Laura Stevens

Unit Conversions and Dimensional Analysis

11th/12th Grade Physics, Introductory College Science Lab
~30 minutes

What and Why

Beginning science students are *terrible* at unit conversions. It requires being able to generalize algebra to a new situation, and that can be difficult for students. Further, many students aren't in the habit of including units throughout every step of working a problem, and just slap on the units they think they should have at the end of the problem. But being comfortable working with units throughout an equation and doing unit conversions is essential to being able to work with data and solve physics problems, so this is something I want to give students some dedicated time to mastering.

I'm going to have students do some pair work, so some collaborative learning will take place. I'll also work with the students in developing an algorithm, so if they lack confidence or have a low numeracy, they can have a set of rules to rely on.

Prerequisites: basic algebraic skills: ability to cross-multiply, cancel, and work with variables.

I will ask students to work a few basic cross-multiplication problems with just numbers and variables, no units, in order to assess whether they have the prerequisites.

This is a foundational lesson; I would begin the school year with a short "basic math for physics" unit and this would likely be the third lesson in it, after a lesson on significant figures and scientific notation, and a lesson on SI units. A longer block period could combine the SI lesson with this one. Afterwards, we would work on basic trigonometry—trig functions, the Pythagorean Theorem, and the unit circle.

Standards

Montana Curriculum Standards

- **HS.MP.2. Reason abstractly and quantitatively.** High school students seek to make sense of quantities and their relationships in problem situations. They abstract a given situation and represent it symbolically, manipulate the representing symbols, and pause as needed during the manipulation process in order to probe into the referents for the symbols involved. Students use quantitative reasoning to create coherent representations of the problem at hand; consider the units involved; attend to the meaning of quantities, not just how to compute them; and know and flexibly use different properties of operations and objects.

IEFA

- n/a

NGSS Curriculum Standards

- **HSN-Q.A.1** - Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
- **HS-PS2-1** - Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

Essential and Supporting Questions

How do we successfully work with units when solving scientific equations?
How do we apply our abstract mathematical knowledge to a real-world situation?

Instructional Goals

Students will be able to …

- Explain the importance of units in scientific calculations.
- Explain each step in the process of converting from one set of units to another.
- Convert from metric to imperial units, and vice-versa.

Materials

- Units PPT (just to guide me; can be chalk talk)
- Units worksheet
- Units table

Methods

One-step problem solving, unit canceling.

Hook

Mars Climate Orbiter (~5 min)

I will spend about five minutes talking about the Mars Climate Orbiter and Lockheed Martin's programmers being RIDICULOUS and using IMPERIAL UNITS INSTEAD OF METRIC! THIS IS SPACE TRAVEL! IT ISN'T AMATEUR HOUR! No online video was able to capture the emotional depth of this story, so it's up to me to impress upon my students how important using correct units is.

Instructional Activities

1. **Lecture** (~ 10 min)
   I will demonstrate one-step problem solving and cancellation for students using a simple algebraic equation with no units. I will then show that you can cancel units just as you can cancel factors and variables. I will demonstrate two methods of unit conversion: setting up an equation and dimensional analysis. Students will work three sample problems with me. By the end of this time, we'll have developed an algorithm that I will keep on the board for the rest of the lesson.
   Differentiation: Students are likely comfortable with cross multiplication in algebra, so this should proceed pretty quickly. Students with reading LD may have a hard time distinguishing similar units (e.g cm vs km), and those students may benefit from using symbols (smileys, hearts) as units instead. Any other accommodations students may need will have to be handled on the fly.

2. **Pair/trio practice** (~ 10 min)
   Students will work four problems together: A simple conversion (e.g. Solve: 5 cm = x inches), a challenge conversion (going through a couple unit conversions), and a scientific word problem (see handout.) I will sit near the students so I can give them some guidance when they need outside help.
   Differentiation: Likely not needed, but will be as flexible as possible.

3. **Present Solutions** (~ 5 min)
   Each student will work through one of the problems on the board, so I can assess while they teach each other.
   Differentiation: Students with strong social anxiety can show me their work instead. They will need to write an explanation of what they do in each step.

Concepts	**Skills**	**Content**
One-step problem solving	Abstract reasoning, algebra	With simple algebraic equations and then units
Cancellation	Abstract reasoning, algebra	With simple algebraic equations, then unis

Assessment

They will successfully complete each step of solving one of the problems given to them. If there's time, I can give a new problem to each of them to complete individually.

After having taught the lesson, here's how I assessed.

Diagnostic: The initial part of the lesson forms a diagnostic assessment; it's recap of some basic algebra concepts exactly as you would see them in a math class. So rather than jumping straight to the new context and information, I can assess how comfortable they feel with their foundations.

Formative: I really let them guide me through the PPT portion of the lesson, which provides a lot of opportunity for formative assessment. If they gave me bad guidance, I was able to ask them to explain their thought process so we could figure out where they went wrong. And while they're working on their worksheet, I was able to listen in and give guidance as necessary.

Performance: The content really lends itself to performance assessments rather than summative assessments, since it's all about skill application. Each problem I gave them would qualify as a performance assessment—especially the word problems, since the setup of a problem helps make it relevant.