1.5 Verification and searching for facts—experimentation.

It sounds like physics is a straightforward application of mathematics. This is not true! One specific difference between mathematics and physics is that everything physics does has to happen in the real world. How do we know that what we are doing relates to the real workd? The only way to be sure is to measure something.

When a model is constructed, the way to test its predictions is to conduct an experiment. We build an apparatus that we hope duplicates a natural event, or reveals the results of a natural event, and then rule out as many influences from outside of our considerations as is possible. For example, in constructing Eq. (1) through Eq. (3), you would isolate the system so that the only variables that might influence the experiment are the pressure, volume, and temperature of the gas being studied. In reality this isolation is extremely impossible to achieve, we cvan only achieve it approximately. This is one source of experimental error. Much effort goes into trying to account for, and control, possible errors that might creep into an experiment. Despite such efforts, we still get significant errors. For instance, a famous experiment that indicated that neutrinos (a nearly massless subatomic particle) move faster than the speed of light (something that is impossible according to Einstein's secial theory of relativity) was discovered to be wrong when it was determined that a plug in an instrument was put in the wrong way. Of course, even if we do not make such mistakes, there is always error in the results from an experiment, because we cannot make a measurement without error!

One thing about experiments that is interesting is that while you need some knowledge of shop-craft and electronics to do physics experiments, you do not need a long list of background knowledge to get into it. Thus experimental physics is more suitable for immediate immersion, and pursuit by amateurs, than theoretical physics.

The process of observational physics is almost identical to experimental physics, except that the apparatus you design and build are only to observe phenomena, and not to control it. In either case the goal is to actually learn something about nature. Here you measure some quantity and we then state that the quantity is given by a measurement. ***We know that every measurement result is the sum of the sought-after information plus some uncertainty introduced by the process of measurement.***

One of the goals of data analysis is to understand and account for the uncertainties. This allows us to establish error bounds, we state that a measurement is accurate within those error bounds.