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ETP Type: Create a New Lesson
Physics: 9th Grade
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June 27, 2016

Space, Time, and Scale

0. Abstract

We usually navigate our worlds using limited "tools" like our eyes, hands, feet, and ears. As such we typically surround ourselves with object sizes that are within 3-4 orders of magnitude to our own bodies and participate in events that typically take seconds, maybe hours. Rarely, if ever, do we interact with the distance between fibers on a sheet of paper or the time it takes for the light on this screen to reach our eyes, then the time it takes for our brain to receive the information from our eyes. Slow motion capture, scenic elevation view points and microscopes offer exciting glimpses into these worlds smaller or larger than our own; but the further we explore, the more we need the tools and language to guide the exploration. This lesson is an attempt to offer similar exciting glimpses into worlds, large and small, and to learn common terminology (units and prefixes) to navigate the world.

I. Standards/Skills/Objectives/Assessment

1. Focal Standard or Skill:

The Athenian School Standards:
Students will be fluent in metric prefixes.
Students will know the correct unit for each quantity.
Students will be able to use units and metric prefixes to identify the reasonableness of the result.

2. Measurable Objective(s):

Students will be able to use metric prefixes and convert into appropriate quantities during analysis.
Students will memorize the standard SI units for common quantities like length, mass, volume and time.
Students will be able to use both units and prefixes to predict units and size of other quantities.

3. Assessment:

Introductory Activity - series of questions to illustrate our difficulty working in these scales.

Prefix and Unit Quiz - students will be able to perform dimensional analysis and conversions with scientific notation.

II. Fellowship Connections

1. 21st Century Skill(s):

- Use various reasoning (inductive, deductive, etc.) as appropriate to the situation.
- Interpret information and draw conclusions based on the analysis.

2. 21st Century Skill(s) Application:

- Students will have to reason through the dimensional analysis process. This includes identification of what quantities are being measured and the connection between various quantities. In addition, prefixes offer framework for students to explore "how big is big?" or "how small is small?"

- Units offer a guideline for the connection of ideas. For example, if velocity is a change in displacement over time, students should be able to conclude what the units for velocity would be. Or if a student sees a quantity with certain units, kW*hr, for example, they should be able to use the units to tell a story. "The kW*hr is really a unit that indicates how much energy one has used over a given period of time."

3. Fellowship Description:

1) Fellowship Project: My project was an investigation of how print conditions affect the morphology of the substrate when using ink-jet printing for electric circuits.

2) Skills I used: I synthesized the silver nanoparticles from silver acetate which involved specific chemical reactions. I completed molarity calculations, massing, measuring, and centrifuging.

3) Careers I was Exposed to: Academics, researchers, Defense Advance Research Projects Agency (DARPA), solar panel production,

4) The Work of my Lab: My mentor is investigating nanoparticles and its various different applications for fabrication of electric components. Investigations include viscosity of printed inks, solubility of nanoparticles, morphology of fabricated elements, conductivity of lines and components, fabrication of capacitors, transistors, dielectrics and conductive materials.

4. Fellowship Connection to School/Classroom:

At the end of the electricity and magnetism unit, we have the students build a speaker, microphone, a breadboard circuit with LED's and transistors. My hope was to open up the space after these projects for the students to build something of their own. Go find a need at your house or with someone you love, discuss how you can solve a problem and design something to help. Applications are limitless! I'd use my experience here at Cal to open their perspectives as to the size and scale of electronic components. What if we had tiny

electronic parts that swam in our blood? What if we had sensors that lived on our skin that were too light to notice? What if we had an electronic circuit you can literally download from the internet (like a pdf) and print at your own house, instead of buying it at a store? The possibilities are endless!

III. Instruction

1. Instructional Plan:

- Introduce ideas about Space and Time, specifically how it relates to our daily lives.
- Begin by asking questions to students and getting them comfortable. "Can you describe to me where you are right now?" "Where do you live?" "How long did you brush your teeth this morning?"
    - Note: Watch equity issues here. Avoid questions about house size or income, etc.
    - Note: Note to students the difficulty of explaining either space or time without a reference point. Two miles **from here**. To the left **of the white board.** We typically use ourselves or the ground as a reference point.

- Students will probably be a bit too comfortable. Note that we have difficulty identifying sizes and times that we don't interact with often. This is typically distances and sizes that are really large or small in comparison to our reference points.

- Pop quiz! (no grade attached) ask them questions and reveal answers right away. Maybe use a personal white board for students to write responses on.

- Ask students to think of a question themselves and share with the class.

- "As we explore these worlds smaller or larger than our own, we need tools. It was really difficult for me as I worked primarily with nanoparticles at UC Berkeley. I would deal with units of measurement like the picoliter or the micron. Since our naked eyes have difficulty seeing these sizes and I have had zero experience working with objects of this size, I had no frame of reference for these in my mind. This changed the way I worked with these particles. I felt very anxious. I needed something concrete to stand on."

- SI Units: We use these base SI units to standardize communication throughout the world.

- Metric prefixes: We use these prefixes to make working in different scales easier. If I deal primarily with distances about 0.0000001 m wide, it gets cumbersome to write all the zeros, and my chances of error increases. So we use prefixes. Memorize! Both units and prefixes!

- Sample problems: practice dimensional analysis with students. Sample problems attached.
- Quiz tomorrow!

2. Supply List:

Supply List:
Personal white boards
Dry erase markers
[Space, Time, and Scale] ppt
[Dimensional Analysis Practice] Worksheet
[Quiz - Dimensional Analysis] Quiz Worksheet

3. Bibliography:

"Metric Unit Prefixes." Tools for Learning. N.p., n.d. Web. 09 Aug. 2016.

"Standard Units (SI Units) - Boundless Open Textbook." Boundless. N.p., n.d. Web. 09 Aug. 2016.

4. Keywords:
Metric, Units, Dimensional analysis, prefixes, scale

IV. Attachments

[Dimensional Analysis Practice] Document

[Dimensional Analysis Quiz] Document

[Space, Time, and Scale] Slides