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Using mathematics to make sense in undergraduate physics

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Physics courses involve the study of physical quantities constructed to facilitate the characterization of nature, and the study of the connections between these quantities. These connections are often ratios or products of more familiar quantities. Learning to use the predictive power these relationships provide is an important part of learning to make sense of the physical world. Mathematically inspired reasoning is foundational to the way physicists make sense of the natural world and math is often referred to as the language of physics. Students rarely understand the relationships between the physical quantities in the way their instructors hope they will. There is often a disconnect between the specialized way we use mathematics in physics and the broad spectrum of processes that students learn to master as they progress through the pre-college mathematics curriculum. We are often surprised by how little math our students are able to use in physics, despite successful performance in their previous math classes. Much of the reasoning used in introductory physics is borrowed from mathematics that is taught in middle school and early high school (facility and practice with integers, fractions and ratios, multiplication and division using symbolic representations, manipulation of linear equations, analyzing right triangles.) But physics is a very different context, with confounding factors that often render the mathematics opaque to the learner. In this talk, I will discuss the specific ways in which physicists' use of mathematics differs from what many students acquired in their math classes. I will discuss how a weak mastery of conceptualizing fundamental mathematical operations interferes with students' ability to make sense in physics, and can carry over into difficulties with subsequently more abstract reasoning at higher levels. I will also offer suggestions for ways in which instructors can be more cognizant of (and transparent about) their specialized use of mathematics, thereby helping their students to effectively use mathematics for making sense of the physics they are learning.