

What Goes Up...

Math / Physics
Middle / High
Regressions / Data Collection

Introduction: Tossing a ball through the air is a common enough experience in the lives of most people. However, what is uncommon is the ability of people to understand the mathematics that describes such events. The motion of everything from baseballs to space shuttles are described by Newton's Laws of Motion, the Law of the Conservation of Energy and power of mathematics. Baseballs and space shuttles are projectiles, thrown in to the sky, and out of it, by forces great and small, and brought back by the force of gravity. The activity below will help students see the relationship between projectile motion and the mathematics used to describe them.

This experiment will show that by dropping and tossing objects, and plotting their height vs. time, the general quadratic $f(x)=ax^2+bx+c$ can be developed as a model for projectile motion.

Objectives: Students will be able to...

1. Collect data by following an experimental procedure.
2. Input data in a graphing calculator.
3. Compare results.
4. Draw conclusions.
5. Determine the governing math model
6. Discuss applications of results.

Related Key Words: projectile motion quadratic equation kinetic energy
potential energy conservation of energy gravity

Materials: CASIO CFX9850-Ga Plus or CFX9850-G COLOR GRAPHING CALCULATOR
CASIO EA-100 CASIO Data Collector (CDA)
Vernier motion detector
Medium-weight book, playground ball, heavy hat or some other object to drop

Purpose: This experiment involves the collection, graphing, and analysis of two special cases of projectile motion:

1. Dropping an object from directly over a motion detector.
2. Tossing an object and allowing it to fall directly over a motion detector.

In both cases, the plot of the resulting data will appear to be quadratic.

STEP 1— Connect the EA-100 unit to the CFX9850-Ga Plus or CFX9850-G calculator with the unit-to-unit link cable using the I/O ports located on the bottom edge of each unit. Press the cable ends in firmly.

STEP 2— Connect the Vernier motion detector to the SONIC port on the right side of the EA-100 unit

STEP 3— Place the motion detector on the floor (facing up) in an open area of the classroom.

STEP 4—

Select three students to perform the experiment and identify them as the “Catcher,” the “Dropper,” and the “Trigger Operator.”

- Catcher sits beside the motion detector and catches the dropped object before it hits the detector.
- Dropper: Holds and drops the object.
- Trigger Operator: Controls the EA-100 unit.

STEP 5—

Select an object to drop. (It is best if the object is large enough to give the motion detector a good area to detect).

STEP 6—

Turn on the EA-100 unit and the CFX-9850G OR GA PLUS calculator. The EA-100 can now be set up manually. Push the gold [SHIFT] key followed by the [MODE] key just below it for SETUP. On the right side of the screen, the words “READY, SAMPLING, and DONE” should be blinking. If they are not, press the [Halt] key next to the red ON/OFF switch, followed by [SHIFT], and [MODE].

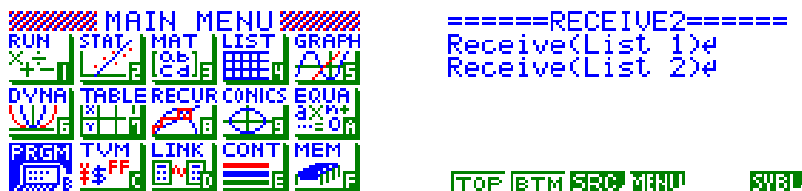
STEP 7—

We will set the parameters of the EA-100 to collect 100 data points in two seconds. The time interval will set to 20.0 msec. Hit the [DATALOG] key for NEXT until this option appears. Press [TRIGGER] for ENTER to store that value. The number of data points will set to 100. Hit the [DATALOG] key until 100 appears. Press [TRIGGER] for ENTER to store that value. Time will be measured as a running clock. Hit the [DATALOG] key until 1 appears. And press [TRIGGER] to store that value. On the right side of the screen READY should appear.

Note: The motion detector cannot detect motion closer than 1.5 feet. Be sure the object is dropped from at least 5 feet or you might not have enough data points to develop a model for the motion.

STEP 8—

When the EA-100 unit displays READY, the Trigger Operator should press TRIGGER on the EA-100 and tell the Dropper to release the object. Since the EA-100 unit is programmed to only record data for 2 seconds, the Dropper should release the object immediately after TRIGGER is pressed. When the Catcher catches it, see if the object fell directly toward the middle of the detector. IF not, restart the experiment from Step 7.



STEP 9—

Analyze the collected data on the CFX-9850G OR GA PLUS calculator by using the receive program to transfer the data to the STAT menu on the calculator.

Tossing an Object

STEP 10— Place the motion detector (facing up) on the seat of a chair so the motion detector will detect an object being tossed up over it.

STEP 11— Make sure the EA-100 is turned on. Use the same parameters on the EA-100 as before. The motion detector starts clicking.

STEP 12— Have the Dropper hold the object over the motion detector so that his hands and arms are not sensed by the motion detector's beam. When READY is displayed on the EA-100 unit, the Trigger Operator should press TRIGGER on the EA-100, and immediately tell the Dropper to toss the object directly above the motion detector.

A good toss will start directly above the motion detector and return to the same location.

Be sure the Dropper catches the tossed object before it hits the motion detector.

STEP 13— Repeat from Step 8 until you have a good data set to analyze.

Questions and Problems:

Level 1: Answer the following questions in complete, well-structured sentences.

1. What is the shape of the curve in both methods?
2. What regression line gave you the best-fit curve? Does this match the objective of the activity?
3. Trace the relationship of kinetic and potential energy in both methods.
4. Where should the value for the acceleration appear in your equation?
5. If you were in Denver Colorado, would your results differ? Explain your response.

Level 2:

1. Identify three sources of error for this experiment.
2. Repeat the first half of the experiment with 3 objects of the same size, but different masses. How does your data change? Should it change? Explain your reasoning.
3. For the second method of the activity, determine the line of symmetry, the maximum point of the curve, and the relationship between them.
4. For the second method of the activity, sight examples of Newton's Three Laws of Motion along the position vs. time graph.

Extension: Have students research the topic of modern rocketry and how it relates to the Newton's Laws of Motion. Have them build and launch model rockets.