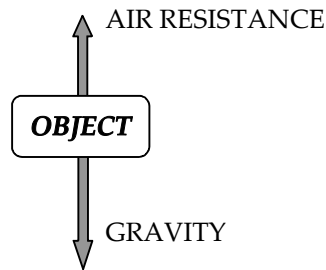


Constant Velocity

Introduction:

Objects experience two different forces as they fall to the ground: the force of gravity and the force of air resistance. The force of gravity (also known as the weight of the object) is always pulls downward, whereas the force of air resistance (also known as drag) pushes upward:



For drops close to the ground, the force of gravity is always constant, but the force of air resistance is generally a complicated function of the object's speed, shape, and orientation as it falls. We can say that the faster an object falls and the greater its surface area, the greater the air resistance acting on it. Parachutes are excellent examples of objects that experience large forces of air resistance because of their huge surface areas.

Let us consider a detailed analysis of a falling skydiver. When the skydiver jumps from an airplane, s/he begins accelerating downward because the force of gravity is greater than the force of air resistance (Newton's 2nd Law). As s/he reaches higher speeds, the air resistance increases until it exactly balances the force of gravity. By Newton's 1st Law, the acceleration ceases and the velocity remains constant (i.e. steady or uniform). This final constant velocity downward is called the terminal velocity.

In this experiment you will be dropping coffee filters from a fixed height (in meters) and measuring the time (in seconds) it takes them to reach the floor. Coffee filters reach terminal velocity almost immediately after they are dropped. Their terminal velocity is calculated from the formula

$$\text{Terminal velocity} = \frac{\text{Height}}{\text{Time}} \quad \text{in m/s}$$

Make sure that your group has a meterstick, a stopwatch, a scientific calculator, and at least 20 coffee filters. You will also be using Microsoft Excel in order to plot your data and to fit your data to a curve (formula).

Data Collection:

- 1) Open Excel.
- 2) Measure a height of 1.5 meters along a wall. Make a small mark at this level.
- 3) Align the bottom of a single coffee filter with this mark and drop it. Measure its time to reach the floor and type it in Column A of the spreadsheet.
- 4) Calculate the terminal velocity in Column B.
- 5) Repeat Step 3 with a stack of 2, 3, ..., 20 filters.



Plotting the Data:

- 1) Highlight Column B. Pull down the Insert menu and pick Chart.
- 2) Select chart type XY (Scatter) then click Next > twice.
- 3) Fill in the chart title as "Terminal Velocity vs. Mass". The X axis value is "# of Coffee Filters" and the Y axis value is "m/s".
- 4) Click the Gridlines tab and remove the check mark.
- 5) Click the Legends tab and remove the check mark, then click Next > and Finish. Your graph has been inserted into your spreadsheet. Ask your instructor to inspect your graph before you proceed to curve fitting.

Curve Fitting:

- 1) Select your graph. Little black boxes will appear in the corners.
- 2) Pull down the Chart menu and pick Add Trendline. Select chart type Power.
- 3) Click the Options tab and place a check next to *Display equation on chart*. Click OK. Be sure that your graph resembles the sample shown below.

To finish this experiment, print out your graph and write your names at the top. On the reverse side of your graph, answer the following questions in complete sentences:

1. Use your formula to calculate the terminal velocity of 100 dropped coffee filters.
2. Describe at least two ways to improve the accuracy of your time measurements.

TURN IN YOUR GRAPH AND THE ANSWERS TO THE QUESTIONS BEFORE YOU LEAVE THE LAB.

