

## On a Roll Challenge Lab

### Teacher's Guide

**Topic:**

Vectors and Forces

**The following information is provided to the student:**

**Question:**

What is the speed of a cart after rolling from rest a given distance along an inclined plane with a specified angle? How does it relate to the predicted speed?

**Purpose:**

To use Newton's laws, vectors and motion equations to predict the speed of a cart near the bottom of a hill and to evaluate the accuracy of the prediction with a measurement.

A complete lab write-up includes a Title, a Purpose, a Data section, a Conclusion and a Discussion of Results. The Data section should include a diagram of the inclined plane with assigned values of mass and distance and the appropriate x-y measurements needed to determine the incline angle. A free-body diagram and Newton's law analysis is included in an effort to determine the predicted speed. All work is clear, labeled and documented. A photogate time and flag width should be included along with a calculation of the measured speed. The Conclusion reports the predicted and the measured speed. The Discussion of Results should include an error analysis along with a percent error calculation.

**Materials Required:**

Cart; track; lab poles and clamps; photogate system; photogate flag.

**Description of Procedure:**

Student lab groups are assigned an incline angle and an initial height. Each group uses the track to form an inclined plane which is inclined at the specified angle. They will eventually release the cart from rest from the assigned height and determine its speed after it has rolled to a position which is 20 cm from the end of the track. Before releasing the cart, they first use Newton's laws and kinematics to determine the expected speed at a position 20 cm from the bottom of the track. Measurements are taken and calculations are performed until the predicted speed has been calculated. Once predicted, they prepare their incline and their cart for release. The teacher is called over to use a photogate system to assist in a speed measurement and a check of student answers.

**Alternative Materials and Procedure:**

Alternative materials and procedures are not recommended.

**Safety Concern:**

There is always a higher than usual level of risk associated with working in a science lab. Teachers should be aware of this and take the necessary precautions to insure that the working environment is as safe as possible. Student *horseplay* and off-task behaviors should not be tolerated.

**Suggestions, Precautions, Notes:**

## The Laboratory

1. This lab can be performed with a single photogate. When students are ready to release their cart, the teacher visits the station with the photogate and records a photogate time. Once a single trial has been performed, the teacher can migrate to the next group which is ready.
2. A 2-3 cm wide photogate flag can be made from a note card and taped to the carts.
3. This lab requires a lot of thinking – thinking about angles and distances and heights and forces and relationships. Providing students the necessary time to talk through and think through all the relationships will maximize the effectiveness of the experience.

### Auxiliary Materials:

None

### Scoring Rubric:

VF7. On a Roll Challenge Lab	Score
____ Included, labeled and organized all parts of the lab report. ____ Data section includes a diagram with assigned values, $x$ - $y$ measurements, angle calculation, free-body diagram (with labeled forces) and a Newton's laws analysis. Documentation is clear, labeled and thorough. Photogate time and flag width are included (with units) and the measured speed is calculated; work is clearly shown. ____ Conclusion reports the predicted and the measured speed. Results reflect careful measurement and analysis. ____ Discussion of Results includes an evaluation of the lab results and a percent error calculation; work is shown.	____ / ____

### Connections to The Physics Classroom Tutorial:

The following reading is a suitable accompaniment to this lab:

<http://www.physicsclassroom.com/Class/vectors/u3l3e.cfm>

### Connections to Minds on Physics Internet Modules:

Sublevels 5 and 6 of the Forces in Two Dimensions module are a suitable accompaniment to this lab:

<http://www.physicsclassroom.com/mop/module.cfm>