**Rolling Ball**

**Materials:** Motion Sensor, Boxes (to act as ramps), 2 Large Balls each with a different mass (could use Soccer, Basketball, or Kickball), Computer, Fathom

**Groups:** Teachers need to be in groups of 3-4. Roles include: ball roller, motion detector holder, person to set up and turn on experiment in Fathom, and recorder.

**Mathematical goals:**

* Represent data with plots on the real number line (dot plots, histograms, and box plots). (S-ID.1.)
* Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.
  + a. Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Use given functions or choose a function suggested by the context. Emphasize linear, quadratic, and exponential models. (S-ID.6)

**Technological goals:**

* Teachers will be able to set up experiment in Fathom using a Motion Detector
* Teachers will be able to create table and graph of their data
* Teachers create sliders to model an a function that fits their data

**Lesson Outline:**

**Background:**

One of the most popular stories about Galileo (1564 - 1642) is that he threw objects from the Leaning Tower of Pisa to demonstrate that objects of the same kind but with different masses reach the ground at essentially the same time. Galileo stated that a hundred pound iron ball and a one-pound ball falling from the height arrive at the same. To study accelerated motion, Galileo used inclined planes to slow down free fall and minimize the effects of air resistance. Galileo was able to corroborate experimentally his conclusion, obtained through mathematical reasoning, that “if a moveable descends from rest in uniformly accelerated motion, the spaces run through in any times whatever are to each other ... as the squares of those times.”

**Make Predictions and Conjectures:**

Discuss with your group the following questions. Record your answers.

*1) If we keep the slope of the ramp constant, what balls will roll up/down faster? Why?*

*2) What happens if we increase the slope of the ramp?*

*3) Will the balls reach the same speed if we only roll them partway up the ramp?*

Let teachers play informally to test out their predictions.

**Set up the experiments in Fathom.**

1. Open a new Fathom Window
2. Plug in the Go!Motion Detector into your computers USB drive
3. Go to the icon “Meter” at the top of the window
4. Motion Detector should be at the top, choose it (If Motion detector isn’t at the top restart Fathom and try again. Sometimes it’s a bit finicky)
5. Create a new collection
6. Drag plug into this collection (Inspector window should open)
7. Create a table and graph with the attributes time and distance
8. Design the experiment to be 20 cases per sec for 1.5 seconds (you may choose to change this, but these are good starting values)
9. Run your experiments

**Experiment 1:**  Use one ball, keeping the mass constant, and change the slope of the ramp, and roll the ball down ramps of different slopes (this also will work best if you have different Fathom windows for each ramp of a different slope).

1. What mathematical model would best model your data? Use a formula and sliders to test this conjecture. Are there any data points that are irrelevant?
2. What formula seems to model your data the best (right click, plot formula, don’t forget that Fathom needs you to insert all multiplication symbols)?
3. How do the formulas compare to each other? Why do you think this is?
4. Explain what various features of your graph mean, including x-intercepts, y-intercept, and vertex.
5. Are your predictions correct? Why or why not?
6. What conclusions can you make from your experiment?

**Conclusion**

Galileo’s genius allowed him to see that movement along inclined planes would give him a better understanding of free fall and accelerated motion. This is a great way to make quadratic functions come alive in your classes.

**For Further Exploration:**

**Experiment 2**: Use the same ramp kept at a constant height and then roll balls of different masses down the ramp (it seems to work best with different Fathom windows for each different ball).

1. What mathematical model would best model your data? Use formulas and sliders to test this conjecture. Are there any data points that are irrelevant?
2. What formulas seem to model your data the best (right click, plot formula, don’t forget that Fathom needs you to insert all multiplication symbols)?
3. How do the formulas compare to each other? Why do you think this is?
4. Explain what various features of your graph mean, including x-intercepts, y-intercept, and vertex..
5. Are your predictions correct? Why or why not?
6. What conclusions can you make from your experiment?