

Force and Acceleration



Prelab Questions



These questions need to be completed before entering the lab. Please show all workings.



Prelab 1:

Draw the free body diagram for the cart on an inclined plane. Tilt the coordinate axes to match the incline and break the weight vector into components.



Prelab 2:

Does the acceleration of the cart depend on mass? Explain.



Prelab 3:

Write, in a sentence or two, the objective of this experiment.

Introduction

In this experiment, you will measure the acceleration of an object moving down an inclined plane.

Using Newton's Second Law, namely

$$\Sigma \vec{F} = m\vec{a}$$

we can analyze the motion of a cart/block down an incline plane.

You will analyze your data to determine the value of the acceleration due to gravity.

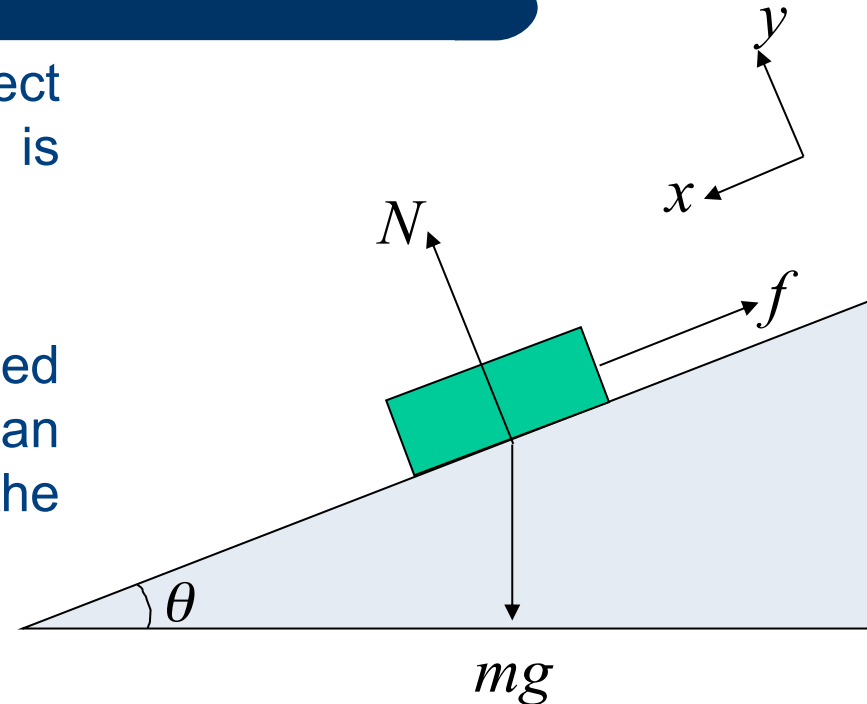
Remember, with every vector expression, to utilize it we must break vectors into their components and would start with expressions of

$$F_x = ma_x \quad \text{and} \quad F_y = ma_y .$$

Introduction

The free body diagram of an object rolling down an inclined plane is shown here.

Newton's second law may be applied in the x -direction to obtain an expression for the acceleration of the block down the incline.



Note the chosen coordinate system is aligned along the incline in the direction of acceleration. This generally simplifies our expressions. Due to this, $W = mg$ would now have y and x -components.

Apparatus and Setup

You have been provided with the following:

- digital inclinometer
- motion detector
- cart
- track
- rods
- clamp
- card



Apparatus and Setup

Plug the motion detector into **DIG SONIC 1** of the *LabPro*.

Place the support on a rod screwed into the desktop. Screw the support into the opposite side of the track at approximately 120 *cm*.

Place the motion detector at the top of the track.

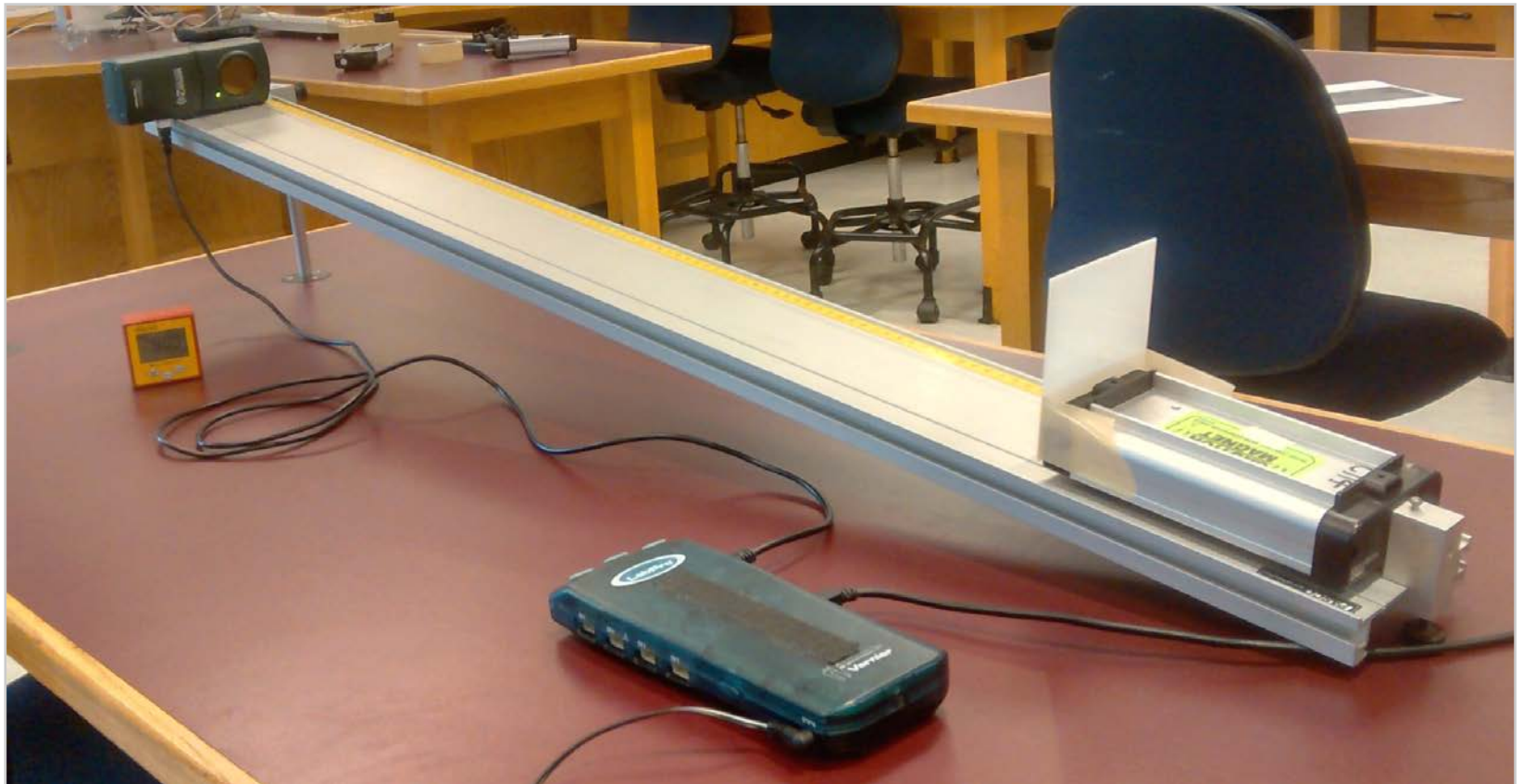
Raise one end of the track as high as it will go.

Tape the white card onto the cart and lay it on the track. (Be sure that the card faces the motion detector.)

Photo of complete setup is on the next slide.

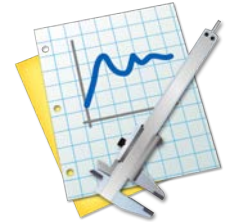


Apparatus and Setup



Experiment

Click on the icon to open Logger Pro



Logger Pro will open with two graphs:

- position vs time and
- velocity vs time

Lay the digital inclinometer on the track and read the angle.

LW

Record the angle θ in **Table 1** of your Laboratory Workbook.

LW

Calculate and record $\sin \theta$ in **Table 1**.



Apparatus and Setup

Hold the cart on the track near the top about 15 *cm* from the motion detector.



Data collection

Hit **COLLECT** in *Logger Pro*



Once the motion detector makes a clicking noise, release the cart gently.



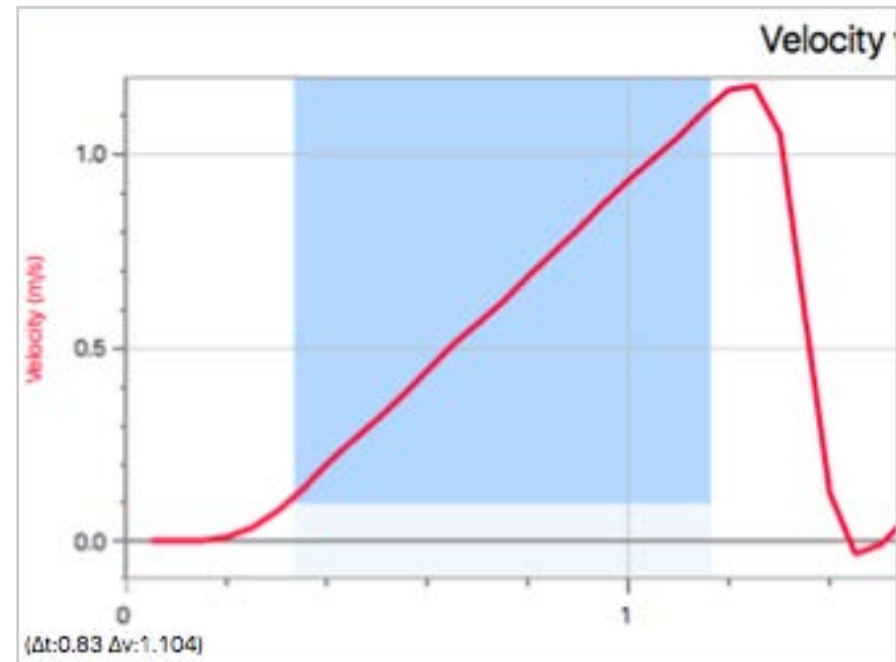
Be sure to catch it before it hits the other end!

If you are happy with your data:

Highlight the linear portion of the velocity vs time graph.

Create a line of best fit:

Click **Analyze** then **Linear Fit**.
Record the acceleration in **Table 1**
of your Lab Workbook.



Data Collection

We'll change the angle of incline and see the resulting change in acceleration of the cart. Use the track rod clamp and lower the track by about 2 cm.

LW Measure and record θ and $\sin \theta$ in **Table 1**.

Use *Logger Pro* to find the acceleration and record your results.

! Uncertainty in acceleration is not needed in the table.

Continue decreasing the angle of the track and recording the data until your table is complete.

Analysis

Q

QUESTION 1: Draw and label the forces acting on the cart as it traverses the incline, ensuring that you label each force clearly. Given the coordinate system provided, break the weight vector into components.

Q

QUESTION 2: Write the equation for Newton's Second Law in the x -direction for your cart.

Q

QUESTION 3: Compare the equation from the Question 2 to the equation for a straight line graph, namely $y = mx + b$. Given that we will produce an acceleration vs $\sin \theta$ graph (recall, y vs x), determine the expression for the slope and intercept based on comparing these equations. Explain.

Analysis



Click to launch Graphical Analysis

LW

In Graphical Analysis, enter the values of acceleration and $\sin \theta$ from **Table 1**.

Create a line of best fit by clicking **Analyze** then **Linear Fit**.

To obtain the uncertainty, double click on the box containing the slope and check the option for **Show Uncertainty**.

LW

Record your results in **Table 2** of your Laboratory Workbook.

P

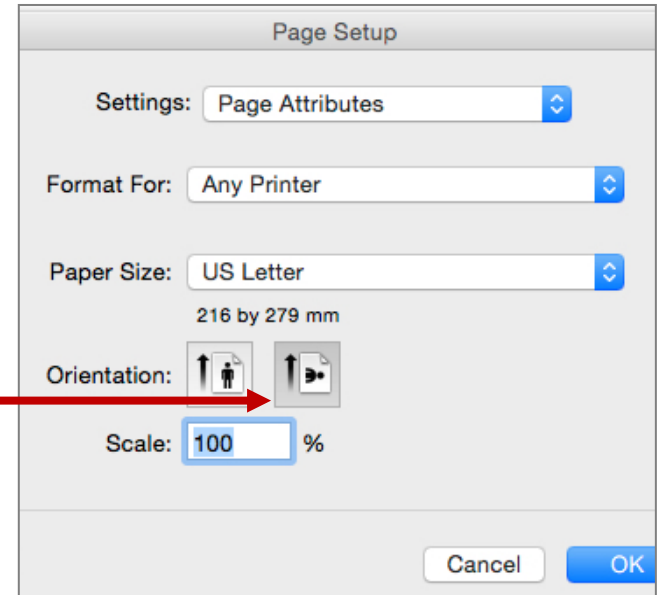
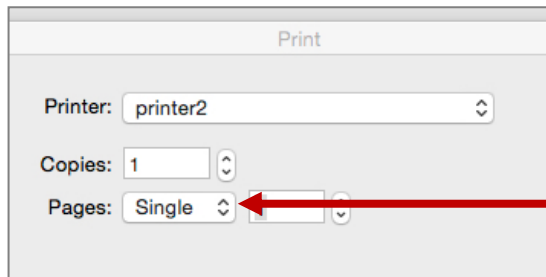
Include title, axes labels, and fit information.
Follow print instructions on next slide.

Printing Your Graph

Click **File** then **Page Setup** and choose the landscape orientation.

Click **File** then **Print**.

To select the only necessary page:
Click **Pages** and choose **Single**.



Staple your graph in your workbook.

Analysis

QUESTION 4:

- a) Considering the value of slope and the results of Question 3, what is the acceleration due to gravity, g ? Be sure to include units and uncertainty.
- b) Write the range of g and determine if it agrees with the accepted value of 9.81 m/s^2 . Comment on any differences.

QUESTION 5: If the mass of the cart and card is $m = 526.8 \pm 0.5 \text{ g}$, use your value for you intercept from Table 2 and estimate the value of the frictional force on your cart. Include the uncertainty. Show all workings.

Summary

Q

QUESTION 6: List at least three sources of the experimental uncertainties. Classify them as random or systematic.

Q

QUESTION 7: Write a brief paragraph summarizing the experiment and your findings.

Ensure that you have completed all **Tables** and answered all **Questions** completely.

Attach your **graph** to the appropriate page.

Submit your workbook to the appropriate shelf/box as directed.