1. Show that DSPACE$[n] \neq$ NP. [Hint: use a Hierarchy Theorem.]

2. Let EMPTY-CFL $= \{G \mid G$ a context-free grammar and $\mathcal{L}(G) = \emptyset\}$. Prove that EMPTY-CFL is P-complete.

   [Hint: to show that a given CFL, G, generates no strings, I suggest that your develop a linear-time marking algorithm which marks all nonterminals, N, as "useful" if there is a derivation from N to some $w \in \Sigma^\star$. For example, if there is a rule $A \to a$, for $a \in \Sigma$, then you would mark A as useful. To show that EMPTY-CFL is P-hard, I suggest that you reduce $\overline{\text{MCVP}}$ to it.]

3. Let $A \subseteq \{0,1\}^\star$ be a random oracle in the sense that each string w is either in A or not in A with probability 1/2, independent of all the other strings.

   Prove that with this distribution of A's, the probability that $\text{P}^A = \text{NP}^A$ is 0.

   [Hint: this is somewhat similar to the construction we did in class of a B s.t. $\text{P}^B \neq \text{NP}^B$. Just consider unary languages, and now we'll look for a run of consecutive w's that are in A. For a given length, the probability of the existence of such a run, should be 1/2.]