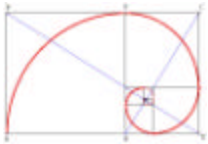
Disseminating information



into our community

University of California Berkeley

Applied Design Engineering Project Teams (ADEPT)

ADEPT is funded by a grant from the National Science Foundation

Launch Force

Objective/Purpose:

Students will develop a method for measuring force using springs. Students will then use their force measuring technique to accomplish a task, namely launching an object onto a target. Students will learn about scales, standards, balanced and unbalanced forces, and the effects of forces on objects. Students will also gain exposure to ways engineers use springs in real machines.

Topic:

Forces. Measuring force. Balanced and unbalanced forces. Related engineering applications: Mechanics of materials, simple mechanisms.

Grade Level: 7-9

Pre-Requisites:

Forces

- Ability to distinguish between balanced and unbalanced forces
- Knowledge that balanced force means net force is zero

Graphing skills

- Labeling axes
- Independent and dependent variables
- Numbering axes constantly
- Locating coordinates
- Creating best fit lines for linear relationships

Lesson Process Summary:

Prior to module

1. Build spring launchers – see document LF_Launcher_Build_Instructions.doc for instructions. This is the main step in preparing the lesson, and will require the bulk of preparation time the first time the lesson is done.
2. Acquire station materials: rubber bands, balls, and a variety of springs or spring-like objects, to illustrate the wide variety of springs that we encounter in daily life. The more the better.

Prep—Time: 60-90 minutes

Lesson Time: 120-180 minutes

Material List:

Per Student—

- (2) sheets graph paper
- Paper for answering questions

Per Group per class-

- (1) 3x5 Index card
- (1) printed paper ruler

Per Group, re-used in each class—

- (1)-(2) copies of Launcher Questions
- (1) "heavy" block or mass (~250 grams in mass)
- (3)-(4) Weights, equal in mass but possibly differing between groups (fishing sinkers of 50-100 grams work well.)
- Various smaller weights, at least 80 grams per group.
- (1)-(2) Plastic bags, approximately 2"x3" in size.
- (1) Paperclip
- (1) ½" diameter wooden ball

Per Set of Stations –

- (1)-(3) copies of Station Questions
- (1) Foam or soft rubber ball
- (3)-(4) Thick rubber bands
- (3)-(4) Thin rubber bands
- (3)-(4) Rulers
- Assorted springs

Materials list continued on next page-

✍ Session 1: Preparation

In the first session, students rotate through 3 stations, working in groups. The stations do not need to be done in order, so a class with 12 groups, for example, would need 4 of each station. The space required for each station is about the size of a typical desk. Station worksheets are provided in LF_Station_Questions.doc.

1. Identify workspaces to set up the necessary number of stations in the classroom.
2. Attach the Station 1 worksheet and place a soft foam or rubber ball and a supply of graph paper at each Station 1 workspace.
3. Attach Station 2 worksheets and distribute spring samples among Station 2 workspaces.
4. Attach the Station 3 worksheet and place a ruler, rubber band, and piece of graph paper at each Station 3 workspace.
5. Ideally, set up an auxiliary station for groups that finish early. An example of the station used in our class is included at the end of the lession plan in "Extensions".

✍ Session 1: Initiating The Class

1. Introduce the idea that "force" is an extremely important quantity for engineers. Examples: knowing when a bridge will break; how much force to launch a rocket into orbit.
2. Tell students that their goal in this project will be to launch a small ball onto a target, but first they will need to learn how scientists measure force in order to accomplish this goal.
3. Ask the class for ideas on how we could measure the forces on an object, even though we can't "see" force.

Material List, continued:

Per Launcher Assembly (each used by one group per class)

- ✍ Wood – (1) 8" long piece and (1) 12" long length of a 1x4 board
- ✍ (2) springs (recommended dimensions: 11/32" x 1.5" x .025")
- ✍ (1) 3" long 10-32 thread bolt
- ✍ (1) 10-32 thread nut
- ✍ (2) 10-32 thread wing nuts
- ✍ (1) 4" long, 1"diameter PVC pipe
- ✍ (1) 4" long, ¼" diameter dowel
- ✍ (1) small hinge
- ✍ (2) nails, ~1.5" long
- ✍ (1) 2" long, ½" square piece of basswood, or similar.
- ✍ (2) thumbtacks
- ✍ Glue or duct tape
- ✍ (Optional) ¼" diameter dowels of varying lengths, 1"-6".
- ✍ (Optional) Protractor

Tools-

- ✍ Saw(s) – for cutting wood and PVC
- ✍ Drill
- ✍ Drill bits, ¼", 3/16", and a smaller bit for pilot holes
- ✍ Screwdriver
- ✍ Hammer

Session 1: Procedures

1. Separate class into groups of 3-4 students
2. Tell the class that there are 3 different stations, and that they will rotate between stations when they are finished with their current station. Emphasize to need to give clear, complete answers, and to work diligently in order to finish in the time allotted.

Note: This is intended to be a self-paced investigation, especially if extension activities are available. A few extra stations may make it easier for students to move between stations as soon as they finish.

3. Send groups to initial stations. Circulate around the room answering questions as students work. Groups may move to other stations as they finish each one.
4. Provide 15 minute "warnings" to keep groups on pace.
5. At the end of the session, ask all students to finish the question they are working on and tidy up the station they are at. Re-group for discussion questions, if desired.

Session 2: Preparation

In the second session, groups will work through a lab in sections, taking a quiz at the end of each section. After the teacher approves of the quiz answers, the group may pick up the materials for the next section of the lab, and move on to the next set of questions

1. Separate materials for sections of the lab:
    a. Section 1: Spring Launcher without pusher, "heavy" block
    b. Section 2: Weights, baggies, paperclips, index cards
    c. Section 3: Printed ruler and graph paper
    d. Section 4: Pusher, ball, dowels
2. Select a distance for the launching test at the end of the day, and identify the initial spring force required to launch balls that distance.
3. Mark a circle (or octagon, etc.) with tape around a plastic lid or bowl serving as a target, at the distance selected.

Vocabulary:

- *Force*
- *Weight*
- *Balanced Forces*
- *Unbalanced Forces*
- *Net Force*
- *Scale*
- *Newton*
- *Spring*
- *Spring Force*

CA Science and Math Standards:

ID those standards met by this module
http://www.cde.ca.gov/be/st/ss/index.asp

Grade 8: Science Standards
Forces
2.B When an object is subject to two or more forces at once, the effect is the cumulative effect of all forces.
2.C When the forces on an object are balanced, the motion of an object does not change.
2.D How to identify separately two or more forces acting on a single static object, including gravity, elastic forces due to tension or compression in matter, or friction
2.E When the forces on an object are unbalanced, the object will change its motion (that is, it will speed up, slow down, or change direction).

Investigation and Experimentation
9.B Evaluate the accuracy and reproducibility of data.
9.D Recognize the slope of the linear graph as the constant in the relationship y=kx and apply this to interpret graphs constructed from data.
9**.E** Construct appropriate graphs from data and develop quantitative statements about the relationships between variables.

Session 2: Initiating the Class

1. Show students a spring launcher, and how it can launch a ball at a target.

2. Explain that a measurement of initial force will be needed to hit the target, and that they will be using their understanding of change in shape with an applied force to produce a force measurement.
4. Explain the system for the lab, i.e. rotating between stations, quizzes, materials…

Session 2: Procedures:

1. Separate class into groups of 3-4 students.
2. Distribute Launcher Questions (LF_Launcher_Questions.doc) to each group of students. Have one student from each group pick up a launcher and heavy block.
3. As each group finishes the 1st section of questions, they should ask for Quiz 1. Allow members of a group to work together to finish the quiz.
4. When the group is done with the quiz, they should call on the teacher to review their answers. If the quiz answers are acceptable, they may pick up materials for the next section of the lab. If the quiz answers are incorrect, ask the group to go over their questions again, and try the quiz again.
5. Repeat this procedure for the 2nd and 3rd sections of the lab, checking over the quiz after each section.
6. For the 4th section of the lab, allow each group to finally pick up their pusher and ball, making a launch possible. Tell them to practice launching and answer the questions in section 4. Students should work on quiz 4 when they are comfortable with both parts.
7. For the final question in quiz 4, provide students with the force identified by the teacher beforehand. The group should identify the corresponding stretch on the springs from their graph developed in the earlier sections of the lab, and use this number to launch at the target.

Reflections

1. Students should think about how they know a force is acting, and how they can tell how much force is acting.
2. Students should describe in their own words how they were able to set up a scale for measuring force.
3. Students should describe how they decided how far to pull back their springs to launch the balls using their graph.