

## On the Descent of Balloons<sup>1</sup>

Fall 2025

**Tasks 1 and 2 are to be completed before coming to lab.**

**Show your instructor your work as soon as you come into lab.**

***1 point will be deducted from your grade if these tasks are not completed beforehand!***

### Introduction

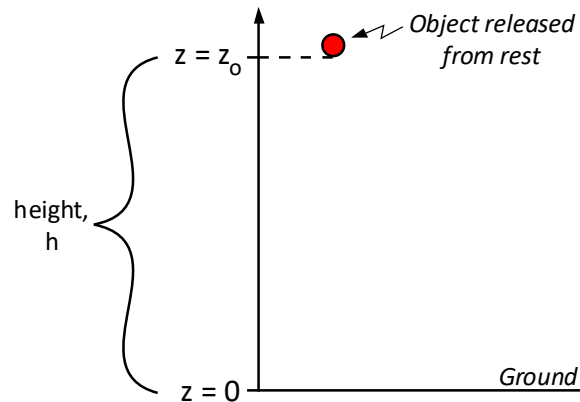
In class, you studied systems moving under the influence of a time-independent net external force (that is, a net force that does not change with time). We treated an object falling near the surface of the Earth as an example of such a system; gravity was the only force acting on the object (recall that we neglected air resistance in our studies). We found that  $a$ , the acceleration of the object does not depend on time, and  $z$ , its position as a function of time  $t$ , can be modeled by the following equation:

$$z(t) = z_o + v_o t + \frac{1}{2} a t^2 \quad (\text{Eqn. 1})$$

where  $z_o$  is the initial position of the object and  $v_o$  its initial component of velocity. If the object is released from rest from a height  $h$  above the ground (see *Figure 1*), Equation 1 simplifies to:

$$h = \frac{1}{2} g t_{\text{tot}}^2 \quad (\text{Eqn. 2})$$

Here,  $t_{\text{tot}}$  is the total time it takes for the object to fall distance  $h$ .



**Figure 1:** An object released from height  $h$  above the ground.

<sup>1</sup> Adapted from *Physics Education*, November 2005, Vol. 40, pp. 550-555, by Tim Erickson and Eric Ayars

Task 1: Show how to get Equation 2 from Equation 1 for this situation.

Task 2: Let's do a thought experiment (this will help you gauge whether you understand Equation 2, which is crucial for Task 3). Let's say you record how long it takes for a **brick** to fall to the ground from different heights, and then, you plot  $h$  as a function of  $t_{\text{tot}}^2$  (that is,  $h$  is on the y-axis and  $t_{\text{tot}}^2$  is on the x-axis), what kind of trend do you expect to see in your data (linear, quadratic, or cubic)? Be sure to explain your answer.

→ If you put a linear fit through your data points, what value do you expect to get for the slope of the line?

Task 3: You have been contracted by *SpaceY* to study the mock-up of a system that they intend to use to deliver a payload from the atmosphere of the Earth to the ground. They want to know if they can use Equation 2 to model their system. So, your job is to determine if their system follows Equation 2 as it falls to the ground. If it does not, they want you to speculate on why the behavior of their system deviates from the model.

- Design an experiment to test whether their system can be modeled with Equation 2. The materials available to you are the following: the mock-up system which is a balloon (due to proprietary reasons, *SpaceY* is hiding the actual details of their system but are confident that the balloon approximates it well) and a meter stick. Please ask your instructor if you need anything else. Think carefully about what you will plot on the y-axis and on the x-axis, and what fit you will use through your data points to determine if the mock-up system obeys the model described by Equation 2.
- Additional notes:
  - a. Use the stopwatch app on your smartphone.
  - b. Feel free to use any additional functions of your smartphone that you feel might improve the quality of your data.
- Make sure that you follow normal laboratory procedures. Use the skills, analysis and record keeping techniques (for example, making a proper table to store your measurements) you have been practicing all semester.
  - a. Give an introduction.
  - b. Make a sketch of your experiment that defines your variables.
  - c. Briefly describe your experiment and how you collect your data.
  - d. Include a data table.
  - e. Include your calculations and graphs.
  - f. Plot your data as it is collected.
  - g. Restate and discuss your results, as well as any sources of error. **Be sure to explain whether the system can be modeled by Equation 2 or not. Use your data and graphs to justify your conclusion.**
  - h. Attach Tasks 1 and 2 to your journal when you hand it in.