Assumptions

What is an assumption? In everyday language we say "I assume" in almost any context. The use of the word *assumption* in everyday language is DIFFERENT from the way physicists use the term. In ISLE (which is a model of how physicists think and reason) we use the word *assumption* to mean something very specific: For example, if you are asked to calculate how far a metal ball from the projectile launcher will travel, it is probably safe to *assume* that there is no air resistance. Doing this allows you to perform a much easier calculation that doesn't require a computer. ***So an assumption is some factor in the physical situation you choose to ignore that simplifies a calculation or a model, or an experiment.***

Physicists make assumptions when modeling a situation. For example, in the ideal gas model, it is *assumed* that the particles in the gas do not interact with each other. This assumption determines many of the features of the model and the equations that come out of it to describe the behavior of the gas.

Every assumption has a domain of validity. As previously mentioned, if you want to shoot a metal ball out of a PASCO projectile launcher and hit a target, it is safe to ignore air resistance (an assumption). However if you were an artillery gunner in world-war-1, trying to hit a target several miles away, you CANNOT ignore air resistance. You must factor air resistance into the calculation, which is very difficult. Including air resistance makes the calculation much harder and must be done numerically. The problem of correctly aiming artillery guns was one of the driving forces behind the development of the modern (electronic) computer. The validity of ignoring air resistance depends both on the surface to volume ratio of the object flying through the air AND on how fast it is moving. Deciding when an assumption is valid or not can be quite challenging.

Often in a physics problem it will say something like "ignore air resistance" or "a string passes over a frictionless pulley." These statements are basically telling you to make an assumption. What is different in ISLE is that you are seldom going to be told what assumptions to make, particularly when you are designing experiments. You are going to have to decide what assumptions you should make and decide whether it is valid or not to make that assumption. You also have to evaluate and decide whether your experimental result or outcome is "off" because you chose to ignore a factor that you should not have. These are the sorts of skills you need in the real world when you are trying to solve a real-life problem. For example, is it safe to ignore air drag when constructing a high-rise building? Answer: It depends on the height, and super-tall buildings like Burj Khalifa have special aerodynamic features included into their construction whereas a building like the Empire State Building doesn't need them. Being able to understand and evaluate assumptions is a key part many branches of science and engineering. That is why you are expected to figure out your assumptions rather than being told what to assume. The core of the ISLE philosophy is getting you to start thinking and reasoning like a physicist and thinking about assumptions is one of the key habits of mind of physicists and scientists in other fields.

A lot of the time you don't even realize you are making an assumption. It is only after you've done an experiment and something seems to not be working out the way you expected, that you may go back and think about a fundamental assumption that you made and realize that you maybe should not have made it. You will experience this many times while in the ISLE class. You will often have to repeat a calculation using different assumptions or redesign an experiment to evaluate the effect of an assumption you maybe should not have made. This is *the very nature of the process of doing physics!* Namely deciding what simplifying assumptions you should make and when it is reasonable to make them. There are ALWAYS assumptions implicit in any experimental procedure. If you are stuck you should ask an instructor for help.

A lot of students have trouble figuring out the difference between *assumptions* and *uncertainties* because they both introduce "error" into our calculations, models, and experiments. The fundamental difference is this:

- **Uncertainties** are errors due to **random** variations either inherent in the experiment itself or in our measurement procedures. When stopping the stopwatch, you might either stop it too early or too late. This means that the variation about your average measured value is in both directions. There will be some measured times higher than the average and some that are lower than the average. Uncertainties can be reduced by (for example) measuring a longer time interval.
- On the other hand, assumptions introduce **systematic error** into our measurements and calculations. What that means is that **every** measurement or number in a calculation will be off in the **same** direction. For example, if you assume your scale is properly zeroed and it isn't, **EVERY** measurement will be too high or too low (depending on which way it wasn't zeroed). That is a **systematic error**, not an uncertainty from random variation! Here is another example: Air resistance will slow down EVERYTHING more than you expected, biasing all your measurements and calculations in the same direction.