Answer each question carefully. Answer questions 1 and 2 here and the rest on the paper provided. There are 10 questions worth 100 points. Point values are located in parentheses to the right of each question. Unless otherwise specified all languages are over the alphabet \{0,1\}.

1. For each of the following statements indicate if the statement is true or false (T or F).
   (2 ea)
   
   _____ a. A PDA can be constructed to recognize any language recognized by a DFA.
   
   _____ b. A DFA can be constructed to recognize any language recognized by a PDA.
   
   _____ c. The pumping lemma is false for all strings in a non-regular language.
   
   _____ d. A grammar is ambiguous if and only if all strings derived from the grammar have two or more different leftmost derivations.
   
   _____ e. Every finite language is context free.

2. For parts a, b and c below select ALL of the items from the list (A-F) that answer the question.
   (3 ea)
   
   A. Create a regular expression that describes the language.
   B. Create a context free grammar that describes the language.
   C. Create an NFA that recognizes the language.
   D. Use the pumping lemma.
   E. Use the closure properties of the regular operations.
   F. Create a pushdown automata that recognizes the language.

   a. Which are correct ways to show a language is regular?

   b. Which are correct ways to show a language is NOT regular?

   c. Which are correct ways to show a language is context free?
3. Draw a transition diagram for a DFA that recognizes the language
   \[ L_1 = \{ w \mid w \in \{0,1\}^* \text{ and } w \text{ contains the string } 011 \}. \] (10)

4. Build a context free grammar for the language
   \[ L_2 = \{ awb \mid a, b \text{ are single symbols such that } a \neq b \text{ and } w \text{ is a palindrome} \} \] (so \( a, b \in \{0,1\} \) and \( w \in \{0,1\}^* \)). (10)

5. Draw a transition diagram for a PDA for the language
   \[ L_3 = \{ 1^n w \mid n \geq 0, \ w \in \{0,1\}^* \text{ and } |w| = n \} \] (10)

6. Suppose you wanted to show that the language \( L_3 \) from the previous problem is not regular. Which of the following would be good choices for the string \( s \) in the proof. If it a good choice, show how it breaks the pumping lemma (e.g. how it can be "pumped"). If it is a bad choice, explain why. (4 ea)
   a. \( 1^p 0 1^p \)
   b. \( 1^p 0^p \)
   c. \( 1^p 1^p \)
   d. \( 1^p 0 1^{p-1} \)
   e. \( 11110000 \)

7. We have shown that if a language is regular then its complement is regular. Suppose we know that a language is not regular, can we deduce that its complement is also not regular? Explain your answer. (10)

8. Let \( P = \{ w \mid w = w^r \text{ and } w \in \{0,1\}^* \} \) (the language of palindromes). Is \( P \cup L(\{0 \cup 1\}^*) \) regular? Explain your answer. (10)

9. Suppose \( L_4 \) is a context free language described by grammar \( G(V, \Sigma, R, S) \). Define a grammar for the language \( L_4^* \). (10)

10. I needed an extra point so I wasn’t stuck with a 99 point exam. Suppose \( L_5 \) is a context free language that appears on this exam. What is its alphabet? (1)