



Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
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Scaling the Natural World Using Dimensional Analysis

Guide for Curriculum Unit 91.06.03
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Nature's most distant reaches have been probed by many new inventions within the last 25 years. Lasers, rockets, accelerators, fantastic photographic capabilities combined with space telescopes have tremendously expanded our vision of what surrounds us. In 20 years computer scientists have gone from speaking in terms of milliseconds (thousandths of seconds), to nanoseconds (billionths of a seconds). Physicists can detect gravity waves by an amount of a million trillion smaller than an electron. That's smaller than anything on the atomic scales. The launching of a space telescope was supposed to enable astronomers to see ten times farther than can be seen with present instruments!

Scientists are now looking at bigger, smaller, older, farther, and faster orders of magnitudes than have ever been known before in the natural world. Today, they are probing phenomena that are as tiny as $1/1,000,000,000,000$ of a centimeter in an explorable universe whose edge lies at least 100,000,000,000,000,000,000 miles away. We are studying phenomena so short lived that they occur in $1/10,000,000,000,000,000,000$ of a second. By contrast astronomers tell us the universe is some 10,000,000,000 years old by using astrometry to mathematically measure stars and masses in space. For scientists, the frontiers of space hold the key to scientific questions about the existence of life on other planets, the real size of the universe, and Earth's role in it.

The sheer scale of explorable nature has burst beyond our wildest assumptions with incredible proportions. Even as the U.S. surpasses a trillion dollar debt, this amount appears small when compared to our exploding microscopic and telescopic world. Increasingly, students and average people are bombarded with facts and figures of enormous proportions. Such numbers are very awkward to learn and are constantly getting more difficult to comprehend. As our need to deal with more and more zeros increases and decreases, our interest to handle these magnifications is being met by growing indifference. But since we must be prepared to use and manipulate large and small numbers, there must be a way to handle them.

This curriculum unit will address the sheer volume of incomprehensible numbers (speed, distance, age) in the natural world. The major goal of this interdisciplinary math and science unit is to enable students to understand the scale of the natural world using the concept of rates, proportions and dimensional analysis. These concepts greatly simplify the learning process for orders of magnitude problem solving in an innovative way. This curriculum should help clarify thoughts about the magnificent scale of the rapidly changing natural world and human beings place within it.

In addition, by the end of this curriculum unit, the student will be able to calculate problems such as the following: Measurements indicate that the continents of Europe and North America are separating (plate tectonics) at the rate of about 2 centimeters per year. If Columbus could repeat his famous voyage of 1492, about how many feet or yards must he travel further?

(Recommended for Mathematics and Science, grades 9-12)

Key Words

Mathematics Ecology Environmental Science Problem Solving Dimensional Analysis Physics Science Quantitative Physical Measurements

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