Challenge Homework 1
Physics 201
Due 10/9/2012

1. Light in a vacuum travels at a constant speed of $3.0 \times 10^8 \text{ m/s}$. (a) How many feet does light travel in 200 nanoseconds? (b) How many minutes does it take light to travel from the sun to the earth. (c) If traveling at the speed of light, how many episodes of *The Simpsons* could you watch while you travel from Earth to its nearest star, Proxima Centauri.

2. The mass density of water is 1.00 g/cm$^3$. (a) What is the mass density of water in SI units? (b) How many (b) kilograms and (c) pounds are in a 2-L bottle of water.

3. Solids consist of a crystalline lattice of atoms - a unit cell that has a certain configuration of atoms that is repeated over and over. The picture to the right of stacked metal spheres represents a lattice configuration called face-centered-cubic (fcc). Calculate the packing fraction for this case, e.g. the amount of the volume occupied by the metal spheres divided by the total volume of the pyramid structure.

4. Consider a system where the three fundamentally important quantities are the speed of light $c$ with dimensions $[L]/[T]$, Planck’s constant $h$ with dimensions $[M][L]^2/[T]$, and the mass of the proton $m_p$ with dimension $[M]$. (a) What combination of ratios and/or products of $c$, $h$, and $m_p$, will yield a new quantity of dimensions $[L]$? (b) What combination of ratios and/or products of $c$, $h$, and $m_p$, will yield a new quantity of dimensions $[T]$?

5. (a) Estimate the number of raindrops that fell on Corvallis during the rainstorm the weekend before class began. Clearly state all assumptions and document any references you use. (b) Using your assumption from part (a), how many pint glasses could this fill up?

6. A famous 20th century physicist, Enrico Fermi, is known for being found of asking his students estimation problems, so much so that these problems are often referred to as Fermi problems. In the spirit of Fermi estimate the number piano tuners in Chicago using only the population as a data input. Clearly state all assumptions.
7. A pirate hid a treasure in the M.U. Quad. Use the five trees labeled \( A \) - \( E \) as waypoints to find the hidden location. His map states to start at point \( B \) and go half the distance to point \( C \). Then go a third the distance to point \( A \), a fourth the distance to point \( E \), and finally the treasure is located a fifth the distance to point \( D \). (a) Symbolically write out the vector operations described above. Use clear notation. (b) Overlay a grid on the picture and give a reasonable estimate of the grid spacing. (c) Find the location of the final position vector using origin \( O \). Express this vector as a magnitude and direction from the \(+y\) axis. (d) Show if you repeat the exercise of finding the treasure but change the order of which you go from point to point you end up at the same final position. You can start from any point, but must follow the order of decreased magnitude and occupy each point once. (e) Extra credit: Prove the order doesn’t matter.