Introduction to Nanoscience and Nanotechnology

(Two reoccurring themes throughout the course are nano in nature and applications. Rather than separate the two, they are integrated into the following topics.)

This is a two-credit hour course and has been designed for 8 weeks, two, 2 hour sessions per week.

The first offering will be in a 4wk summer session, therefore, each week will consist of two 4yr session per week plus online work.

Course Outline

Week 1

- Introduction – web-based hybrid course
- Nanoscience vs. Nanotechnology
- Sense of Scale: Macro, micro, nano

Week 2

- Nano in Nature (Brief overview, then integrate this concept throughout the course)
- Historical Perspective
    - Nanotechnology in BC and beyond
        - Stained glass
        - Optics vs. Size (gold and silver)
    - Microsystems technology enables nanotechnology (There's Plenty of Room at the Bottom)
- Nano Optics
    - In Nature (butterfly wings)
    - Thin films interference and light interaction
    - LED – light, wavelengths, energy and bandgaps
    - Nanoapplications

Week 3

- Surface Treatments - Hydrophobic vs. Hydrophilic
    - Stenocara bettle
    - Lotus Leaf
    - Lipid bi-layers
    - Nanoapplications
- Material Structure (Crystallography)
    - Solids – Amorphous, polycrystalline, crystalline
    - Miller Indices

Week 4

- Many faces of carbon – fullerenes (grapheme, Buckey-balls, CNT), amorphous and diamonds
- Surface Area (SA) to Volume (V)
    - The relationship between SA and V

- SA: V ratio of nanoparticles vs micro and macro systems
- The effects of this ratio to nanotechnology
- Nanotechnology applications

Week 5

- Physical properties at the nanoscale
  - In nature (Abalone Shells, Lipid bi-layers, Gecko, Spider Webs)
  - Contact forces – stiction
  - Density, Buoyancy and Surface Tension
  - Nanoapplications
- Self-Assembly
  - Crystal growth
  - Biomolecular self-assembly (DNA, microtubules, muscle contraction using nano-motors, supramolecular structures (form nanoscale particles/fibers such as nanowires and nanotubes)
  - Bottom Up vs. Top-Down assembly
- Nanoapplications of nanostructures and self-assembly

Week 6

- Nanotechnology Devices
  - Lab-on-a-chip
    - Microfluidics
    - How do fluids flow at this scale?
  - BioMEMS and DNA Microarrays
  - "The Borg"
  - Consumer Products
  - Future Trends and Commercialization Concepts

Week 7

- Cantilevers
  - Resonance vs. scale
  - Chemical Sensor Array

Week 8

- Introduction to Nanofabrication – Cleanrooms
- Nano and Society
  - Ethics
  - Careers
- UNM interdisciplinary programs

Lecture Topics

Week 1

- Introductions – web based hybrid course
- NanoScience vs NanoTechnology (Students will have developed their own definitions and taken an online quiz prior to class)
- Sense of Scale (Cut to Scale hands-on Activity)

Week 2

- Historical Perspective of Nanotechnology

- Nano in Nature (Brief overview)
- Optics in Nature (thin films and light interference)

Week 3

- Surface Treatments - Hydrophobicity
- Material Structure
    - Crystals, amorphous and poly crystal

Week 4

- Many faces of carbon - fullerenes
    - Surface Area to Volume

Week 5

- Physical Properties at the nanoscale

Week 6

- Research and guest speaker

Week 7

- Cantilevers – Macro – Micro - Nano

Week 8

- Introduction to Nanofabrication: The Cleanroom
- Nano and Society –
    - Ethics, Careers, UNM interdisciplinary programs

Assignments submitted electronically. Some assignments will include posting to discussion boards. The discussion boards will require you to respond to at least two other postings.

Hands-on Classroom Labs

Week 1

- Cut to Size

Week 2

- History and Nanotechnology
    - (http://www.discovernano.northwestern.edu/whatis/History/HistoryPopup)
- Thin films and light interference - Rainbow Wafer
- LED – light, wavelengths, energy and bandgaps (Matt needs to buy – colloidal liquid (silver or Au)

Week 3

- Magic Sand
- Miller Indices
- Breaking Crystalline Silicon Wafers

Week 4

- Surface Area to Volume – Alka Selzer experiment
- Calculation problem (how much platinum do you need in a catalytic convertor?)

Week 5

- Self assembly – crystal growth using Sodium Acetate Trihydrate
  - (http://scme-nm.net/scme_2009/files/Crystal%20Self-Assembly%20Module.pdf)
- Aerogel – need to purchase some – do activity with heat conduction

Week 6

- Research and guest speaker – no hands-on activity

Week 7

- Dynamic Cantilever: Microcantilevers enable nano and are enabled by nano
  - Resonance Vs Geometry and Mass added
  - Relate to the chemical sensor array

Week 8

- Discussion on ethical issues surrounding of nanotechnology.

Outside Assignments, Discussions, and Activities

- Knowledge Probes:
  - Pre-course survey – attitudes and understanding on Nanoscience and Technology including careers.
  - Nanoscience vs. Nanotechnology
  - Scale and Metrics

Week 1

- Define and compare nanoscience vs. nanotechnology
- Zoom In - Zoom Out

Week 2

- Historical Perspective Tutorial
  http://www.discovernano.northwestern.edu/whatis/History/HistoryPopup
  - (Reinforce with on-line or in-class quiz)
- Research - Nanoapplications that exploit the properties of light (include references and attachments) - Post results to the discussion board

Week 3

- Marketing Project - Nanoapplications that exploit hydrophobicity (assign after in-class activity and lecture) – Create an application and write up a marketing plan.
- The importance of crystal structure to nanotechnology - Discussion Board

Week 4

- Calculations for SA:V (to be turned in)
- The effects of SA:V in nanotechnology
- What is aerogel?

Week 5

- Exploration of Bottom-up fabrication and Nanoapplications of self-assembly (turn-in)
- Pick a field and research the applications of nanotechnology in that field, the advantages, challenges, and future trends

Week 6

- Choose a specific nanodevice and describe its applications, how it works, advantages and disadvantages, and fabrication (turn in)
- Posting – Post the answers to the following three questions:
    - What are cantilevers?
    - What are some examples of cantilevers?
    - What are some applications of cantilevers in micro and nanotechnology?

Week 7

- Research the application of a chemical sensor array (CSA) used in one of the following areas.
    - Biomedical
    - Environmental
    - Aerospace
    - Bioterrorism
    - Food Science
- Discuss the components of these CSA, how it works, how it is fabricate, current and future applications, advantages over previous methods, limitations

Week 8

- Research the various careers available in nanotechnology. Choose a specific job in nanotechnology that interests you. Write a paper on the accessibility of this career, educational requirements, skill and knowledge requirements, locations of job, and the challenges you face in getting such a position.