity that you want it to reach its maximum height right as it goes through the first window. What must its initial velocity be in the y direction for this to happen?

(3) Exiting the first window, the object only has velocity in the x direction. How long does it take to fall to the height of the second window? How fast must it be going to cross the alley in this time and enter the second window?

(4) Given the horizontal and vertical components of initial velocity, how far back from the first window do you have to stand to get the object through it?

(5) Given the components of initial velocity, what is the magnitude of initial velocity? At what angle with respect to the floor must the object be launched?