CHAPTER 17

Teaching Suggestions

Science and Mathematics Lab

(Course 3, Lesson 12-1)

Simulating Radioactive Decay

OVERVIEW

This activity provides students with the opportunity to explore the concept of radioactive decay. Students will be required to predict and measure exponential decay in a simulation of radioactivity.

RECOMMENDED TIME

1 class period

MATERIALS

- small bag of dried split peas
- 250-mL beaker
- grid paper
- bag of dried lima beans
- large baking tray

PREPARATION

No special preparation is needed.

TEACHING THE LAB

1. Have students work individually or in pairs.
2. Have students compare their results. You may want to find an average half-life by using the data of the entire class.

Answers and Conclusions

1. Answers will vary slightly. The half-life is about 5.1 minutes.
2. Each atomic nucleus of the parent that decayed became a stable nucleus of the daughter element. As the number of parent nuclei decreased, the number of daughter nuclei increased.
3. Only Question c can be answered. It is impossible to predict which split pea will fall flat side up or when a particular split pea will fall flat side up. However, one can predict the number of split peas remaining after 3 observations. (About 34 split peas should be remaining after 3 half-lives.)

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Science and Mathematics Lab

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Simulating Radioactive Decay

INTRODUCTION

Certain elements are made up of atoms whose nuclei are naturally unstable. These elements are said to be *radioactive.* The nucleus within an atom of a radioactive element will decay into the stable atomic nucleus of another element by emitting or capturing atomic particles. The unstable element is called the "parent" element and the stable element is called the "daughter" element. It is impossible to predict when the nucleus of an individual radioactive atom will decay. However, if a large number of nuclei are present in a sample, it is possible to predict how much time it would take for half of the nuclei in the sample to decay. This time period is called the *half-life* of the element.

Atoms are too small to see with our eyes. Special laboratory equipment is needed to count atomic nuclei in elements. To eliminate this problem, you will simulate the decay of unstable nuclei by using materials that are easy to observe. In this lab, you will use dried split peas to represent the unstable nuclei of the parent element. Dried lima beans will represent the stable nuclei of the daughter element. Your observations will allow you to model how the atomic nuclei of radioactive elements decay.

OBJECTIVES

In this lab, you will:

- simulate the decay of a radioactive element.
- graph the results of the simulated decay.
- determine the half-life of the element.

MATERIALS

- small bag of dried split peas
- 250-mL beaker
- grid paper
- bag of dried lima beans
- large baking tray

PROCEDURE

1. Count out 200 dried split peas and place them in a beaker.

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Simulating Radioactive Decay (continued)

2. Place the baking tray on a flat surface.
3. Hold the beaker over the tray and sprinkle all of the split peas onto the tray. Try to produce a single layer of split peas on the tray.
4. Remove all the split peas that have *not* landed flat side down. Count the split peas that you have removed from the tray and return them to the bag. Replace the number of peas that you have removed from the tray with an equal number of lima beans.
5. Count the number of peas and the number of lima beans on the tray. Record these values in the Data Table as Observation 1.
6. Scoop the peas and beans from the tray and place them into the beaker.
7. Predict how many split peas you will remove if you repeat Steps 3–5.
8. Repeat Steps 3 through 6, recording your data in the Data Table as Observation 2.
9. Predict how many observations you will have to make until there are no split peas remaining.
10. Repeat Steps 4 through 6 until there are no split peas remaining.

DATA AND OBSERVATIONS

Observation	Time (Minutes)	No. of Split Peas	No. of Lima Beans
0	0	200	0
1	5		
2	10		

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Simulating Radioactive Decay (continued)

ANALYSIS

In this experiment, each split pea represents the nucleus of an atom of the radioactive parent element. A split pea that has landed flat side down represents the nucleus of an atom of the parent element that has not yet decayed. Each split pea that has *not* landed flat side down represents the nucleus of an atom of the parent element that has decayed. When the parent element decays, it forms a new element called a *daughter,* which is represented by a lima bean.

Assume that the time period between each observation was 5 minutes. Observation 1 will have been made at 5 minutes, Observation 2 at 10 minutes, and so on. Complete the time column in your data table.

1. Use graph paper to graph the results of your experiment. Plot on the vertical y-axis the number of parent atoms remaining after each observation. Plot the observation number on the horizontal x-axis.

2. Use your graph to construct another graph. Plot on the vertical y-axis the number of daughter atoms remaining after each observation. Plot the time of the observation on the horizontal x-axis.

3. Determine the half-life of the parent element from your graph.

Questions and Conclusions

1. What is the half-life of the parent element?

2. The two graphs you constructed are mirror images. Explain why this is so.

3. Suppose you are given 400 dried split peas to do this experiment. Explain which of the following questions you could answer before starting this experiment.

- **a.** Can you identify which split peas will fall flat side up?
- **b.** Can you predict when an individual split pea will fall flat side up?
- **c.** Can you predict how many split peas will be remaining after 3 observations?

CHAPTER 18

Teaching Suggestions

Science and Mathematics Lab

(Course 3, Lesson 12-2)

The Way the Ball Bounces

OVERVIEW

This activity will involve students in graphing quadratic equations. They will be asked to make predictions and to use information from the graphs to learn about constants.

RECOMMENDED TIME

1 class period

MATERIALS

- TI graphing calculator
- Calculator-Based Ranger (CBR)
- grid paper
- ball (racquetball or basketball)

PREPARATION

Before starting this exercise, it is recommended that you clear all previous programs from the graphing calculator memory to ensure proper functioning of the CBR program. To do this, turn the calculator on. Then press [2nd] [MEM] 5 1 2.

Download the Ranger program into the calculator by connecting the CBR to the calculator. Press [2nd] [LINK] [▶] [ENTER] on the calculator. Press the 82/83 button on the CBR. Start the Ranger program by pressing [PRGM] on the calculator. Select RANGER from the menu and press [ENTER]. Select 3: APPLICATIONS from the main menu. From the UNITS? menu, select 1: METERS [ENTER]. From the APPLICATIONS menu, select 3: BALL BOUNCE [ENTER] [ENTER].

TEACHING THE LAB

1. Have students work in groups of three. One student should release the ball, one should hold the CBR unit, and one should record the data from the calculator.

Teaching Suggestions

Science and Mathematics Lab

(Course 3, Lesson 12-2)

The Way the Ball Bounces (continued)

2. It will be necessary to show the students how to use the CBR. The student holding the unit will need to press TRIGGER to initiate data collection. Emphasize the importance of holding the unit steady while it is collecting data.

3. For best results, do not use a soft or felt-covered ball. The student who releases the ball should be reminded to remove his or her hands quickly.

Answers and Conclusions

1. Students should graph the following points and draw a parabola to connect them.

   $y = -1(x - 3)^2 + 5$

x	*y*
1	1
2	4
3	5
4	4
5	1

2. Students should graph the following points and draw a parabola to connect them.

   $y = 1(x - 3)^2 + 5$

x	*y*
1	9
2	6
3	5
4	6
5	9

   Changing the sign of *A* inverts the parabola.

3. Answers should be either positive or negative.
4. Answers may vary; no change, increase, or decrease.
5. Answers may vary, but should be approximately –4.9.
6. gravity

CHAPTER 18

Name ______________________ Date __________

Science and Mathematics Lab

(Course 3, Lesson 12-2)

The Way the Ball Bounces

INTRODUCTION

The motion of a bouncing ball can be described by a quadratic equation. The curve that results from a graph of the height of the ball over time is called a *parabola.* How quickly the ball accelerates and the maximum height that the ball bounces will affect the shape of the parabola. These variables are factors in the quadratic equation.

OBJECTIVES

In this lab, you will:

- graph the distance of a ball from the floor over time as it bounces.
- compare the equations for different bounces to see how they change.

MATERIALS

- TI graphing calculator
- Calculator-Based Ranger (CBR)
- grid paper
- ball (racquetball or basketball)

PROCEDURE

1. Before collecting any data, answer Questions 1–4.
2. Have one person hold the CBR at waist-height. Another person should hold the ball 0.5 meter below the CBR. The person with the calculator should press [ENTER].
3. When the person with the CBR presses [TRIGGER], the CBR will click as it collects data. The person with the ball should release it and quickly remove his or her hands.
4. If necessary, resample by repeating Steps 2–3. When you have finished collecting data, press [ENTER]. The calculator should show a height-time graph of the bouncing ball.
5. Using the arrow keys, find the *x*- and *y*-coordinates near the lower left and lower right of the first complete parabola and the coordinates for the vertex, or highest point, of the parabola. Be sure that the cursor is on the parabola for the lower data points. Record the data in Table 1.

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The Way the Ball Bounces (continued)

6. Press ENTER and select 5: REPEAT SAMPLE from the PLOT menu. Press ENTER again. Repeat Steps 2–5, holding the CBR at shoulder-height. Record the data in Table 2.

DATA AND OBSERVATIONS

Table 1

Location	*x*	*y*
lower left		
vertex (*H*, *K*)		
lower right		

Table 2

Location	*x*	*y*
lower left		
vertex (*H*, *K*)		
lower right		

Questions and Conclusions

1. The quadratic equation for the height of a bouncing ball over time is $y = A(x - H)^2 + K$ (x is time and y is height). Calculate the following y values from the given x values if $A = -1$, $H = 3$, and $K = 5$. First rewrite the equation, substituting in the A, H, and K values. Graph the points and connect them with a smooth curve on a separate piece of grid paper.

x	*y*
1	
2	
3	
4	
5	

2. What effect does changing the sign of A have? Repeat Question 1 using $A = 1$. Compare the two graphs and describe the difference.

x	*y*
1	
2	
3	
4	
5	

3. What do you predict the sign of A will be for the bouncing ball?

4. A is related to the *acceleration* of the ball, in other words, how quickly it speeds up. If you drop the ball from different heights, will A change? If yes, how will it change?

5. Using the calculator and the formula $A = (y - K)/(x - H)^2$, calculate A from the data in Table 1 and calculate A from the data in Table 2. Use the vertex (H, K) and the lower left point (x, y).

A for Table 1 = A for Table 2 =

6. What physical force is responsible for the rate at which the height of the ball decreases?

