# InquirySpace Teacher Guides:
# Independent Project

## 1) Summary

The goal of this activity is for students to independently carry out an experiment of their own design and analyze the results, using the same tools and pattern of investigation as in the previous more structured activities. The Independent Project activity provides the structure and tools: students are asked to come up with a testable question, mess around a bit, and then describe their plan for a more careful experiment. They report on their results and explanations. Screencasts can also be used as a reporting tool. (See the Screencast Lab Reports guide for more information.)

Students may devise a physical experiment using a sensor (motion, force or other sensors, if available) or go further with one of the models. In addition, CODAP has the ability to collect data from two sensors simultaneously! As a starting point, possible mechanics topics are listed at the end of this document.

## 2) Learning Goals

*Students will:*

- Choose a topic and compose a testable question within the constraints of available experimental tools.
- Clearly describe the testable question, a prediction for the results, the experimental procedure and the experimental evidence that will address the question.
- If a model is chosen, collect data for various values of parameters that have not been investigated before and export the data to the CODAP table.
- If a physical experiment is chosen, set up the experiment and use the motion sensor, and/or other sensors, to collect data.
- Make multiple runs changing the variables being investigated while holding all others constant.
- Refine the experimental setup and data collection enough to get meaningful data.
- Troubleshoot the experiment to pinpoint causes of erratic or inconsistent results.
- Find meaningful patterns or portions of the data when the data is noisy or confusing.
- Send the data to the CODAP table and construct graphs to study the results.
- Use the scaling, hide/show, connecting-lines and movable-line features to study the graphs.
- Arrange the data and graphs to see the effect of one parameter at a time.
- Draw conclusions about relationships based on the graphs.
- Propose an explanation for the results based on underlying physical principles.

## 3) Teacher Preparation

The most important step in preparing to run InquirySpace activities with students is to run the “Teacher Version” of each activity. These are available on the InquirySpace Portal.

http://inquiryspace.portal.concord.org

Teacher versions are essentially duplicates of the student versions with the addition of tips for

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successful classroom use. These tips are written in red within each activity. By running the activities yourself, you will become familiar with many important elements of the activity including the:

- flow of the activity between Lab and Experiment Tabs,
- physical set up of the hands-on experiments,
- use and limitations of sensors,
- functionality within the CODAP environment,
- questions that students will be asked to answer, and
- approximate amount of time needed to complete it.

For this particular activity, it is important to guide students in their formation of a meaningful and testable question, while still allowing for an adequate amount of trial and error.

**4) Materials**

Break students into groups of three. Each group will need the following:

*An account on the InquirySpace Portal.* For help on registration and class set up, please see the Portal and Quick Start Guide.

*Hands-on experiment (per group):*

- Computer
- Internet connection
- Sensors
- Any other student selected equipment

*Simulation-based experiment (per group):*

- Computer
- Internet connection

**5) Potential trouble spots**

*Picking a topic*

Generally students have had little difficulty coming up with an experiment. Most chose from the list, with a few choosing an activity they had not done before and a handful inventing a new question.

Even if they choose from the list, however, they still must formulate a testable question and describe and experiment that would address that. It is also important, and more like real science, to "mess around", collect some interesting data, and try to make sense of it using the graphing tools.

There are issues in two directions.

a) Students choose a question that is very close to what was already done, to get through the project quickly and with little effort.
b) Students choose a question that requires an experiment that is impossible or produces very erratic data. This is fine as long as they have enough time to explore and adjust their procedure or question.

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*Carrying out an experiment*
Ideally, students have done several of the more structured InquirySpace activities prior to attempting the Independent Project so that they are used to the pattern of investigation. But there are several differences that should be explicitly brought out:

- **Find a testable question.** "Canned" activities provide a question that the writer knows can be managed with the time and equipment available. This is harder than students usually imagine, and the teacher must insist that there's at least some hope of getting good data that addresses the question.
- **It's good to "mess around".** Experiments never work right the first time around. It's normal to "rehearse" an experiment and work out the bugs before collecting data that seems solid and worthy of further analysis. Identifying the problems, their relevance, and their meaning in terms of the physics is a huge and valuable part of learning to be an experimenter.
- **Collect multiple runs.** The idea of reproducible results is fundamental and often neglected in "canned" experiments. Students can experience it first-hand when they are defining their own experiment. They should do enough runs to have confidence in the accuracy of their results.
- **Surprises are fun.** Science gets exciting when things don't come out the way you expected, but then you are able to figure out why. With luck and encouragement, students will land on some experiment that challenges them in an engaging and rewarding way.

*Time Constraints*
The most difficult aspect of this activity is the time constraint. With too little time (one or two periods), students tend to either pick something simple and zoom through it with no real engagement or struggle with something too complex for the amount of time given. To have an authentic experience as an experimentalist, teachers must provide enough time and encouragement for students to be adventurous as well as support and suggestions when they run into difficulties.

### 6) Discussion topics

The main research focus of the InquirySpace project is the process of doing experiments and interpretation of experimental data, rather than content understanding. However, please do not hesitate to take advantage of teachable moments to connect these experiences to the underlying physics concepts that are part of your larger curriculum!

### 7) NGSS Standards

This activity potentially addresses all eight of the science practices listed below. Keep these in mind as you facilitate the work of each group.

1. Asking questions
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations

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7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

**8) InquirySpace Independent Project Ideas**

Here are some ideas to help you get started with your Independent Project for InquirySpace. You could extend one of the experiments you have already done or you can try something new!

**Extended Experiments**
*A. Continue with the mass-spring system.*
*B. Continue with a parachute system.*
*C. Explore a pendulum, which has cycles like a mass-spring system.*
*D. Explore a ramp-cart system to learn about energy and friction.*

**New Experiments**
Find some other interesting testable question for which you have the equipment. The measurement tools available to you include a force sensor, a motion sensor, and other sensors if available. Two sensors can even be used simultaneously. Students have used basketballs, yo-yos and toy cars for this experiment. This is a chance to be creative!

*A. Continue with the mass-spring system.*

- Look for other variables that affect the period, for example, the number of springs.
- Try rubber bands as springs.
- Compare the physical experiment with the simulation. Do the results match?
- Measure the spring constant k of the springs directly and plot that against the period. The spring constant is defined as the change in force divided by the change in length. The units are Newtons/meter (N/m).
- Make a “coupled” system: set up two spring-mass systems side by side (hanging from a common horizontal string) and see if you can get them to pass energy back and forth.
- Try ‘damping’ the system in various ways so it slows down more quickly. What is the pattern of slowing down?
- Try a compound system– spring and mass hanging from a spring and mass.

*B. Continue with a parachute system.*

- Invent your own parachute, perhaps one where the size or some other feature can be changed.
- Test other objects and determine their terminal velocity—but but nothing that will damage the sensor!
- Find the exact numerical relationship between mass, area, and terminal velocity, either with the model or the physical setup.

*C. Explore a pendulum, which has cycles like a mass-spring system.*

- Find the variables that do or do not affect the period. Compare this to the mass-spring system.
- Run the pendulum model and explore the effect of the variables. Compare these results to the mass-spring system.
- Compare the physical with the simulation. Do the results match?
- Make a pendulum and a mass-spring system that have precisely the same period. Try to exactly double the period of both so that they are again exactly the same.

- Make a “coupled” system: set up two spring-mass systems side by side (hanging from a common horizontal string) and see if you can get them to pass energy back and forth.
- Study a “compound pendulum” (two masses in different positions) or a rigid pendulum (rod instead of string).

*D. Explore a ramp-cart system to learn about energy and friction.*

- Find the relationships among variables for a cart rolling down a cardboard ramp and across the floor, stopping after a certain distance.
- Take on the distance-prediction challenge: Explore the variables so you can make a cart roll any given distance. Then have the teacher set a ‘challenge’ distance and see if you can make the cart stop there.
- Change variables such as mass of cart, friction, type of surface, slope of ramp – find out what effect they have on stopping distance.
- Use the motion sensor to explore the velocity of the cart. Is the shape of the graph the same on the ramp and the floor?
- Use the force sensor to measure the rolling friction of the cart.
- Build a “bonker” – a mass on a pendulum that hits the cart – and explore the motion and energy transfer of this system.

*E. Other possible experiments.*

- Bouncing ball: what is the pattern of decreasing height?
- Bungee jump: study what happens to a bungee jumper, using force or motion or both.
- What else could you explore and measure using force and motion sensors?  Multiple sensors can be used with CODAP simultaneously!

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