The Power of Nano

Subject Area(s): Mathematics, Science and Technology

Associated Unit: A Fraction of Engineering

Lesson Title: The Power of Nano

Header Insert Image 1 here, Centered

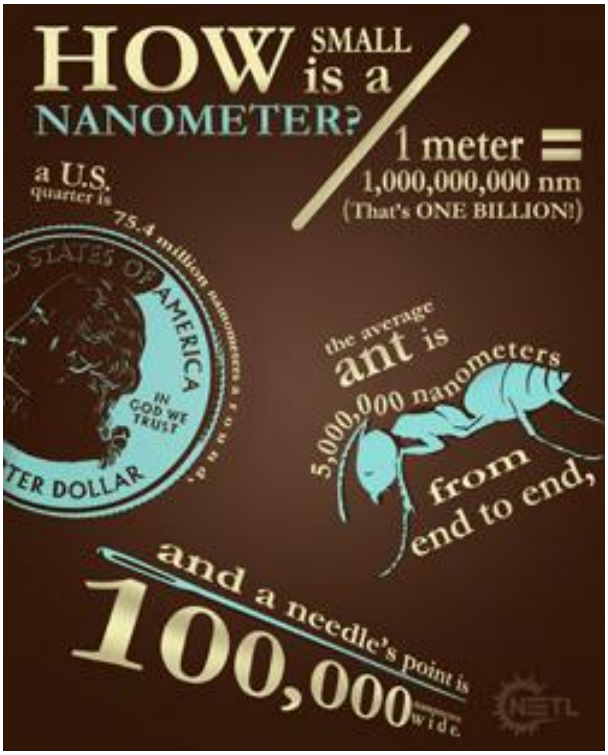

Image 1

ADA Description: Understanding the size of a nanometer is the first step in understanding nanotechnology. 1 meter = 1,000,000,000 nanometers (That's ONE BILLION).

Caption: None (Leave Blank)

Image file: how_small_is_nano.jpg

Source/Rights: Copyright © 2011 NETL in article "NETL Nanotechnology Flies High" http://www.netl.doe.gov/newsroom/features/02-2011.html

Grade Level 8 (6-8)

Lesson # 3 of 3

Lesson Dependency None

Time Required: 1 Hour

Summary

The first step in understand the new emerging area of nanotechnology is to understand what nano really means. The purpose of this lesson is for students to understand to the size of a nanometer by relating it to other objects. Within the unit "A Fraction of Engineering", students review the concept of negative exponents (as a fraction) in order to quantify how many nanometers objects are.

Engineering Connection

In recent years, engineering has moved past what the naked eye can see and into a new realm (nanometer sized). The application of nanotechnology in engineering is everywhere: materials, fluids, etc. Moving to a nanoscale allows engineers and scientist to manipulate particles into having unique properties. Carbon Nanotubes have unique properties that can strengthen material while nanoelectricalmechanical devices can be used to improve existing equipment. These are just a few examples of the applications nanotechnology has in the engineering.

Engineering Category = #1

Keywords
carbon nantubes exponent, fraction, nano, nanometer, nanotechnology, ratio, nanoelectricalmechanical devices

Educational Standards

International Technology and Engineering Educators Association (ITEEA) Standards

Standard 1, Grade Level 6-8, F. New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology.

Standard 3, Grade Level 6-8, F. Knowledge gained from other fields of study has a direct effect on the development of technological products and systems.

Texas Essential Knowledge and Skills (TEKS)

Technology Applications

126.12 (c) (7) (B) create and edit spreadsheet documents using all data types, formulas and functions, and chart information;

126.12 (c) (7) (D) demonstrate proficiency in the use of multimedia authoring programs by creating linear or non-linear projects incorporating text, audio, video, and graphics;

Math

111.23. (b) (4) (A) generate formulas involving unit conversions within the same system (customary and metric), perimeter, area, circumference, volume, and scaling;

111.23. (b) (13) (A) identify and apply mathematics to everyday experiences, to activities in and outside of school, with other disciplines, and with other mathematical topics;

111.23. (b) (14) (A) communicate mathematical ideas using language, efficient tools, appropriate units, and graphical, numerical, physical, or algebraic mathematical models; and (B) evaluate the effectiveness of different representations to communicate ideas.

111.24. (b) (1) (D) express numbers in scientific notation, including negative exponents, in appropriate problem situations; and

111.24. (b) (14) (A) identify and apply mathematics to everyday experiences, to activities in and outside of school, with other disciplines, and with other mathematical topics;

Pre-Requisite Knowledge
None (Leave Blank)

Learning Objectives
After this lesson, students should be able to:

- Define an exponent
- Identify the difference between negative and positive exponents
- Define nano
- Understand how small is nano
- Describe why something so small matters

Introduction / Motivation

How would you define an exponent? Call on a student to give his or her thoughts pointing out that an exponent is a way of writing repeating multiplication. On the board, write "3^4" and ask a student to come up and identify the base and the exponent. The base is 3 and the exponent is 4. Then ask another student to ask how to write this out using multiplication. Provide the students with a few more examples to make sure that class understands what an exponent means.

In the next example, use a negative exponent and ask the students if they know how to deal with this scenario. Point out that a negative exponent is just a fraction – one over a positive exponent. Just like the ratios and fractions we are talking about in this unit, this represents another way engineers use this concept to understand what scale they are at: meter, millimeter, micrometer, and nanometer.

A meter is the starting point (1) for the metric system. Our base for the metric system is 10 and for meters the power is zero. Engineers use the metric system worldwide as a form of measurement. When talking about very large units, the power is increased in the positive direction. For example a kilometer can be used to measure the distance between two towns is 10^3 meters.

However, when we are looking at very small units of measure, we use negative exponents to move down from meters. For example, a millimeter might be used to measure the thickness of your finger and is 10^{-3} meters. Can someone show me what this looks like in fraction form? A new field of study is emerging and is called nanotechnology and occurs at a nanometer. Today, we are going to use our understanding of fractions and negative exponents to examine how small a nanometer is.

Lesson Background & Concepts for Teachers

Nano- is the prefix meaning a billionth and is represented by 10^{-9}. This means that for every nanometer, there is 10^{-9} meters and in one meter this is 10^{9} nanometers.

Image Insert Figure 1 here, centered

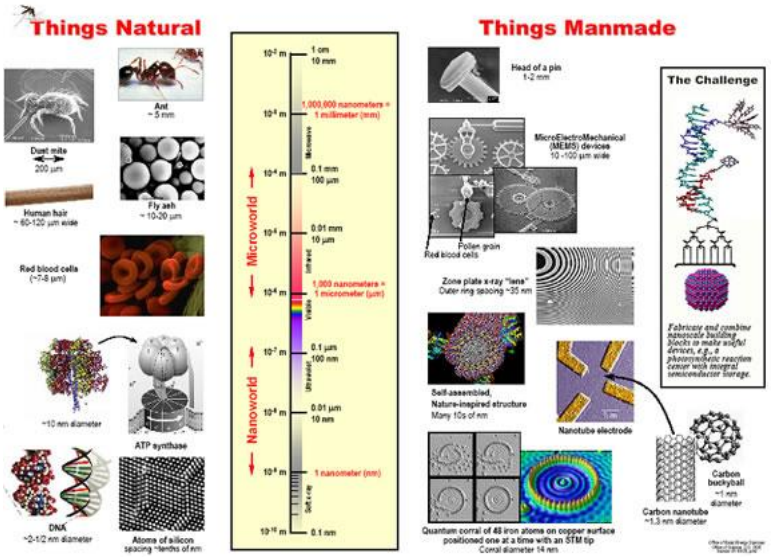

Figure 1

ADA Description: This image shows the different in objects as you move down the metric scale starting at centimeters all the way to nanometers

Caption: Figure 1: Understanding nano- compared to everything else

Image file: scaling_nano.jpg

Source/Rights: Copyright © Industrial Hygiene and Occupational Safety
http://orise.orau.gov/ihos/images/scaleOfThings.jpg

Figure 1 one shows nano- as it relates to other items. At each scale, naturally occurring and manmade items exist. Nanotechnology is the study or use of structures at a nano-scale and refers to the manmade items denoted in Figure 1.

Nanoelectromechanical (NEMS) Devices at it base is a nanoscale device that integrates electoral and mechanical functionality. The main application of this technology is in atomic force microscopes where sensitivity and efficiency is improved from NEMS (Figure 2). [2]

Image Insert Figure 2 here, left justified

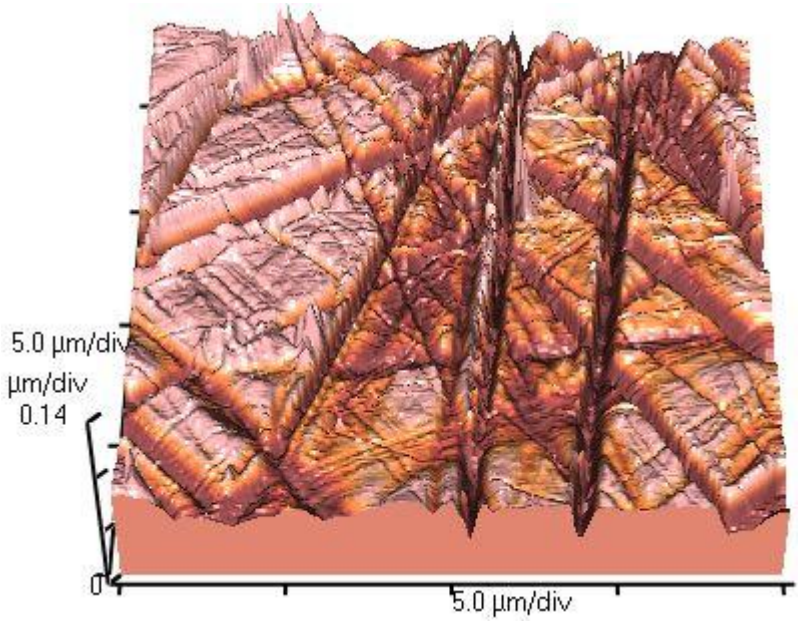

Figure 2

ADA Description: This image is an atomic force microscope scan of a glass surface made possible by nanotechnology

Caption: Figure 3: Atomic Force microscope scan using NEMS

Image file: NEMS.jpg

Source/Rights: Copyright © 2005 Chych, Wikimedia Commons
http://upload.wikimedia.org/wikipedia/commons/e/e8/AFMimageRoughGlass20x20.JPG

Carbon nanotube are cylinders that are long compared to their width (diameter ranges between 1 to 10 nanometers). It has many properties that include increased hardness, kinetic, and electric properties which can allow it to be applied to material. [1]

Image Insert Figure 2 here, left justified

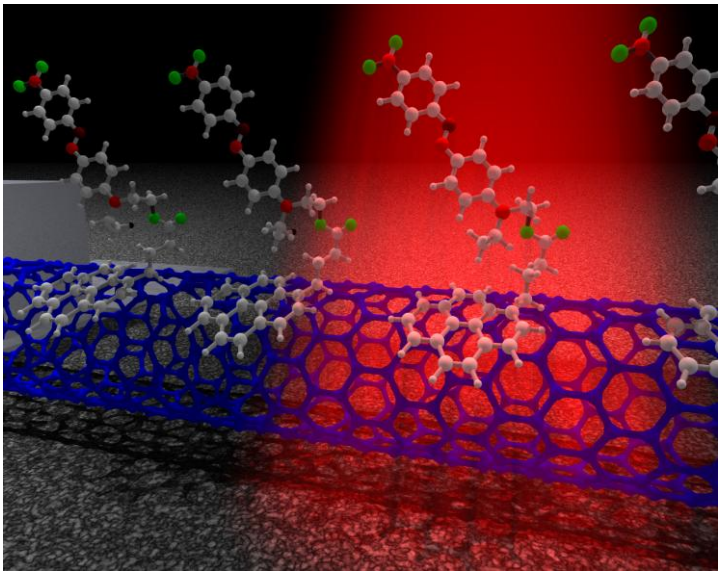

Figure 3

ADA Description: This image shows a chromophores attaching to a transistor made from a single carbon nanotube

Caption: Figure 3: Single Carbon Nanotube Transistor

Image file: carbon_nanotube.jpg

Source/Rights: Copyright © 2009 Sandia Corporation in article "Sandia researchers construct carbon nanotube device that can detect colors of the rainbow" https://share.sandia.gov/news/resources/news_releases/images/2009/nano_detect2.jpg

As will be demonstrated in the Lesson Closure, when engineers and scientist work at a nano-scale, different force are at play or become increasing important.

Vocabulary / Definitions

Word	Definition
Nanotechnology	The study or use of structures at a nano-scale
Nano	The prefix meaning a billionth http://en.wikipedia.org/wiki/Nano-
Nanoelectromechanical Devices	nanoscale device that integrates electoral and mechanical functionality [2]
Carbon nanotube	Carbon tubes with a diameter ranging from 1 to 10 nanometers. These tubes have unique properties and applications [1]
Exponents	Represents repented multiplication where the base is multiple by itself a number of times specified by its power

Associated Activities

None (leave blank)

Lesson Closure

Demonstration 1: The Power of Nano [3]

Figure 4

ADA Description: This image is from a show that aired on public television starting in April 2008, "Nanotechnology: The Power of Small" (www.powerofsmall.org)

Caption: Figure 4: Understanding nano- compared to everything else

Image file: scaling_nano.jpg

Source/Rights: Copyright © 2008 *The Convergence Project*

http://www.nsf.gov/news/news_images.jsp?cntn_id=111351&org=NSF

The demonstration shows students how forces change as we move down towards nano-scale. The goal is to show students that as you get smaller, different forces become more important and the process is more complicated than making something small.

NOTE: This demonstration was based on: Jones, M. Gail, Michael R. Falvo, Amy R. Taylor, and Bethany P. Broadwell. "Shrinking Cups: Changes in the Behavior of Materials at the Nanoscale." In Nanoscale Science: Activities for Grades 6-12. pp. 89-94. Arlington, VA: NSTA Press.

Demo 1 Material List

- Regular size tea cup
- Dollhouse size tea cup
- Container of water
- Paper towels
- Plastic table cloth
- Powdered Sugar
- Granulated Sugar
- Clear plastic cups

Procedure:

1. Pose the question "But why do things so small matter?" - Note: When it comes to force, size does not always matter.
2. Present the two sized cups. Which cup is it easier to pour water out of and why?
3. Have the students dip the regular size cup in water and pour out the contents back into the container.
4. Ask them to do the same with the dollhouse size cup without any extra shaking or tapping. Which one was easier?

Explain to the students that different forces are operating on the water depending on the size of the cup. In the regular size cup gravity is the dominant force on the water in the cup. With the smaller cup it is surface tension which plays a more important role than gravity. When you tip the regular cup, the force of gravity pulls the water out of the cup. But with a small amount of water, surface tension can counteract gravity. So when you tip the miniature cup, gravity isn't strong enough to overcome the natural tendency of water molecules to stick together, and the water stays in the cup.

5. Now present a cup or granulated sugar and a cup of powdered sugar. What is the difference between powdered sugar and regular sugar? Which cup will pour easier and why?
6. Have the students dip the regular size cup in water and pour out the contents back into the container. Which one was easier?

Explain to the students that the same principle applies, at "nanoscale" different forces like surface tension are more important. Intermolecular forces become more and more important as you get to smaller scales.

Assessment

Pre-Lesson Assessment: Use the questions during the Introduction/Motivation to see where to students stand on the topic.

Post-Lesson Assessment: The attached worksheet is to be used as a post-lesson assessment. Instruct the students to use Figure 1 to fill in the information requested. There are two options for this assessment. (1) Students can use the template attached (how_small_is_nano.tmp) and fill in the information required. This allows students to use the capability of excel functions. (2) Students can complete the worksheet by hand (how_small_is_nano.pdf).

Lesson Extension Activities
None (leave blank)

Additional Multimedia Support

References

[1] "Sandia researchers construct carbon nanotube device that can detect colors of the rainbow", Accessed May 2, 2012. https://share.sandia.gov/news/resources/news_releases/sandia-researchers-construct-carbon-nanotube-device-that-can-detect-colors-of-the-rainbow/

[2] Nanoelectromechanical Systems, Accessed May 2, 2012. http://en.wikipedia.org/wiki/Nanoelectromechanical_systems

[3] Jones, M. Gail, Michael R. Falvo, Amy R. Taylor, and Bethany P. Broadwell. "Shrinking Cups: Changes in the Behavior of Materials at the Nanoscale." In Nanoscale Science: Activities for Grades 6-12. pp. 89-94. Arlington, VA: NSTA Press.

Attachments

Worksheet	-	how_small_is_nano.pdf
Excel Template	-	how_small_is_nano.tmp
Image	-	worksheet_reference.pdf

Other

Redirect URL

Contributors
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