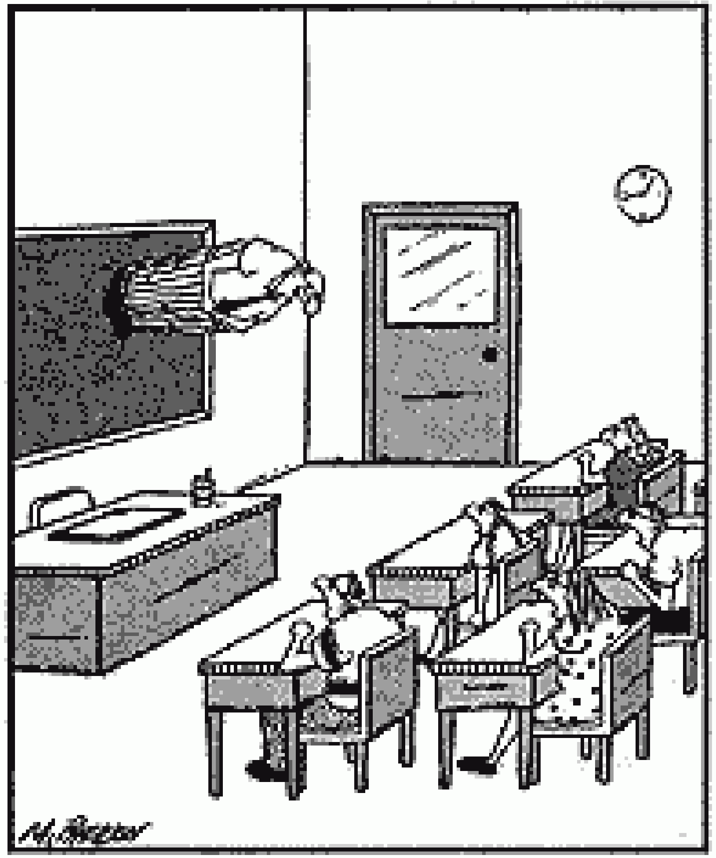
Physics in the Classroom (Physics 304)

Timothy D. Usher Ph.D.
CSUSB



"Good morning, and welcome to The Wonders of Physics."

Please write down your responses to the following.

- Why are you hear? Go deeper by asking “why” to your response and writing that answer down. Continue this process.

Form “buddy” partners

- I will help you form buddy partners.
- Introduce yourselves, and exchange pleasantries for a **couple of minutes**.
- Share your responses to the “Why am I here?” question.

Form buddy teams

- I will help you form teams of four people from pairs of partners
- Again, explore your responses to the “Why am I here?” question.

Present your findings to the class.

- Select a representative to present your findings to the class.
- Does anyone think they came up with a really interesting response to the question?

Good Science

- What distinguishes good science from bad science?
- Good science agrees with experiment. Bad science does not.
- **EXPERIMENT IS VERY IMPORTANT !**
- You will spend three hours per week in the laboratory and only one hour in the classroom.

Example

- The Great Theory of Tables (GTT) says that this desk is 1.6 meters long.
- How do I test the theory?
- Right! Measure the table.
- I measure the table to be 1.5 meters. Is that close enough?

Experimental Uncertainty

- Science is NOT an “EXACT Science”.
- All scientific measurements must have an uncertainty associated with them.
- An uncertainty specifies a range of values for the measurement. The experimenter is confident that the actual value is within that range.

Back to the example

- My measurement of 1.5 meters was not complete because it did not specify a range.
- Suppose that after taking into account the accuracy of the meter stick I was using, my ability to eyeball things and other factors, I determined that the range could be anywhere from 1.4 meters to 1.6 meters.
- It is written as 1.5 $\pm$ 0.1 meters.

Significant figures

- Significant figures give an important indication as to the precision of a measurement.
- In our example, the number 1.5102 would indicate a much more precise measurement than 1.5.
- The difference is very important. It could reflect the difference between a ten dollar meter stick and a ten thousand dollar interferometer.

Significant figures (rules)

- Zeros between other digits are always significant.
- For example the zero in 1.5102 is significant. The number has five significant figures.
- Zeros to the left of other digits are NOT significant. 0.15102 also has five significant figures.

Zeros to the right.

- Zeros to the right of other digits are considered significant. 1.5102 has five significant digits but 1.51020 has six significant digits. Mathematically they are the same but 1.51020 represents a higher precision measurement and the last zero is very important!

Scientific notation.

- Scientific notation is a simple shorthand for writing very large or very small numbers.
- The speed of electromagnetic waves in a vacuum is roughly 300000000 m/s. rather than writing all of those zeros out, it can be written as 3×10^8 m/s

Scientific notation (cont.)

- Small numbers can be written conveniently too, using scientific notation.
- The radius of an atom is roughly 0.00000000005 meters. This can be written as 5×10^{-11} meters.

UNITS

- Once upon a time there was a cook named Unice Units. She sent a message to the market, requesting 5.
- The market venders had a terrible argument. The apple vender insisted that she wanted 5 apples. The orange vender was certain that her request was for 5 oranges and the banana vender was convinced that the order was for 5 bananas.

“Metric” units

- Most scientist, in fact most countries, use System International (SI) units, commonly referred to as the “metric” system.
- The key to success with metric units is to stop thinking in “American” units and converting to metric but to think in metric units directly.

The beauty of the metric system.

- The conversion from one metric unit to another is often simply a matter of moving a decimal.
- 1.5102 meters is equal to 15.102 centimeters or 0.0015102 kilometers.

Basic units

- Time : seconds
- Distance: meters
- Mass: kilograms

Combining units.

- Units, which are combinations of basic units, are often used to describe other aspects of things.
- Example. The speed of something is expressed in terms of two basic units. The unit for speed is meters per second. Conveniently abbreviated as m/s.

Units in calculations

- In calculations the units are treated much the same way numbers are treated.
- Sam Speed goes ten meters in two seconds. The numeric part of the answer is obtained by dividing 10 by two to obtain 5. Remember, in science, the units are very important. The unit part of the answer is obtained by dividing meters by seconds to obtain meters per second or m/s.

Units can save your life

- It is very tempting to simply remember that the units for speed are m/s and skip the units calculation.
- RESIST TEMPTAION
- Suppose Sam had incorrectly remembered that the speed is calculated as the time divided by the distance. He would have incorrectly gotten 0.2 for the numerical part of the answer

Units can save your life (cont.)

- However, Sam resisted temptation and calculated the units part as seconds per meter, or s/m which he knew to be incorrect.
- Sam went back and discovered his error.

Graphs

- Graphs provide a very powerful method for representing information.

Answering questions with graphs.

- Polly Pendulum really enjoys the playground swings and wonders what would make her swing faster.

① Swinging higher.

② Holding something heavy while she swings.

③ Changing the length of the swing.

First a little terminology

- Period: The time for Polly to finish one **complete** swing.
- Amplitude: How high the swing swings.

Period - Amplitude data

- First Polly swings with a given amplitude while Tim Timer times how long it takes here to swing ten times.
- Now Polly swings with a different amplitude while Tim times here for ten swings again.
- This is repeated for several different amplitudes.

Period - Mass data

- Polly and Tim perform another set of experiments.
- First Polly swings holding several large rocks while Tim times her swings.
- Next Polly throws away one rock and Tim times her swings again.
- They repeat this several times until they run out of rocks.
- They are careful to always swing at the same height.

Period - length data

- In this final set of experiments Polly and Tim change the length of the swing.
- They determine the swing time for several lengths.
- They try to keep the amplitude constant. Of course they assume Polly's mass does not change during the experiment.

Graphing the data

- Polly and Tim plot three different graphs, one for each set of data.
- They called the first graph period - amplitude. They plotted the amplitude on the horizontal axis and the period on the vertical axis.
- To their surprise the graph was a horizontal strait line, indicating that the period was about the same, regardless of the amplitude.

- They called the second graph the period - mass graph.
- This time they plotted the mass on the horizontal axis and the period on the vertical axis.
- Again they were surprised to find that the period did not depend on the mass.

- Finally they plotted the third graph and called it period - length.
- This time they did not get a horizontal line. They got a line that curved upward, indicating that the period does depend on the length.