Re: Measurement and Error

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jhelfand@umd.edu (Joe) wrote in message news:<e62610ea.0410052227.1ffdc657@posting.google.com>...
> *Someone told me whenever you make a measurement, you need to say what*
> *the uncertainty is. (Do you agree?!) If I mesaure with a ruler,*
> *what's the uncertainty?*

Ok, first you need to go back and complain to your 8th grade science teacher for not teaching you this. I recall many tedious hours spent measuring the football field using first a 1 cm ruler, then a 1 m ruler, then a 30 meter tape measure.

All measurements of real quantities (as opposed to digital quantities such as "how many lions are there in my bathtub?") involve uncertainty. Without some indication of the accuracy, the measurement is less useful than it could be, possibly even totally meaningless. (Digital quantities involve uncertainty as to identifying or missing counts. "Is that a lion? Are there any lions hiding under the soap? Is that lion actually in the tub or do we count that as in the soap dish?")

The typical uncertainty in something like a ruler is half the smallest division on the scale. However, there can easily be more uncertainty than that. If you were trying, say, to measure the height of water up the beach, then you'd be dealing with waves, rough beach shape, etc. So you might be measuring with a ruler with 1 mm divisions, but you might only be accurate to a few cm if there were waves moving the water up and down that much. Or to a few 10's of cm is the waves were bigger, or a few meters if the waves were bigger. And so on.

Uncertainty is a fundamental of measurement and science. You have to know how accurate a measurement is. If the measurement is reported as 1.554243 m, then the default uncertainty is plus or minus 1 in the last digit, or +/− 0.000001 m. Those who have pocket calculators will often report some calculation as though it had accuracy to the last digit. "One seventh of my 4.5m board is 0.64285714285714285714285714285714 m." Clearly, if I'm using a typical wood saw, I'm not really getting those last digits, probably no more than an accuracy of +/− 1mm. The same is true

of all scientific measurements, and all calculations based on them.

It is fairly frequent to meet silly mistakes in uncertainty reporting. Pocket calculators are just one. Recently I was reading a report about a nuclear reactor. The dimension of a part was reported as 4.5 feet. But we've all gone metric, so that had to be in meters. This was dutifully reported to 5 significant digits, 1.4 etc. meters.

Uncertainty can arise through standard things like reading a scale. It can arise through physical process that jumps around, like waves messing up a water level measurement. It can arise through repeatability issues, such as manufacturing with impurities, flaws, variations in temperature, etc. And, at very fundamental levels, it can arise from quantum mechanics.

Uncertainty means we have only a finitely accurate view of reality. This means that, in the very typical case, there are many theories that cannot be resolved with that accuracy. If two (or more) theories manage to get inside the error bars on all measurements, then there is no physical reason to prefer one over the other. There are usually reasons of simplicity to prefer one. Or reasons of prior art, or existing mathematical work, etc. Thus, at this time, the standard theory of gravity is general relativity. There are other theories. But so far, GR has worked every time we've tested it, and most of those other theories are more complicated.
Socks