Problem Set 8
Due: Dec. 3, 2003

1. **Oh the Humanity** (6 pts)

   (a) Estimate the mass of all the humans on earth, in grams. (Hint: assume a reasonable average mass per person and research the Earth's population if you don't know it.)

   (b) Calculate the average density of a neutron star with $M = 1.4$ $M_\odot$ and $R = 15$ km, in g/cm^3.

   (c) The mass of everyone on Earth is equaled by what volume of neutron star material? Give your answer in teaspoons, 1 tsp = 5 cm^3.

2. **Using pulsars to measure an AU** (3 pts)

   The arrival times of pulses from a pulsar are modified by the Earth's motion around the sun. Calculate the difference in arrival times of pulses, relative to a uniformly ticking clock, between the point in the Earth's orbit when it is closest to the pulsar, and when it is furthest away. Express your answer in milliseconds. Your answer will depend on the angle $i_\oplus$ between the plane of Earth's orbit, and the line of sight to the pulsar. Include a drawing (similar to the one in the lecture notes) to clarify the geometry of the problem. How does this signal compare to the time delays caused by the pulsar planets (approximately 1 millisecond)?

3. **Protein chains and large numbers** (6 pts)

   (a) Consider a protein consisting of a chain of x amino acids. Each of the x positions in the chain could be occupied by any one of the 20 biologically important amino acids. Write down a mathematical expression for the number N of possible different proteins containing x amino acids that could exist. (Hint: there are 20^2 possible combinations for two amino acids.)

   (b) Evaluate N to order of magnitude for $x = 100$, roughly the size of the smallest and simplest known proteins. Express your answer in exponential notation.

   (c) Write down mathematical expressions for the number of codons C required on a strand of nucleic acid to generate a protein containing x amino acids, and for the number of nucleotide base pairs B that these C codons would contain.

   (d) Consider all nucleic acids strands that specify a protein of x amino acids. Is the number of these, more than, less than, or equal to the number of possible unique proteins of x amino acids? Explain your answer.