

## Creating an Adaptive Graduated Cylinder



You can create a tactile adaptive graduated cylinder by cutting 5 ml. notches in a plastic strip, attaching it to a Styrofoam disk, and placing it in the cylinder. It floats when liquid is added! (Developed at Lawrence Hall of Science)

## **Lesson Plan for “Egg Drop”**

**Objective:** Students will use engineering design to solve a problem involving forces and gravity.

**Materials:** Eggs (1 per team), building materials (such as plastic bags, paper towels, tape, popsicle sticks, cardboard, glue, packing peanuts, bubble wrap, or other packing supplies, toilet paper or paper towel tubes, cotton balls, rubber bands), rulers and meter sticks, data sheets, photos of various people such as bicyclists, football players, and automobile drivers/passengers using safety equipment (examples: helmets, padding, and safety belts), *I Fall Down* by Vicki Cobb or *Forces Make Things Move* by Kimberly Brubaker Bradley.

**Timeframe:** 2 class periods plus additional time for extensions.

**Grade Levels:** 3-5

### **Connecting to the NGSS:**

This investigation relates to the following *Next Generation Science Standards* (NGSS Lead States 2013):

Performance Expectations:

- 3-5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
- 5-PS2-1 Support an argument that the gravitational force exerted by the Earth on objects near Earth’s surface is directed toward the Earth’s center.

**Engage:** Show students photos of people using safety equipment such as bicyclists, skateboarders, football players, drivers/passengers in a car, baseball catchers, or skiers. How are they protected from impacts? (Helmets, padding, air bags, seat belts, face guards, etc...). How do these pieces of equipment protect them? (By providing cushioning, slow body down from hitting objects quickly, create a barrier between body and colliding objects.)

**Explore:** Challenge students, working in teams of 3 or 4, to create an apparatus that will protect an egg when dropped. The apparatus can be no larger than 20 cm (8 inches) on any side. The height, determined by the teacher, can be as low as 3 meters or as high as the classroom window or on top of a stairwell (Note: For the higher heights, safety measures should include having a second adult present at the bottom of the drop to ensure that students and others are not in path of egg apparatus). During the first class period, students decide on materials, draw a plan, and once approved, build the apparatus. During the second class period, teams test their apparatus by dropping the protected eggs from the height and recording their results.

**Explain:** Have student teams present their results to the class, explaining what factors they feel contributed to successes or failures in apparatus design. Give students the opportunity to share and compare data so that they can begin to think about the variables involved (example: type and amount of materials used, arrangement of materials, how apparatus is held together, etc.).

Discuss the drop results in detail. Why did the eggs drop down and not up? (Gravity is a force that pulls objects down). Why do eggs break when they hit the ground without protection? (When objects collide, they change speed and shape. When the egg hits the ground, its speed changes very fast so its shape changes a lot). How did successful egg protection apparatus work? (By providing cushioning for the egg during collision; by slowing the egg down during impact

with the ground). Why did we drop our eggs from the same height? (To have a fair test where only the apparatus design was a variable). Read *I Fall Down* by Vicki Cobb or *Forces Make Things Move* by Kimberly Brubaker Bradley to solidify understanding of gravity as a force that pushes down.

**Extend:** Challenge students to revise their designs for either a higher drop distance or with different building constraints. For example, students can be challenged to create new apparatus that are no longer than 15 cm (6 inches) on any side. Or, assign prices to various materials (example: 1 packing peanut = 50 cents, 1 paper towel tube = 1 dollar, etc.) and give students a cost limit for their designs.

**Evaluate:** Students are challenged to create a commercial for their “eggs-cellent” egg protectors. The commercial must explain how their protector is constructed and why it works. Students are assessed on their ability to use evidence-based arguments to explain how their designs work. Full credit is given to teams that refer to gravity as a downward pulling force, the effect of collisions on objects (changing speed and shape), and the effect of cushioning (slowing speed of collision so that shape doesn’t change).

#### Egg Drop Activity Rubric

STANDARD	3	2	1
Completed Egg Drop apparatus construction and testing within given time, material, and size constraints	Student completed entire activity according to constraints	Student partially completed activity according to constraints	Apparatus was not constructed according to constraints
Demonstrated an understanding of gravity as a force that pulls things down, and that objects (i.e., egg) change motion and shape after a collision.	Student demonstrated a clear understanding of both concepts using a lab notebook and/or	Student demonstrated partial understanding of these concepts	Student was unable to demonstrate understanding of either concept via any modality

	verbal description		
Used correct units and scientific terms	Student used appropriate units for height measurement and terminology for key terms including <i>gravity</i> , <i>force</i> , and <i>collision</i> on all responses	Student used appropriate units and terminology on some responses	No use, or inappropriate use of scientific units and terms
Developed and communicated logical connections between the experimental results and the construction of the apparatus during the commercial	Student developed and communicated logical connections between their experimental results and their apparatus design.	Student attempted to develop and communicate logical connections between their experimental results and their apparatus design.	No evidence of development or communication of logical connections between their experimental results and their apparatus design.

### Lesson Plan for “Sprouting Seeds”

**Objective:** Students will identify various factors, including sunlight and water, which promote plant growth.

**Materials:** Paper cups, soil, tap water, lima bean seeds, graduated cylinders or measuring cups, rulers, data sheets, digital camera (optional), *Oh Say Can You Seed?: All About Flowering Plants* by Bonnie Worth or *From Seed to Plant* by Gail Gibbons.

**Timeframe:** One period for lesson introduction and planting; several weeks for observations and extensions.

**Grade Levels:** 2–3

**Connecting to the NGSS:**

This investigation relates to the following Next Generation Science Standards (NGSS Lead States 2013):

Performance Expectations:

- 2-LS2-1 Plan and conduct an investigation to determine if plants need sunlight and water to grow.
- 3-LS3-2 Use evidence to support the explanation that traits can be influenced by the environment.

Science and Engineering Practices

- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. (2-LS2-1)
- Make observations (firsthand or from media) to collect data which can be used to make comparisons. (2-LS4-1)

**Engage:** Show students a variety of seeds and allow them to examine them closely. Ask, “What do seeds need to grow?” Student answers will include water, sunlight, soil, warmth, etc. Ask, “Can seeds sprout without light or without water?” “Can seedlings grow well without light or water?” and “How could we test this?” Guide the students in brainstorming fair tests for seed growth by asking questions like, “If we are testing the amount of sun a seed receives, can we also change the amount of soil or water?” (No, because we won’t know if it was the amount of sunlight, soil, or water that made the difference in the growth). Record their suggestions on a whiteboard or chart paper. Ask students, “How will we know if a seedling is growing well?” (By observing the height, number of leaves, color of leaves, development of flowers, etc.).

**Explore:** Challenge pairs of students to develop tests to see what seeds need to sprout and grow. Each pair of students can choose either sunlight or water amount as their variable. The type of

seed (lima bean or radish), amount of soil, number of seeds, depth of planting, and temperature (classroom temperature) remains the same. Give each pair of students two cups, and instruct them to add soil to each until about  $\frac{3}{4}$  full. Each student should plant three seeds in each cup, at a depth that is best for growth according to the seed packet. (Note: lima beans are usually planted between  $\frac{1}{2}$ "–1" deep; radishes are planted at  $\frac{1}{2}$ " depth). Students can use rulers to measure and push soil down to appropriate depth. Have students write their test condition on each cup (i.e., if they are testing sunlight, each student in the pair will write either "sun" or "shade" on their cup. Likewise, if they are testing water amount, they will write either "60 ml" (which is approximately  $\frac{1}{4}$  cup) or "120 ml" (which is approximately  $\frac{1}{2}$  cup). Students testing sunlight place their cups in sunny spots by the window or in cabinets or boxes for shade, while students testing the amount of water should keep their cups next to each other to ensure their light condition is the same. Allow students to observe and record their observations over the next several weeks on a data sheet that includes the date, height of seedling, and other observations including color of stem/leaves, number of leaves, appearance of flowers, digital photos, and so on. Student teams should create line graphs of their seedlings' growth by plotting the height of the plants (y-axis) against the number of days (x-axis). Different colored pencils can be used to distinguish between the two plants (example: orange line = sun; purple line = shade).

**Explain:** Have student teams present their findings to the class. Lead the group through a discussion of the findings that seem consistent among the teams. Note: Students will notice that seeds can sprout without light, which is very surprising to many of them. This occurs because seeds provide food for the young plant before it is able to make its own food through photosynthesis. Seeds left in the dark can sprout but will eventually die as they are not able to produce food without light. Elicit discussion on why some seedlings may have grown differently

even when they were exposed to the same conditions (even within a particular variety of seeds, individual seeds may differ in their healthiness/heartiness and best growing conditions. Also, even though the conditions seemed the same, small differences in the amount of water, sunlight, space, or depth of planting can make a difference in growth). Read either *Oh Say Can You Seed?: All About Flowering Plants* by Bonnie Worth or *From Seed to Plant* by Gail Gibbons to review seedling anatomy and growth requirements.

**Extend:** Challenge students to identify and test other variables that might impact seed growth such as planting depth, type of water (tap, distilled, or carbonated), temperature, proximity of seeds/number of seeds per pot, use of “plant food,” or alternative liquids (orange juice, vinegar, lemonade, etc.). Safety Note: Have students use safety goggles when using these acidic liquids. Remind students to develop fair tests by keeping everything the same (type of seed, sunlight, frequency of watering, etc.) except the variable they are testing. What conditions promoted seed growth? What conditions inhibited or decreased seed growth? Other extensions can include growing a variety of different seeds (example: How does amount of sunlight affect bean, corn, and sunflower plants?) or growing seeds in different mediums (example: water, sand, gravel, and so on).

**Evaluate:** Have students write a “How To” manual on growing seeds to be shared with parents, school staff, or local botanical gardens. Their manual should include instructions on what should be provided or avoided in order for seeds to grow well. Students should include drawings, photos, graphs, and other data from their investigations as evidence for their explanations.



### Sprouting Seeds Rubric

STANDARD	3	2	1
Student designed and performed an investigation on seed sprouting including recording of data	Student completed entire investigation including recording of data	Student partially completed investigation with some data recorded.	The investigation was not completed and/or no data was recorded.
Student demonstrated an understanding of variables (i.e., sun, water, number of seeds) involved in seed sprouting and set up a “fair” experiment to test one.	Student demonstrated a full understanding of variables and set up a controlled experiment to test one.	Student demonstrated some understanding of variables but was unable to design a “fair” experiment to test one.	No evidence of understanding variables or the design of a “fair” test.
Student used correct units and scientific terms	Student used appropriate units for length, volume, temperature, and correct names for seedling parts (i.e. seed, roots, stem, leaves)	Student used appropriate units and/or seedling part names on some responses	No use, or inappropriate use of scientific units and terms
Student communicated results in a “How to” manual which contained clear and accurate evidence-based claims.	Student communicated results in a “How to” manual which contained clear and accurate evidence-based claims.	Student communicated results in a “How to” manual but did not support claims with evidence from experiment	Student did not communicate results.