ScienceCube

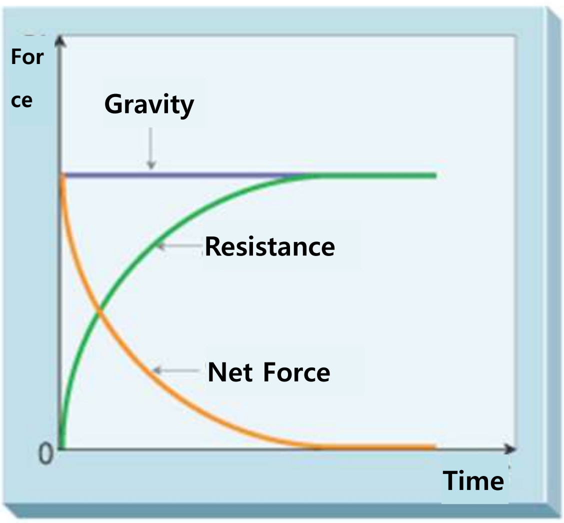
Terminal Velocity

1. **Observe and explain the terminal velocity of objects falling through the air.**
2. **Compare and explain terminal velocity based on mass.**

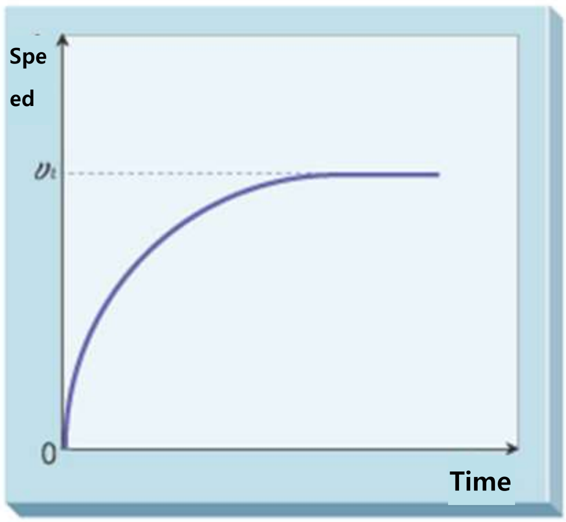
Fundamental Concept

1. Terminal velocity

When an object falls through the air, its fall speed initially increases due to gravity, but it eventually reaches a constant speed. This constant speed is called terminal velocity.



(A) Change in Force Acting on an Object Over Time



(B) Change in Speed of an Object Over Time

As time progresses, the force acting on the object changes, and the speed of the object changes over time. The air resistance depends on the speed and shape of the object. Generally, the resistance force is proportional to the object's speed. An object falling through the air experiences air resistance in the opposite direction of gravity. Therefore, the net force on the object is the gravitational force minus the resistance force.

When an object is dropped from a height, it initially has a small speed and therefore a small resistance force, resulting in a relatively large net force and a rapid increase in speed. As the speed increases, the resistance force also increases, reducing the net force and causing the speed to increase more slowly. Eventually, the resistance force becomes equal to the gravitational force, making the net force zero and stopping further acceleration. This constant speed is the terminal velocity.

For an object with mass m and speed v, the resistance force can be expressed as kv (where k is a proportional constant depending on the object's size, air density, temperature, etc.). Therefore, the net force is $mg-kv$. At terminal velocity v, the resistance force is kv and the net force is zero, resulting in $mg-kv=0$, giving $v=mg/k$.

Experiment

Materials Needed

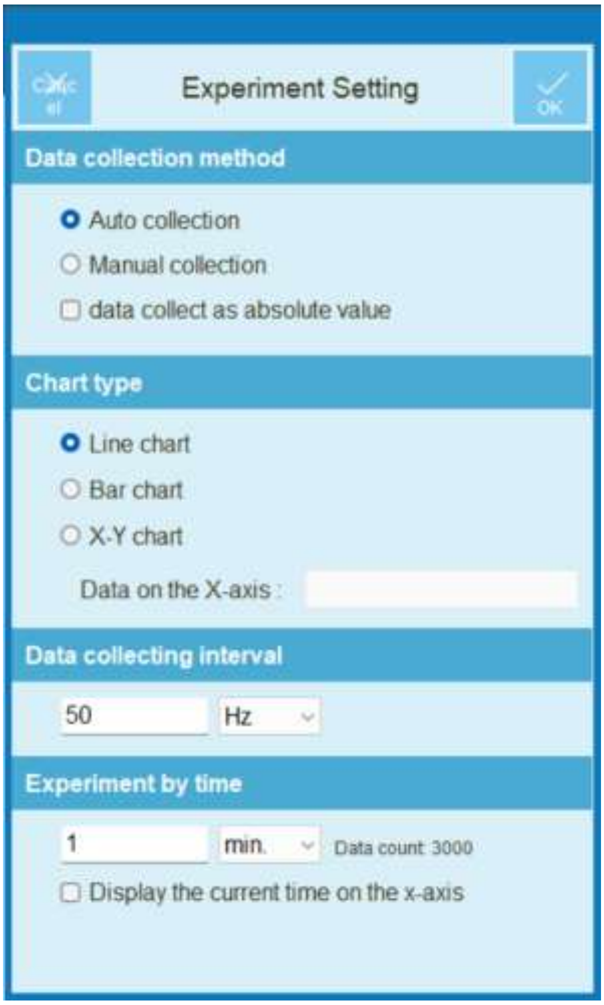
Interface, Science# Program, Motion Sensor, Coffee Filters (4), Electronic Scale

Preparation of Experimental Setup

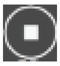
1. Measure the mass of a coffee filter using the electronic scale.
2. Place the motion sensor on the floor in an open area free of obstacles.

Interface Setup

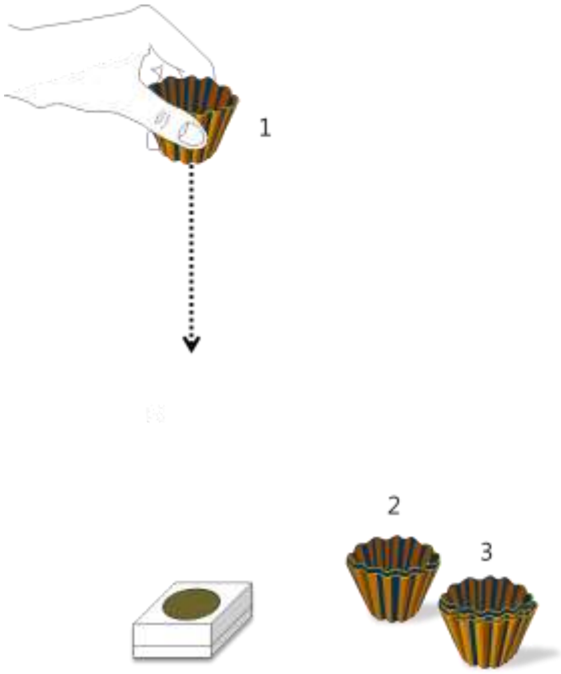
1.  Launch the Science# program.
2. Connect the motion sensor to the interface.
3. Click  to set up the experimental environment as shown below, or use the automatic setting option ..



데이터 수집

1.  Click to start data collection.
2. Drop one coffee filter from a height of 1 meter above the motion sensor.
3. When a clear fall graph is drawn, click  to end the experiment.
4. -  Click and continue adding one coffee filter at a time, collecting the <time-distance> data for each mass increment.
5. After the experiment, click  to delete all but the falling portions of the data..
6.  Click and set B to ' - Start time of valid data' in [Data Conversion (X-axis)] to align the x-axis to zero.

7.  Click and set A to '-1' in [Data Conversion (Y-axis)] to invert the graph. This ensures positive values when plotting the <time-velocity> graph..
8.  Select [Basic Analysis – Derivative] to draw the <time-velocity> graph..
9.  Select [Basic Analysis - Quadratic f(x)=Ax^2+Bx+C] to modify the graph for better visualization..



Data Analysis

Recording Data

1. Measure and record the mass for different numbers of coffee filters..

Number of Coffee Filters	1	2	3	4
Mass (g)				

2. Compare and plot the <time-distance> graph for free-falling coffee filters of different masses in one chart..

3. Compare and plot the <time-velocity> graph for free-falling coffee filters of different masses in one chart..

Data Application

1. Explain the motion and speed changes of the free-falling coffee filters using the motion and speed graphs as a reference.

2. Describe the relationship between mass and terminal velocity based on the free-fall experiment with varying masses of coffee filters..


Report
(For Teachers)

Report
(For Students)