

2019

# Question 1: Driving Rain, Question 2: Cooking off Ammo

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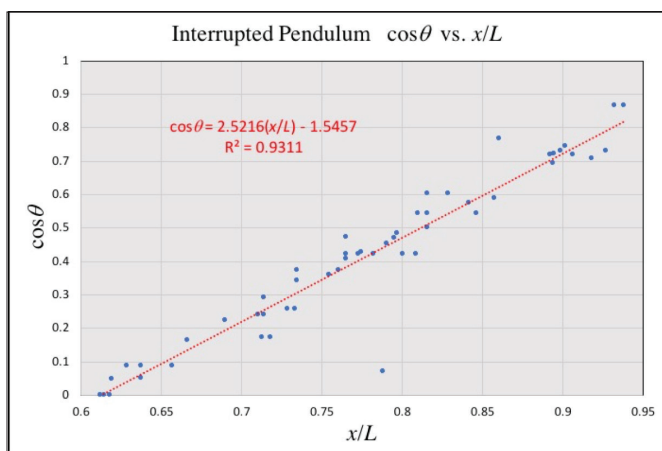
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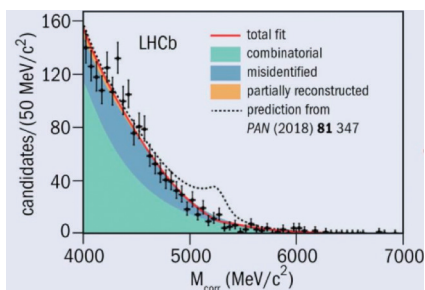
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**Fig. 3.** The graph of  $n = 57$  measurements by a class of 18 AP Physics C students in one lab block. The slope of a linear trend-line represents less than 1% error and the intercept is within 3% of the theoretical value, in spite of several large outliers.

### Final thoughts

Prior to this lab, I show students a video clip in which Richard Feynman discusses how an experiment is used to validate a theory.<sup>5</sup> Regarding the theory, he states, “If it disagrees with experiment, it’s wrong. In that



**Fig. 4.** Large Hadron Collider data that challenges the Standard Model as obtained from very large data sets. Note the error bars.

simple statement is the key to science.” The results of this analysis provide an open door for discussion of measurement outliers, accuracy vs. precision, use of error bars, and the process of experimental validation of theory.

Often the question of a less-than-great coefficient of determination value is brought up in discussion of the “goodness of fit.” My answer to that is to look at the conclusions made from extremely large data sets, such as those in high-energy physics.<sup>6</sup>

My motivation for writing this article comes from my students and the excitement they share when a discovery is made. Special thanks go out to Rachel, Gabe, and Daniel.

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## Fermi Questions

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### ► Question 1: Driving rain

How much does our highway gas mileage decrease in a heavy rain? (*Thanks to Alex Godunov of Old Dominion University for suggesting the question.*)

### ► Question 2: Cooking off ammo

Guns have long barrels to take full advantage of the force of the expanding gases to propel their projectiles. What would be the initial velocity of a bullet if the propellant in its cartridge exploded outside of a gun?

Look for the answers online at [tpt.aapt.org](http://tpt.aapt.org)

Question suggestions are always welcome!

For more Fermi questions and answers, see *Guesstimation 2.0: Solving Today's Problems on the Back of a Napkin*, by Lawrence Weinstein (Princeton University Press, 2012).

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