4. Motion on an Inclined Plane

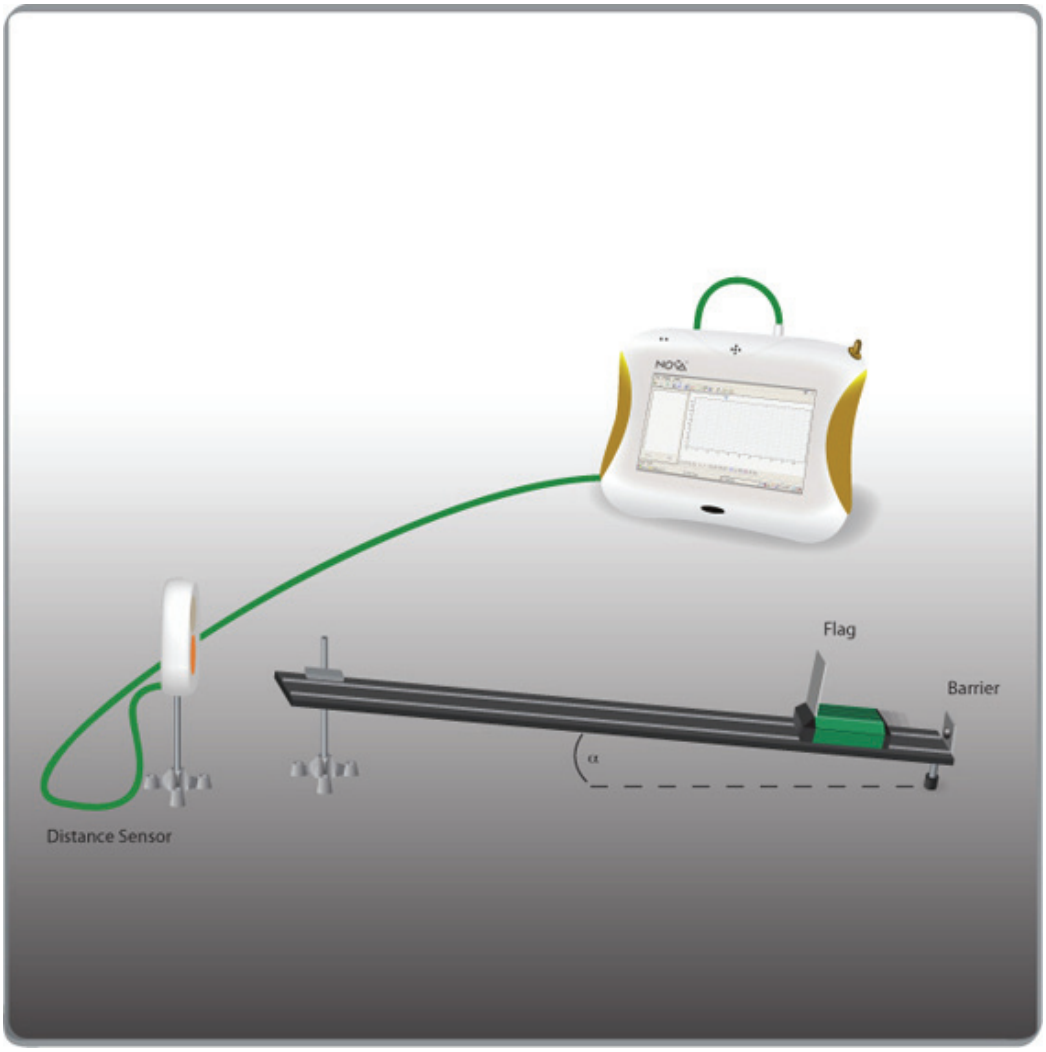

Figure 1

Introduction

When a body is placed on an inclined plane it will move with constant acceleration. If the plane is friction free the acceleration of the body up the plane will be equal to the acceleration down.

In this experiment we place a cart on an inclined plane and explore the properties of the motion.

Equipment

- Nova5000
- Distance sensor
- Cart
- Square piece of cardboard 10 x 10 cm (*flag*)
- Inclined plane (as friction free as possible)
- Laboratory stand or books to vary height of inclined plane

Equipment Setup Procedure

> ***Note**: Ensure that the AC/DC adapter is connected as the Distance sensor consumes relatively high current.*

1. Launch MultiLab.
2. Connect the Distance sensor to Input 1 (I/O-1) of the Nova5000.
3. Assemble the equipment as shown in Figure 1.
   a. Place the Distance sensor at the upper end of the inclined plane.
   b. Place a stopper at the bottom of the plane. The stopper should not block the line of sight between the sensor and the cart.
   c. The distance between the cart and the stopper during the motion should be more than 50 cm.
4. Click **Setup**  on the upper toolbar and program the data logger according to the setup specified below.

Data Logger Setup

Sensors:

Input 1: Distance

Rate:

10 samples per second

Samples:

50 samples

Experimental Procedure

1. Set height of inclined plane at ~5 cm. Record the height in data table.
2. Hold the cart at the top of the inclined plane.
3. Click **Run**  on the upper toolbar. Release the cart when clicking of the sensor begins. A graph of the results will appear automatically. (The cart may jump several times before the end of the measurement).
4. Click **Save**  .

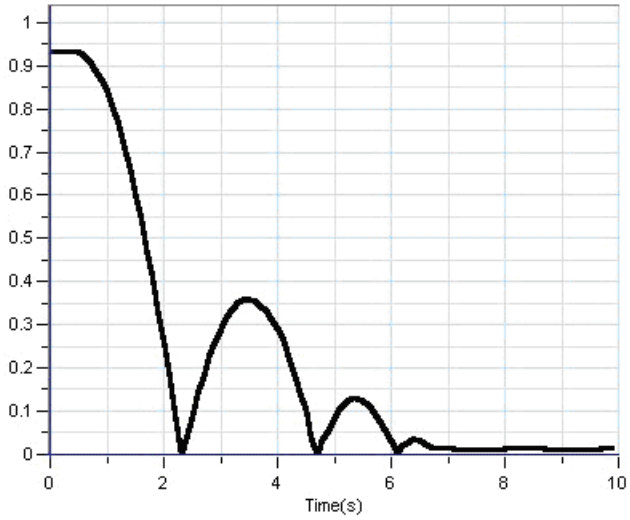

Figure 2

Data Analysis

1. The measurements of the sensor will inevitably contain some random noise. To lessen the effect of this random noise it is recommended that you apply smoothing on the raw data. Click **More smoothing**  on the graph toolbar.
2. Complete the following steps to mark the first downward slope of the graph using the cursor function.

The Cursor: You can display up to two cursors on the graph simultaneously.

Use two cursors to display the difference between two coordinate values or to select a range of data points.

To display the first cursor: Double click on an individual data point or click **Cursor**  on the graph toolbar. You can drag the cursor with the mouse onto any other point on the plot, or onto a different plot. For finer cursor movements click **Forward**  and **Backward**  cursor.

The coordinate values of the selected point will appear in the information bar at the bottom of the graph window.

To display the second cursor: Double click again anywhere on the graph area or click **2nd Cursor**  .

The information bar will now display the difference between the two coordinate values.

To remove the cursors: Double click anywhere on the graph area, or click **1st Cursor** a second time. **To remove the 2nd cursor:** Click **2nd Cursor** a second time.

3. Click **Derivative**  on the upper toolbar to display a graph of the velocity of the cart. This will appear as another line on the graph.

   Use the cursors to select two well separated points on the derived velocity line and then click **Linear fit**  on the upper toolbar. The graph of the linear fit will appear on the velocity graph and the fit equation will be displayed in the information bar at the bottom of the graph window. The value of the slope of this graph is the acceleration. Record the acceleration in the data table.

Height of Inclined Plane (cm)	Acceleration (m/s^2)			Average Acceleration (m/s^2)
	Trial 1	Trial 2	Trial 3	

4. Repeat the same procedure changing the height of the incline to 15cm. Record all data in the data table. Repeat again with a height of 20cm. Record all data in the data table.
5. What is the relationship between the height of the incline and acceleration?

Further Suggestions

1. You may want to check that the graph of the distance is parabolic:
   a. Use the cursors to select only one *jump*.
   b. Click **Tools** on the menu bar and then choose **Analysis** and **Quadric Curve fit**. The fit equation will be displayed in the information bar at the bottom of the graph window.
2. If there is significant friction between the cart and the plane, the cart will move up and down the plane with different accelerations. Measure α the angle of inclination of the plane and the acceleration when the cart is moving downwards, in order to calculate the friction coefficient between the cart and the plane:

$$\mu = \frac{g \sin \alpha - a_{down}}{g \cos \alpha}$$

3. Start the motion of the cart at different points on the plane and in different directions and try to predict the shapes of the distance and velocity graphs.
4. Place the sensor at the upper end of the inclined plane and try to predict in advance the form of the graphs of distance and velocity.