1. In this problem, “pumping length” means a $p$ given by the pumping lemma for context-free languages. Let $L$ be the language $\{a^nb^nc^n\}$. What is the minimum pumping length of $L$?

2. Give the definitions of the four types of grammars in the Chomsky hierarchy. (Don’t be long-winded. You can get full credit for a very short answer.)

3. The Bach language is the set of all strings over a three symbol alphabet which have equal numbers of each symbol. For example, $aaabbcccecc$ and $abcbbaca$ are members of the Bach language. Where does the Bach language fit in the Chomsky hierarchy?
4. Let $L$ be the language of all strings over the unary alphabet \{1\} whose lengths are powers of 2. That is, $L = \{1, 11, 1111, 11111111, \ldots\}$ Give an unrestricted grammar, also called a general grammar, which generates $L$.

5. I proved that there is a function $f$ which is eventually greater than any computable function. A student said,

"But Dr. Larmore, didn’t you just give a computation of $f$? Thus $f$ is computable, which implies that $f$ is eventually greater than itself, contradiction."

This does appear to be a contradiction, doesn’t it! Explain why there is no contradiction.

6. Let *primality* be the language consisting of all binary strings which are binary numerals for prime numbers. Prove that *primality* is co-$\mathcal{NP}$.

7. Assuming that Knapsack is $\mathcal{NP}$ complete, give a proof that Partition is $\mathcal{NP}$ complete by giving a polynomial time reduction from Partition to Knapsack.