Instructor: Prof. Miriam Deutsch
Office: 275 WIL
Tel: 6-5973
Email: miriamd@uoregon.edu
Office hours: Friday 2:30-3:30 pm, or by appointment

Class times: Tuesday, Thursday 2-3:50 pm Location: 110 WIL
Classes will meet twice a week. The total of four credit hours will be divided into three lecture hours and one hour of recitation each week. The first weekly meeting will comprise two lecture hours, while the second meeting will have one lecture followed by recitation. The purpose of recitation classes will be to help students analyze data they collected during hands-on explorations conducted in class, as well as assist with homework problems and other individual research assignments.

Course Assistants:
Graduate SLP Scholar Mr. Herbie Grotewohl (hgrotewo@uoregon.edu)
Office hours: Tuesday 3:45-4:45pm and Wednesday 2-3pm, in 175 WIL.
Undergraduate SLP Fellow Mr. Andrew Boomer (aboomer@uoregon.edu)
Course assistants for this class are affiliated with the University of Oregon’s Science Literacy Program. In addition to holding regular office hours and assisting students with homework assignments, these Graduate SLP Scholars and Undergraduate SLP Fellows will actively participate in various classroom instructional activities; they will assist in conducting classroom demonstrations, help supervise hands-on group exploration activities, and moderate some classroom discussions.

Course Grader: Graduate Student Mr. Kahli Burke (kahli@uoregon.edu)
Office hours: Monday 11am-12pm and Wednesday 11am-12pm, in 217 WIL.
Students may also get help from any Physics GTF at the Physics Drop-in Center, located in 147 WIL.

Course outline:
"We believe that nanotech is the next great technology wave, the nexus of scientific innovation that revolutionizes most industries and indirectly affects the fabric of society. Historians will look back on the upcoming epoch with no less portent than the Industrial Revolution."

-- Steve Jurvetson, Partner, Draper Fisher Jurvetson

This quote summarizes well the motivation for offering this course. In order to understand the magnitude of the potential impact of Nanotech, we will first need to develop an understanding of the basic science behind it, or, simply stated, how physical properties of matter change with scale. We will begin by introducing the fundamental principles of surface science, wave and quantum mechanics, and thermodynamics. We will then move on to explore applications of these core scientific theories in Nanotechnology – the field where nanoscale interactions are leveraged to manipulate and engineer new materials and devices. With this knowledge we will arrive at a realization that in addition to its great promise, Nanotechnology may also harbor many hazards, both familiar and unknown. While learning to distinguish between scientific fact and futuristic fiction, we will examine issues such as the ethics of creating new materials, environmental hazards and required containment of nanoparticles, and regulations that must exist for Nanotech to live up to its promise.
Course Topics: The course will cover the following topics:

1. Size and scale
2. Size dependent properties
3. Tools, techniques and characterization
4. Surface dominated behaviors
5. Nanoscience as the foundation for Nanotechnology
6. Nanotechnology – an industrial revolution?
7. The role of Government
8. The future of Nanotechnology

Learning Objectives:

1. Understand the relevant scientific interactions and laws of Nanoscience, how they differ from those we encounter in our daily lives, and how they may be applied to enable new Nanotechnologies.
2. Develop critical reading and reasoning skills, to learn how to distinguish between scientific facts and Nanotech hype.
3. Become cognizant of the tradeoff between the perceived promise of Nanotech and its potential hazards, and understand how society is coming to cope with these problems.

Prerequisites: While there are no prerequisites for taking this course, students who have taken high school level math, physics and chemistry are likely to feel more comfortable with the terminology and reading materials. Students who are interested in taking this course and find themselves needing help with math should make an appointment with me by the end of week 2, to be able to get the necessary help.

Student Assignments: Reading assignments encompassing a selection of reading materials (see further below) will be posted weekly. All reading materials are posted on Blackboard, by week due. Brief reading assessment quizzes, posted weekly on Blackboard (these are worth extra credit – see below), will review reading assignments and test for preparedness before the first lecture of each week. Homework assignments will be posted weekly on Blackboard.

Homework submission: Completed assignments should be placed in the drop-box labeled “PHY 163” located in the west end of the Willamette Hall basement. This is the only acceptable mode for submitting homework. You should not email your completed assignment to either me or any of the course assistants, unless specifically instructed to do so. Assignments sent by email will not be graded and will be marked as missed. Completed assignments should not be submitted through Blackboard. Assignments submitted through Blackboard will not be graded and will be marked as missed.

Late submission policy: Homework submitted up to 24 hours late will not be graded and will only be marked as submitted, automatically receiving 20% of the full credit. Homework submitted later than that will receive a grade of 0 points, as if not submitted. Submission deadlines will be strictly imposed. Special circumstances and/or emergencies may be accommodated on a case-by case basis. In such cases you should contact me as soon as possible to discuss your specific needs. Do not assume you will receive a deadline extension without discussing the matter first with me.

Solutions to Homework: Solutions to select homework problems will also be posted on Blackboard. It is important you review them, as they might hold additional information to what we do in class. I also like to reuse some homework problems in exams, and the solutions will often serve as study guides.

Course website: http://blackboard.uoregon.edu/ I will post reading and homework assignments, reading assessment quizzes, course announcements and handouts. Solutions to homework problems and tests will also be posted here. Students will need to check regularly for updates.
**Attendance policy:** Attendance is required, and will be taken at the beginning of each lecture. Students must attend at least 80% of lectures to receive credit for this course. Students are responsible for making up any missed materials presented in class. Some lectures (to be announced in advance) will involve hands-on student activities. Missed attendance in these classes will result in a lower final grade. Five points will be deducted from the final grade for each such in-class activity that is missed.

**Students with Disabilities:** If any aspects of the program hinder you from fully participating in this course, please notify me as soon as you become aware of them. You may also contact the Accessible Education Center in 164 Oregon Hall, Tel: 346-1155.

**Detailed Schedule:**

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<thead>
<tr>
<th>Week</th>
<th>Agenda</th>
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| 1 | **Topics:** Introduction, motivation and background  
Size and scale: What is a Billion, how tall are you in Nanometers and who cares?  
*Reading:* items #2, 4 (Chapter “Little Big Science”),8 on Readings List  
*Assignment:* Estimation and size scales. How many golf balls does it take to fill your dorm room? Is it true there are more water molecules in a glass of water than there are glasses of water in the world’s oceans? How many fish are in the ocean? |
| 2 | **Topic:** Size dependent properties, where we introduce the fundamental principles of Quantum Mechanics and Thermodynamics.  
*Reading:* items #3 (Chapter 3),12,13,14  
*Assignment:* Independent study: How do familiar properties depend on size? Explore the size and strength of soap bubbles, break water’s surface tension, and observe the color of an oil slick. |
| 3 | **Topic:** Tools, techniques and characterization, in which we will come to appreciate the issues involved with nanoscale probing and visualization.  
*Classroom activity:* What’s in the box? Students, working in groups, will be tasked with deciphering the nature of an object hidden within a sealed container.  
*Reading:* items #3 (Chapter 4),6,7,9,10,18  
*Assignment:* collect samples and materials suitable for imaging in Scanning Electron Microscope, predict what you will see when imaging your sample (group assignment.)  
Complete data analysis from classroom activity. |
| 4 | **Topic:** Tools, techniques and characterization continued,  
*Special Activity:* Tour CAMCOR facilities, use portable electron microscope to analyze previously collected and prepared student samples.  
*In-class Quiz,* covering materials discussed so far (during recitation time, 40 min.)  
*Reading:* items #19,26  
*Assignment:* Analyze and discuss electron microscope data. |
| 5 | **Topic:** Surface dominated behaviors, where we discover why so much of what we see, feel and even hear is dominated by the surface.  
*Video:* Small can be big ([http://www.youtube.com/watch?v=2NySRur62gg](http://www.youtube.com/watch?v=2NySRur62gg))  
*Classroom activity:* Feel the surface. Students, working in groups, will construct a primitive atomic force microscope to demonstrate how it is used to map the contours of surfaces.  
*Reading:* items #21,22  
*Assignment:* Analyze and discuss electron microscope data. Estimate and compare surface area of: grains of sugar contained in 1 teaspoon, the hair on your body, and the lining of your lungs. Compare between processes that occur at surfaces and those that do “in bulk.” |
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<tr>
<th>Week</th>
<th>Topic</th>
<th>Assignment</th>
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<tr>
<td>6</td>
<td>Midterm exam. The midterm will cover all materials discussed since beginning of term. The first two lecture hours of this week will be used to finish discussing surface dominated behaviors and also review for midterm. The exam is scheduled during the third lecture hour and recitation time (duration: 1hr 50 min.) There will be no assignments due this week.</td>
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| 7    | Topic: Nanoscience as the foundation for Nanotechnology, in which we delineate the difference between Nanoscience and Nanotechnology, and begin to understand how one leads to another, as well as where Science ends and Fiction begins.  
Video: The Lotus Effect (http://www.npr.org/blogs/krulwich/ or also from http://www.youtube.com/watch?v=IfUaKXasdD4&feature=player_embedded)
Reading: items #20,24,25  
Assignment: What are the biggest challenges for translating Nanoscience into Nanotechnology? How do you know when a nanotech claim is bogus? Can nanobots really eat us alive? |  |
| 8    | Topic: Nanotechnology – an industrial revolution? We will discuss this topic, compare it to previous, known revolutions (i.e. antibiotics, electricity, railroads and stem engines) and try and understand its scale of impact.  
Reading: items #4 (Chapter “Nanobot Construction Crews”), 23,27,28,29  
Assignment: What current accomplishment of Nanoscience would you most like to see translated into Nanotechnology, and why? Research three different household items that rely on Nanotechnology – how do they work, when was the technology necessary for their operation developed, and how much have they impacted your life? |  |
| 9    | Topic: The role of Government – who funds nanotech research and how is it regulated? What is the impact of Nanoscience on our society, and what role does the government play in shaping it?  
Reading: items #3 (Chapter 11),5,15 and excerpts from list of Government Reports  
Assignment: This will be Essay Week #1. Some possible topics: Should government fund nanotechnology? Who are the main nanotech stakeholders, and how are their decisions influenced by the media? Is nanotech on a path of self-destruction? |  |
| 10   | Topic: The future of Nanotechnology – where is all this going, and what will be the next big (small) breakthrough? How do we use the tools and technology of today to chart our future direction?  
Reading: Items #1,11,16,17,30  
Assignment: Welcome to Essay Week #2. Topic: Envision a new technological frontier, and discuss what knowledge is still missing for your vision to materialize. Example: I would love to have my teeth kept clean all day, without having to brush them more than once. I envision spreading transparent toothpaste like cream on my teeth every morning, where the heat in my mouth activates tiny “scrubbing nanobots” that skate across my teeth all day, mechanically removing anything that would otherwise stick to them. What are some of the Nanoscience and Nanotechnology challenges involved in making this a reality? |  |

**Evaluation:** Exam and grade breakdown are as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Scheduled for</th>
<th>% Weight of final grade</th>
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<tbody>
<tr>
<td>In-Class Quiz</td>
<td>Jan. 30, during class</td>
<td>10%</td>
</tr>
<tr>
<td>Midterm Exam</td>
<td>Feb. 13, during class</td>
<td>20%</td>
</tr>
<tr>
<td>Final Exam</td>
<td>March 18, 1pm</td>
<td>35%</td>
</tr>
<tr>
<td>Homework Assignments</td>
<td>Weekly</td>
<td>35%</td>
</tr>
<tr>
<td>Reading Assessment Quizzes</td>
<td>Weekly, Online</td>
<td>Up to 7 points in extra credit</td>
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The use of personal dictionaries or translators, electronic or in book form is not allowed during exams taken in class. The only electronic devices which may be used during exams are scientific calculators. This means that you will not be allowed to use your smart phone, tablet or laptop computer, as well as any other wireless enabled device during in-class exams. Students MUST take the final exam to qualify for a passing grade; in other words – students who do not take the final exam will automatically receive a grade of F, regardless of their performance during the term.

Extra Credit: Completing the assessment quizzes posted on Blackboard will earn you up to 7 points in extra credit. This credit is for participation in the assessment by completing the quiz, and will not depend on your actual score. You should make an effort to take these quizzes, as they will help you keep up with the material in class. I will also reuse some of the questions in subsequent class exams.

The final grade will be determined as follows:

<table>
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<tr>
<th>Final score</th>
<th>86-100</th>
<th>71-85</th>
<th>56-70</th>
<th>40-55</th>
<th>Below 40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>F</td>
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The broad number ranges will allow room for +/- grades. If I find it necessary, I will curve the grades. Note: The highest grade of any standard distribution or curve will be A. I reserve the grade of A+ only to special cases, when a student’s performance is clearly above the norm. In statistics such cases are known as outliers, and by definition are rare. Hence an average score of 95% does not guarantee you a final grade of A+ in this class.

Readings: The readings listed below are from a wide variety of sources. There is no one textbook which is suitable for a broad introductory course at this level. We will read excerpts from books published over the past 10 years, in addition to popular science articles and government reports. All readings are posted on Blackboard, by week due.

Books (Excerpts)

Articles and online materials


16. “Has all the magic gone?” *The Economist*, Health Section, April 12 (2006), free online at http://www.economist.com/node/6795430

The following articles from *Popular Mechanics*, freely available online at the URLs listed:


The following articles from the *MIT Technology Review*, freely available online at the URLs listed:


**Government Reports**

Select sections from the following reports and proceedings, freely available online at the URLs listed: