ME 4875/ MTE 575 - Introduction to Nanomaterials and Nanotechnology (C17)

Worcester Polytechnic Institute

Mechanical Engineering/Materials Science and Engineering

Prof. Pratap Rao

Homework 1 - Due in class Friday January 20, 2017 (late HW will not be accepted)

Collaboration is allowed, but this should take the form of general discussion of concepts and approaches required for solution of problems. After this discussion students should independently solve the problems. Solutions to problems should not appear as though they were copied from another student, or from solution manuals to any textbook. In addition, all literature sources must be properly referenced.

Questions for all students (50 pts)

Reading Assignment: "There's Plenty of Room at the Bottom" - Richard Feynman, 1959 (available on Canvas)

1. Assume you could write small letters on a surface by placing atoms next to each other in the shape of that letter. How large of an area (in square meters) would you need to fit all of the words of every book ever written by humans? Make your own calculation, and state all your assumptions. (10 pts)

2. Consider a state-of-the-art magnetic storage device (computer hard drive, USB stick, iPhone, etc.). How much data can it hold? Roughly how large of an area does the storage chip occupy? Therefore, back out how large of a square on a side each *bit* of data occupies. Make your own calculation, and state all your assumptions. (10 pts)

3. How large on a side would a cubic particle need to be to contain as many atoms as there are people on planet earth? Express your answer in nanometers (nm), micrometers (um) and meters (m). Make your own calculation, and state all your assumptions. (10 pts)

4. Assume, as in Problem # 1, that you could write small letters on a surface by placing atoms next to each other in the shape of that letter. Now imagine that instead of writing the letters on a thick piece of material, you are writing them on a sheet of graphene which is only 1 carbon atom thick. When each sheet is filled, you stack a new sheet on top. How large of a volume (in cubic meters) would you need to fit all of the words of every book ever written by humans? Make your own calculation, and state all your assumptions. (10 pts)

5. Imagine you have wires standing up vertically from a surface, arranged in a cubic array, with fixed aspect ratio (length/diameter) and spacing between the wire axes equal to twice the wire diameter. Obtain an expression for the ratio of (vertical wire surface area)/(rectangular volume occupied by the array, including empty space). What happens to the ratio when you decrease the wire diameter? (10 pts)

P.T.O.

Extra questions for students registered for MTE 575 (50 pts):

Reading Assignment: “Of Chemistry, Love and Nanobots” - Richard Smalley, 2001 (available on Canvas)

6. What, according to Smalley, is the “fat fingers problem” and the “sticky fingers” problem? Does Feynman describe these problems in his talk? How does a scanning tunneling microscope (STM) place atoms, and how does it deal with these two problems? (25 pts)

7. Assume you have a nanobot that consists of 1000 atoms, and that it can position atoms at a rate of 10,000 per second. Assume that you want to use this nanobot as a 3-D printer. How long would it take to print an object that is 1 cubic centimeter in size, assuming it is fully dense? Now, assume that this nanobot can replicate itself. How many generations of replications and how much time would be necessary to produce a team of nanobots that are capable of together printing the 1 cubic centimeter object in 1 second? Make your own calculation, and state all your assumptions (25 points)