TYPES OF EXPERIMENTAL ERRORS from http://www.physics.nmsu.edu/research/lab110g/html/ERRORS.html

Errors are normally classified in three categories: systematic errors, random errors, and blunders.

Systematic Errors

Systematic errors are due to identified causes and can, in principle, be eliminated. Errors of this type result in measured values that are consistently too high or consistently too low. Systematic errors may be of four kinds:

1. **Instrumental**. For example, a poorly calibrated instrument such as a thermometer that reads 102°C when immersed in boiling water and 2°C when immersed in ice water at atmospheric pressure. Such a thermometer would result in measured values that are consistently too high.
2. **Observational**. For example, parallax in reading a meter scale.
3. **Environmental**. For example, an electrical power “brown out” that causes measured currents to be consistently too low.
4. **Theoretical**. Due to simplification of the model system or approximations in the equations describing it. For example, if your theory says that the temperature of the surrounding will not affect the readings taken when it actually does, then this factor will introduce a source of error.

Random Errors

Random errors are positive and negative fluctuations that cause about one-half of the measurements to be too high and one-half to be too low. Sources of random errors cannot always be identified. Possible sources of random errors are as follows:

1. **Observational**. For example, errors in judgment of an observer when reading the scale of a measuring device to the smallest division.
2. **Environmental**. For example, unpredictable fluctuations in line voltage, temperature, or mechanical vibrations of equipment.

Random errors, unlike systematic errors, can often be quantified by statistical analysis, therefore, the effects of random errors on the quantity or physical law under investigation can often be determined. Example to distinguish between systematic and random errors is suppose that you use a stop watch to measure the time required for ten oscillations of a pendulum. One source of error will be your reaction time in starting and stopping the watch. During one measurement you may start early and stop late; on the next you may reverse these errors. These are random errors if both situations are equally likely. Repeated measurements produce a series of times that are all slightly different. They vary in random vary about an average value.

If a systematic error is also included for example, your stop watch is not starting from zero, then your measurements will vary, not about the average value, but about a displaced value.

Blunders

A final source of error, called a blunder, is an outright mistake. A person may record a wrong value, misread a scale, forget a digit when reading a scale or recording a measurement, or make a similar blunder. These blunder should stick out like sore thumbs if we make multiple measurements or if one person checks the work of another. Blunders should not be included in the analysis of data.

[Whenever possible, you should redo your experiment if you have identified a blunder. If this is not possible, when the blunder has affected only one of several trials, consider invalidating that trial if you have enough other data. If your blunder has affected all of your data and the experiment cannot be repeated, then explain in your lab report.]

Common Sources of Error in Physics Lab Experiments

from https://www2.southeastern.edu/Academics/Faculty/rallain/plab193/labinfo/Error_Analysis/06_Sources_of_Error.html

There is no such thing as "human error"! This vague phrase does not describe the source of error clearly. Careful description of sources of error allows future experimenters to improve on your techniques. This ***long list*** of common sources of error is meant to help you identify some of the common sources of error you might encounter while doing experiments. If you find yourself stuck for words when describing sources of error, this list may help. The list goes from the common to the obscure.

Incomplete definition (may be systematic or random) - One reason that it is impossible to make exact measurements is that the measurement is not always clearly defined. For example, if two different people measure the length of the same rope, they would probably get different results because each person may stretch the rope with a different tension. The best way to minimize definition errors is to carefully consider and specify the conditions that could affect the measurement.

Failure to account for a factor (usually systematic) - The most challenging part of designing an experiment is trying to control or account for all possible factors except the one independent variable that is being analyzed. For instance, you may inadvertently ignore air resistance when measuring free-fall acceleration, or you may fail to account for the effect of the Earth's magnetic field when measuring the field of a small magnet. The best way to account for these sources of error is to brainstorm with your peers about all the factors that could possibly affect your result. This brainstorm should be done before beginning the experiment so that arrangements can be made to account for the confounding factors before taking data. Sometimes a correction can be applied to a result after taking data, but this is inefficient and not always possible.

Environmental factors (systematic or random) - Be aware of errors introduced by your immediate working environment. You may need to take account for or protect your experiment from vibrations, drafts, changes in temperature, electronic noise or other effects from nearby apparatus.

Instrument resolution (random) - All instruments have finite precision that limits the ability to resolve small measurement differences. For instance, a meter stick cannot distinguish distances to a precision much better than about half of its smallest scale division (0.5 mm in this case). One of the best ways to obtain more precise measurements is to use a null difference method instead of measuring a quantity directly. Null or balance methods involve using instrumentation to measure the difference between two similar quantities, one of which is known very accurately and is adjustable. The adjustable reference quantity is varied until the difference is reduced to zero. The two quantities are then balanced and the magnitude of the unknown quantity can be found by comparison with the reference sample. With this method, problems of source instability are eliminated, and the measuring instrument can be very sensitive and does not even need a scale.

Failure to calibrate or check zero of instrument (systematic) - Whenever possible, the calibration of an instrument should be checked before taking data. If a calibration standard is not available, the accuracy of the instrument should be checked by comparing with another instrument that is at least as precise, or by consulting the technical data provided by the manufacturer. When making a measurement with a micrometer, electronic balance, or an electrical meter, always check the zero reading first. Re-zero the instrument if possible, or measure the displacement of the zero reading from the true zero and correct any measurements accordingly. It is a good idea to check the zero reading throughout the experiment.

Physical variations (random) - It is always wise to obtain multiple measurements over the entire range being investigated. Doing so often reveals variations that might otherwise go undetected. If desired, these variations may be cause for closer examination, or they may be combined to find an average value.

Parallax (systematic or random) - This error can occur whenever there is some distance between the measuring scale and the indicator used to obtain a measurement. If the observer's eye is not squarely aligned with the pointer and scale, the reading may be too high or low (some analog meters have mirrors to help with this alignment).

Instrument drift (systematic) - Most electronic instruments have readings that drift over time. The amount of drift is generally not a concern, but occasionally this source of error can be significant and should be considered.

Lag time and hysteresis (systematic) - Some measuring devices require time to reach equilibrium, and taking a measurement before the instrument is stable will result in a measurement that is generally too low. The most common example is taking temperature readings with a thermometer that has not reached thermal equilibrium with its environment. A similar effect is hysteresis where the instrument readings lag behind and appear to have a "memory" effect as data are taken sequentially moving up or down through a range of values. Hysteresis is most commonly associated with materials that become magnetized when a changing magnetic field is applied.

Also see: http://writeonline.ca/media/documents/LabReport_TypesOfExperimentalErrors.pdf