mechanical_fish 1240 days ago | link | parent

This is the college lab experiment that I remember the best. Because my lab partner and I did the measurement and determined that *G* was 15% smaller [1] than the value in the textbooks.

We asked the professor what might have gone wrong. Whereupon he exhibited the key trait of a great science teacher: He refused to tell us.

So we worked. Oh, did we work. We armed ourselves with the backs of many envelopes and brainstormed. We tried to think of every possible source of systematic error. We tried to calculate the likely magnitude of each of those sources. ("How much electric charge imbalance would be needed for static electricity to cause the error?" "What if an elephant were pacing around outside the lab in phase with our experiment?") We redid the experiment several times, changing the orientation of the apparatus, moving ground wires, et cetera.

Nothing helped. In the end, we wrote up a *really* long lab report detailing all the theories and the calculations and the systematic errors that we had tried to correct for. Then we plotted up our results and stated that our measurement was X, plus or minus something like 5%. We noted that every other physicist for the last few hundred years had converged on a value 15% higher than X, which suggested that we'd probably missed something, but that there was nothing we could do about that because we didn't have any more time to experiment.

As I recall, we got an A. I will never know how we managed to screw up the experiment. After we turned in the report, the professor confessed that he had no idea either. If he knew otherwise, he was an excellent actor. They plotted all the class's results on the wall, as a time series, and ours was a big, big outlier -- that damned apparatus worked for the groups before us, and it worked for the groups after us. We got a lot of good-natured ribbing.

I'm not sure I could design a better two-week tour of the scientific experience than that.

---

[1] Or maybe it was larger. As if it really matters. Anyway, it was *way off*.

Herring 1240 days ago | link

This story frustrates me like being unable to find a bug in code. Why would you keep using the same instruments? Trying different ones would have told you whether your technique was off.

---

mechanical_fish 1240 days ago | link

This story frustrates me like being unable to find a bug in code.

That is exactly the feeling, yes.

Here's an interesting fact about the profession of experimental scientist: You feel this way *all the time*. Actual science is not like classroom science. There's no money or glory in doing experiments which have known, explainable, predictable, well-established answers. Nobody will pay you to measure the value of *G* again and again, on the off chance that one day it will be different. We're all pretty well convinced that this doesn't happen.

Instead your job is to do experiments which have odd, inconsistent, unpredictable, poorly-evidenced answers. Sometimes you do those experiments for years and then find that the only reason your results are intriguingly odd is that there's a bug in your technique or your theory. That's depressingly common. Other times -- the interesting times -- you have to invent a brand-new theory to explain your

experiments. And sometimes that theory is even correct, and you get to publish a bunch of papers on it -- perhaps you even get to name it! But you must constantly worry that your brand-new theory is a load of crap -- maybe you're just doing the experiments wrong.

If you can't learn to live with that nagging feeling of uncertainty you may need to find a different profession.

Why would you keep using the same instruments?

As others have pointed out: This is undergraduate physics lab. There is no money to buy anything. More importantly, there is no *time* to assemble another apparatus. (This is another reason why this problem is a great model of real-world scientific life. There is never enough money. There is never enough time.)

Moreover, let's consider the possibilities. The instrument was working the week before. With 20-20-hindsight, we know that it was working on the following week. Odds are that the problem was not with the instrument. It was almost certainly with the experimenters! We screwed it up. I just have no idea how, and I never will. Arrrgh!

---

jgamman 1239 days ago | link

there's a guy doing G-measurements at really small scales here:http://www.stanford.edu/group/kqb/Research/gravity2.html i'm still astounded at just how good the 1/r^2 relationship has held up for what? 300 years?

---

pmjordan 1240 days ago | link

You've never had the pleasure of doing an undergraduate physics lab project then... We were generally pretty limited in the devices we could use.

---

albertcardona 1240 days ago | link

"Trying different ones"

That is like trying to do a numeric division on paper after knowing the answer, because a calculator showed you. I.e. trying to fit a value that "ought" to fit.

I am sure it was greater fun to just examine one's procedures and materials, and take no assumptions. Just imagine: these guys could have stumbled upon a great discovery.

---

mechanical_fish 1240 days ago | link

Just imagine: these guys could have stumbled upon a great discovery.

Note: This sentence is *crazy.* As if the odds weren't 999 to 1 in favor of "experimenters made a boneheaded systematic mistake" rather than "experimenters have discovered the fifth force", or "one of the experimenters is made entirely of lead and has never noticed it before".

But, note also: This sentence is how you have to think if you're going to make a great scientific discovery. The folks who discovered the pulsar were sure that they'd made a boneheaded mistake. The folks who discovered the cosmic microwave background had to work through the "this has got to be a mistake" phase. Even once *you* are convinced there's no mistake, it can take years or decades to convince *others* that there isn't a mistake.

You have to *work through* your mistakes in science. You can't be afraid to face them. The good news is that it's a lot easier to practice this as an undergraduate than when you've got a whole lab full of students riding on

the reputation of your pet theory.
