COS 116
The Computational Universe
Homework 4
Due: April 21, 2011

Q1. Explain in a couple of lines how your web browser figures out that the address www.cs.princeton.edu refers to the computer whose IP address is 128.112.136.35. How many bits does the address 128.112.136.35 have? Does this addressing scheme allow one address for each of the 6 billion humans on earth?

Q2. Explain in a couple of lines two places where quantum mechanics plays a role in manufacturing silicon chips.

Q3. What is wrong with the following "proof" that P is different from NP? Give an example that demonstrates the fallacy in the reasoning behind it.
"NP problems involve a search through all possible solutions, and the number of possible solutions is exponential in the input size. Therefore no algorithm can solve the problem in polynomial time."

Q4. You decide to learn the machine language for a modern CPU. You notice that it assumes that all memory addresses have 32 bits. How large a memory does that imply? Can such a program run on a CPU with 1 Gigabyte memory? Explain in a line or two.

Q5. Suppose we have a computer with a main memory that can hold 10 data items, and a cache that can hold 3 data items. Initially, the main memory contains the numbers 1 through 10, and the cache is empty:

Main memory:

1	2	3	4	5	6	7	8	9	10

Cache:

Recall that, whenever a program requests a data item, it first checks to see whether it is in the cache. If it is, the request proceeds normally. If it's not, the data item is first copied

from the main memory to the cache. If the cache is full, some other data item in the cache must be overwritten.

Assume our computer uses the "Least Recently Used" algorithm to decide which data item will be overwritten. Now suppose we run a program that requests data items in the following sequence: 2, 4, 7, 2, 1, 3, 4, 2, 4, 10, 4, 9, 2, 5, 2, 2. Show the contents of the cache after each request. Also, say how many times during this sequence the requested item was not in the cache.

Q6. Consider a computer with three levels of memory: cache, RAM, and hard disk. The table below gives the time required to access a data item from each of these memories.

Memory Type	*Access Time*
Cache	5×10^{-9}s
RAM	2×10^{-8}s
Hard disk	5×10^{-3}s

Suppose that 98% of data requests are satisfied by the cache, 1.9% by the RAM, and 0.1% by the hard disk. Calculate the average time to access a data item in this computer.