

## The Laboratory

# F-m-a Lab

## Teacher's Guide

### Topic:

Newton's Laws of Motion

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

**Question:**

What effect does varying force and varying mass have upon the acceleration?

**Purpose:**

To use experimental data to determine the mathematical equation which relates force, mass and acceleration.

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 two acceleration-force graphs (one for each mass) with a sketch of the plotted points, the best estimate on the slope of the line, and an indication of the mass of the cart. Class data should be included for the other lab groups. The Conclusion should respond to the question raised in the Purpose of the lab (as always). The Discussion of Results section should reference the Data section and thoroughly discuss the supporting evidence for the conclusion. The effect of mass and the meaning of the slope of the line should be clearly discussed.

### Materials Required:

Cart, computer-interfaced force probe and motion detector, mass balance, masses to add to cart

### Description of Procedure:

A low friction cart is placed upon the accompanying track. A force probe is mounted on the cart and connected to the computer interface box. A motion detector is placed near the end of the track. The software program which accompanies the interface equipment is manipulated to plot data of acceleration (vertical axis) as a function of force (horizontal axis). Data is collected as the force probe is held gently and given relatively periodic pushes and pulls. The equipment detects the force and the corresponding motion and plots the two quantities in real time. A relatively straight line is obtained on the graph. The relevant section on the graph is highlighted and a linear regression analysis is performed to determine the slope of the line. The equation of the line is written in slope-intercept form. The mass of the cart and force probe (combined) is determined. Trials are repeated with extra mass added to the cart.

### Alternative Materials and Procedure:

There are countless means of acquiring force-mass-acceleration data. Many of these methods involve a modified Atwood's machine and either motion detectors or photogate systems. Irregardless of the method used, the objective is to obtain a plot of acceleration as a function of force (or of mass) and then to vary the mass (or the force) and repeat the experiment. This is probably the quickest and most straight-forward method for obtaining a mathematical relationship between force, mass, and acceleration. Data for two different massed carts can typically be collected in 15 to 20 minutes. Other methods are more cumbersome and more complicated and take more time.

### Safety Concern:

## The Laboratory

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:

1. It is useful to pool class data for the slope and the cart mass. List two columns on the board and have students bring their data forward as they obtain it. Quick inspection of all the data will typically reveal that as the more massive carts are characterized by producing lower slope values. More detailed analysis will show that the slopes are roughly equal to the reciprocal of the mass.
2. If necessary, tape the added masses (trials 2 and onward) to the cart.
3. Relatively inexpensive (\$25) mass balances can be obtained from office supply stores.

### Auxiliary Materials:

None

### Scoring Rubric:

<b>NL4. F-m-a Lab</b>	<b>Score</b>
____ Included, labeled and organized all parts of the lab report. ____ Data section includes two Logger Pro plots (sketches only) with the mass and the slope of the best fit line recorded for each. Axes are labeled and units reported. Class data are included and labeled as such. ____ Conclusion describes the relationship and reports the experimentally-derived equation relating force, mass and acceleration; symbols are defined. ____ Discussion of results accurately and thoroughly explains the logical connection between the data and the reported equation. An error analysis is included.	____/____

### Connections to The Physics Classroom Tutorial:

The following reading is a suitable accompaniment to this lab:

<http://www.physicsclassroom.com/Class/newtlaws/u2l3a.cfm>

### Connections to Minds on Physics Internet Modules:

Sublevels 3 and 7 of the Newton's Law module is a suitable accompaniment to this lab:

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