



Classroom Lesson Development

Title of Lesson	Unique Properties at the Nanoscale: An Introduction to Nanotechnology
RET Project Connection	Nanotechnology: Micro Injection Molding In Dr. Barry's lab we are working directly with tooling containing information which is "copied" onto a part. Reading of tooling and parts requires nanoscale technology (AFM, SEM, and MFM).
RET Teacher	Jessica E. Quinn
School	Revere High School
Town/District	Revere Public Schools
Subject(s) taught	Physics-09
Subjects covered in lesson	Newton's Laws of Motion, Atomic Size and Structure, Heat, Surface Area and Volume
Grades appropriate	9
Lesson duration	Approximately 11 days
Goals/Objectives of lesson	Students will be able to: At end of NanoSenseUnit: <ol style="list-style-type: none">1. compare and contrast objects at the Nanoscale and objects in bulk, and properties of each2. arrange objects by using powers of 103. explain size-dependent properties and the unique properties at the Nanoscale4. explain and demonstrate surface to volume ratios5. conduct a series of scientific experiments, following detailed procedures6. describe how technology unique to Nanoscale will help us "see" small things At end of featured lesson: <ol style="list-style-type: none">1. Record observations and data in an organized table2. Determine relationship between the depth that the probe is inserted and the height of the object inside the box3. Determine height of the object inside box at various points4. Draw and analyze topographic map to show the changes in surface height and describe surface features5. Critique magnetic probes and describe how they are used
Background information	This mini-unit will occur at the end of our study of Newton's Laws, Forces and Motion, and Heat.

- Essential questions
1. How small is a Nanometer, compared to a blood cell, a virus, an atom?
 2. How do we see and move things that are very small?
 3. Why do scientific models change over time?
 4. Why are properties of Nanoscale objects often different than those of the same materials in bulk?
 5. What are some of the ways that the discovery of a new technology can impact our lives?

Links to Frameworks and Standards

National Understandings About Scientific Inquiry

Scientists conduct investigations for a wide variety of reasons. For example, they may wish to discover new aspects of the natural world, explain recently observed phenomena, or test the conclusions of prior investigations or the predictions of current theories.

Scientists rely on technology to enhance the gathering and manipulation of data. New techniques and tools provide new evidence to guide inquiry and new methods to gather data, thereby contributing to the advancement of science. The accuracy and precision of the data, and therefore the quality of the exploration, depends on the technology used.

Mathematics is essential in scientific inquiry. Mathematical tools and models guide and improve the posing of questions, gathering data, constructing explanations and communicating results.

Personal and Community Health.

State Introductory Physics

SIS1. Make observations, raise questions, and formulate hypotheses.

SIS2. Design and conduct scientific investigations.

SIS4. Communicate and apply the results of scientific investigations.

1. Motion and Forces

Broad Concept: Newton's laws of motion and gravitation describe and predict the motion of most objects.

1.4 Interpret and apply Newton's three laws of motion.

1.5 Use a free-body force diagram to show forces acting on a system consisting of a pair of interacting objects. For a diagram with only co-linear forces, determine the net force acting on a system and between the objects.

Technology/Engineering

1. Engineering Design

Broad Concept: Engineering design involves practical problem solving, research, development, and invention/innovation and requires designing, drawing, building, testing, and redesigning.

Students should demonstrate the ability to use the engineering design process to solve a problem or meet a challenge.

1.2 Understand that the engineering design process is used in the solution of problems and the advancement of society. Identify and explain examples of technologies, objects, and processes that have been modified to advance society.

1.4 Interpret and apply scale and proportion to orthographic projections and pictorial drawings, such as, $\frac{1}{4}'' = 1'0''$, $1 \text{ cm} = 1 \text{ m}$.

Local Revere Public Schools develop curriculum in accordance with the Massachusetts State Frameworks and Standards

Materials required Numberline activity cards, 8.5x11 paper, Hello ... name tags, Size Dependent Properties Conference Data Sheet, safety goggles, glycerine, toothpicks, 250mL beakers, plastic wrap, food coloring, 10mL test tubes, test tube holder, 1mL pipettes, sugar cubes, granulated sugar, digital scale, 100mL graduated cylinders, 250mL Erlenmeyer flasks, stop watches, Alka Seltzer tablets, mortar and pestle, empty film canisters, Bunsen burners/hotplates, cm rulers, three different sized beakers or flasks, steel wool, steel rod/nail, tongs, $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$ crystals, aluminum foil, stirring rods, teaspoon, various sized shoe boxes, straws, magnets, cm ruler, graph paper, colored pencils, scissors, white paper, Power Point Presentation and Smart Board

Lesson development See NanoSense Unit - Size Matters - for more details

Day 1: Anticipation guide relating to nanoscience and all components of unit. Students will be introduced to nanoscience through scale diagrams, scientific literature explaining nanoscience and technology used to create nanostructures, how we "see" the small structures, and uses for these nanostructures (accompanied with a Power Point Presentation). Homework: Student reading and corresponding worksheet.

Day 2: Visualizing the nanoscale, powers of 10. Number line activity. Students arrange various objects based on their sizes and relate them to powers of 10.

Day 3: Cutting it down activity. Students cut paper and predict how this could be easier, quicker, etc. Student Quiz.

Day 4: Size-Dependent Properties Conference. Students are assigned a size-dependent property and share information with other students at the conference.

Day 5-6: Unique Properties at the Nanoscale - Lab Stations/Lab Quiz
* (Featured Lesson) Day 7-8: Simulating AFM, SEM, and MFM technologies

- Have students read article "Seeing and Building Small Things: Student Reading" for homework the night before.
- Answer questions (Compare and Contrast AFM and SEM, predict what MFM stands for) as warm-up.
- Give students materials to engineer a basic MFM using magnets, graph paper, straws, colored pencils, and a cm ruler.
- Have students map out their unique surface design.
- Students will trade unique designs with each other, map out surface using MFM, test for accuracy by comparing maps
- Rubrics to assess drawings
- Critique MFM methods and probes ... can we improve upon this
- Possible Field Trips: 1. take students to NU to use the Lego series AFM 2. take students to UML to visit characterization lab

Days 9-11: Poster Session! What did you learn? Students investigate different topics related to Nanotechnology. Presentations in PowerPoint.

References National Science Standards (<http://newton.nap.edu/html/nses/6e.html>)
Massachusetts State Standards
(<http://www.doe.mass.edu/frameworks/scitech/0106standards.pdf>)
Lesson - NanoSense (<http://nanosense.sri.com/index.html>)
Dr. Carol Barry, UMASS Lowell

Unit - Unique Properties at the Nanoscale: An Introduction to Nanotechnology

Featured Lesson – Simulating AFM, SEM, and MFM technologies

Jessica E. Quinn

Revere High School

RET-2006

Students will be able to:

1. Record observations and data in an organized table
2. Determine relationship between the depth that the probe is inserted and the height of the object inside the box
3. Determine height of the object inside box at various points
4. Draw and analyze topographic map to show the changes in surface height and describe surface features
5. Critique magnetic probes and describe how they are used

Purpose

Encourage students to:

- Think about how AFM, SEM, and MFM technologies give us pictures of the surface of atoms
- Mimic actions of probes to “see” surfaces
- Highlight basic challenges in scanning probe microscopy

Inquiry Connection

- Students read article on SEM and AFM technology
- Students design/map their uniquely engineered surface
- Students “test” unknown surfaces, design map
- Students compare maps of surface

Materials Available

- Graph paper
- cm ruler
- Colored pencils
- Scissors
- Magnets
- Straws
- White paper

Need to determine:

- Size
- Shape
- Surface

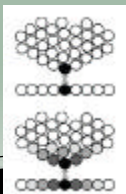
Assessment

- Scientific drawing:
 - a. detailed/accurate account of engineered surface
 - b. detailed/accurate account of unknown surface
- Scientific reasoning questions: critique of methods used

Lab Connection

Interatomic interaction for STM (top) and AFM (bottom): shading shows interaction strength

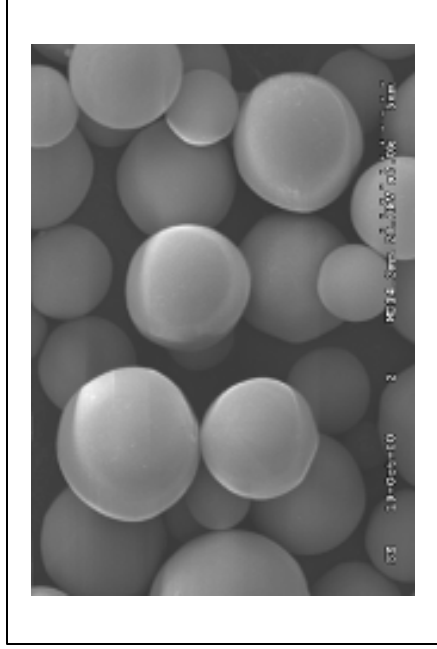
In Dr. Barry's lab, characterization of tooling and parts is pertinent to research successes



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- NanoSense (<http://nanosense.org>)

A Tale of Teenage Nanomolecules



A play written and directed by:
Miss Quinn
Acted out by Physics-09 students
A production of Physics-09, Inc.

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A review of A Tale of Teenage Nanomolecules

Assignment:

Write a review of *A Tale of Teenage Nanomolecules*. Your review must include the following:

1. What physics topic is the play about?
2. What will a person learn from this play?
3. What is the main idea of the play?
4. Was the play a drama, a tragedy, a comedy, a comedy?
5. List the 5 keywords a person should know after watching this play.

The review should be written using 10-12 complete sentences on the **back** of this script.

The review will count as 1 homework grade.

A Tale of Teenage Nanomolecules

A Physics-09 Classroom Production

Written and Directed by Miss Quinn

Cast:

An ant TBD
Bacterium TBD
Nanomolecule 1 TBD
Nanomolecule 2 TBD
Newtonian Force 1 TBD
Newtonian Force 2 TBD
Microscope..... TBD
Atomic Force Microscope TBD
Heart Tissue TBD
Khaki Pants TBD

Crew:

Sound Effects TBD
Lights TBD
Props TBD
Camera Person TBD

TBD = To Be Determined

AFM: Well, I use the interaction of forces between a probe and your surface. Your surface either attracts or repels my probe, so using that data, I can determine your size and your shape. I can also move you around!

Nanomolecules: Finally, someone who understands us!

Act 3 Summary:

1. What tool is used to “see” nanomolecules?

Act 4:

We use nanomolecules in our everyday lives!

Lights on, Curtains open

Pants: Whoa!!! Watch out! Incoming unknown liquid! Prepare for stain control!

Nanomolecule 1: What are you whining about? We create a cushion of air around you and act like peach fuzz which allows liquids to roll off!

Heart Tissue: Nanomolecules, I have to thank you! Before you were added to my Petri dish, I used to grow in all different directions. It was so hard for Doctors to get my fibers lined up right.

Nanomolecule 2: No problem. We are happy to help Doctors grow Cardiac tissue to help humans with heart disease. Helping your fibers grow in the right direction is only one of the many jobs we are most likely going to be used for in medical fields!

Act 4 Summary:

1. What are **two** uses for nanomolecules?

Act 1:

What is “nano”?

Lights on; Curtains open

Ant: (Waiving up to audience) Hey everyone! Can you believe that I am about 1000 times smaller than you?

Bacterium: (*very disgusted*) Oh ant ... you think that you are sooooo special. 1000 times smaller than a human being. Whoopie! I am 1000 times smaller than YOU! So that makes me 1,000,000 times smaller than a human!

Ant: OK, you win. You are REALLY small!

Bacterium: No problem. I just didn't want you to think that you were the smallest thing on Earth!

Nanomolecule 1: (*a little scared*) Um, guys? Hello?

Sound effects: (echo nanomolecule's line)

Ant and Bacterium together: Who is that? Where are you?

Nanomolecule 1: Down here. I don't think you can see me. I hate to burst your bubbles, but I am actually much smaller than either of you. Bacterium, I am 1000 times smaller than you! So I am actually 1,000,000 times smaller than you, Ant. And those humans way up there? Well, I am about 1,000,000,000 times smaller than them! I am really, really small!

Ant and Bacterium together: (*surprised*) WOW! That IS small!

Nanomolecule 1: Yes, it is small. Nano is Greek for dwarf about 10^9 power!

Act 1 Summary

1. What is a nanomolecule?

Act 3:

We need special tools to see Nanomolecules.

Lights on, Curtains open

Microscope: Are you still there? Hello? I cannot see you!

Nanomolecule 2: (annoyed) Yes, we are still here! Where do you think we have gone? And, hey, your light is blinding us!

Microscope: If I turn off the light, I cannot see you! Listen, I don't think this is working. I don't think I am the right guy for you.

Nanomolecule 1: Well, what are we supposed to do? How will people see us?

Microscope: I think I have a friend who can help out, he's a little forceful, but he is a great resource for little guys like you. I am only useful for microscopic things like cells and bacteria.

Nanomolecule 2: (mad) Hey! Watch it! We may be small (1000 times smaller than bacteria), but we are powerful!

Microscope: Uh, sure. Whatever. Anyway, AFM can see smaller than microscopic things.

Nanomolecule 1: AFM? Never heard of him.

AFM: Of course you haven't. I am fairly new to the Science world! Nice to meet you, I am Atomic Force Microscope.

Nanomolecule 1: OK, so just how is it that you see us if the microscope can't even see us?

AFM: Well, I don't really “see” you, I sort of sense you are there.

Nanomolecule 2: Now this, I have to see!

Act 2:

Nanomolecules have unique properties!

Lights on; Curtains open

Nanomolecule 2: (*bored*) Sigh! I am sooooo bored sitting here on this surface! I cannot believe that my life is so boring that all I do is stick to this surface all day long. I would so much rather be in school!

Sound effects: (*laughs*) Ha ha ha ha ha!

Newtonian force 1: Have no fear! Super Newtonian Force Man is here! I can apply a force to you and get you off of this boring surface!

Nanomolecule 2: Really? That would be wicked cool! Thanks Newtonian Force Man!

Newtonian Force 1: Something must be wrong! I have applied many forces to you and you are still stuck to the surface! Newtonian force 2, come help me!

Newtonian Force 2: I have seen this before, this is not a pretty site. But maybe together we can act with a great force and get this molecule off of this boring surface!

Nanomolecule 1: (*angry*) If I were you, I would quit. I had a Newtonian Force try to get me off of this surface once and look at me, I am still here!

Nanomolecule 2: Oh snap! I forgot, Newtonian forces (like applied forces and gravity) don't apply to us because we are so small.

Nanomolecule 1: That is right, we are very unique! Scientists are still studying us and each day, they are finding that Newton's Laws don't apply to us. We abide by our own set of rules because we are 1,000,000,000 times smaller than most objects!

Newtonian Force 1: So you are kind of like sand on Revere Beach!

Nanomolecule 2: Are you crazy? What do you mean we are like sand on Revere Beach?

Newtonian Force 1: Well, if you think about how we see the sand on the beach from far away, it is like a light brown color, right?

Nanomolecules 1 and 2: Obviously!

Newtonian Force 2: So ... if you get up close to Revere beach and actually pick up just one grain of sand, it isn't necessarily brown, is it?

Nanomolecules 1 and 2: No!

Nanomolecule 2: I see, the grain of sand could be clear or dark brown or red. But when all of the grains are put together, they all look like the SAME color!

Newtonian Force 1: RIGHT! So if we took a bunch of you nanomolecules and made you into a larger object, Newton's Laws would apply to you. But since we are just looking at one small part of the large object, you behave differently!

Act 2 summary:

2. Explain why nanomolecules are unique.
3. How are nanomolecules like sand on Revere Beach?