CS 4510 Automata and Complexity

Exam 1: Regular languages

Date: 3:30pm-4:45pm Monday, February 14

- Name: ____ GTID: ____
- **When handing in this test, please go to a TA with your GTID to verify the name on the test.**
- Do not open this exam until you are directed to do so. Read all the instructions first.
- This booklet contains 4 **questions on** 5 **pages**, including this one.
- **Write your name and user id (letters, not numbers) on the top of every page.**
- By submitting this exam, you agree that your actions during this exam conform with the Georgia Tech Honor Code.
- Write your solutions in the space provided. If you run out of space, continue your answer on the back of the last page, and make a notation on the front of the sheet.
- There is a page of scratch paper at the end of the exam. We can provide additional scratch paper if you need it. The only outside material you may use on the exam is one (1) double-sided, hand-written, 8.5"x11" page of notes.
- Calculators are NOT permitted.
- You may use any of the theorems/facts/lemmas from the lecture notes, homeworks, or textbook without re-proving them unless explicitly stated otherwise.
- If you have a question, you may ask a TA. You should not communicate with anyone other than teaching staff during the exam.
- Do not spend too much time on any one problem! If you get stuck, move on and come back to that one later.
- Good luck!

	Grade	Grading TA
Name on EACH page		
True/False		
Closure		
Regular Expressions		
Pumping Lemma		
Total		

Name: _______________________ GTID: _______________________

0. **Following Instructions** (1 point extra credit)

   Please write your name and GTID (letters, not numbers) at the top of EACH page of this exam.

1. **Short answer**

   (a) (4 points each) Circle one. No explanation necessary.

   i. Suppose, for some language L, that there is some NFA that accepts L. Then there is (ALWAYS / SOMETIMES / NEVER) a DFA that accepts L.

   ii. Suppose that, for some language C, you know that $\overline{C}$ is regular. Then C is (ALWAYS / SOMETIMES / NEVER) regular.

   iii. Let R be a regular expression. Then $R \cup \varepsilon$ (ALWAYS / SOMETIMES / NEVER) generates at least one string.

   (b) (8 points) You are using the pumping lemma to show that the language $\{w \mid w$ is a binary palindrome$\}$ is not regular. You have already assumed that L is regular, and let p be the pumping length. Which of the following choices for s allow you to successfully complete the proof, where s is the counterexample string which you show cannot be pumped? (Circle all that apply, if any. No explanation necessary.)

   - 0^p0^p
   - 0^p1^p
   - 01^p0
   - 0^p10^p

Name: ____ GTID: ____

2. **Closure** (30 points)

   Let L be a language, and let $HICCUP(L)$ be the language whose strings consist of a prefix of a string from L, followed by another (possibly the same) full string from L. For example, if $L = \{cat, 110\}$, then some of the strings in $HICCUP(L)$ are the following: $cat, cacat, 110cat, ca110, 1110$, etc. Note that the prefixes of, say, cat are ε, c, ca, cat.

   Prove that if L is regular, then so is $HICCUP(L)$.

Name: ________________________ GTID: ________________________

3. **Regular Expressions** (20 points - 10 each)
   Give a regular expression for the following languages. Please box your final answers.

   - The set of binary strings that do NOT have length exactly 2.

   - The set of strings over the alphabet $\{a, b, c\}$ that contain at least one of each character, such that the first a appears to the left of the first b, and the first b appears to the left of the first c.

     For example, this includes *abcba*, but not *abba* (missing a letter) and not *acbca* (c appears for the first time before the first b).

Name: ____ GTID: ____

4. **Pumping Lemma** (30 points)
   Prove that the following language is not regular using the Pumping Lemma:

   $$L = \{01ww \mid w \in \{0,1\}^*\}$$

   i.e. the set of binary strings that consist of a 0 followed by a 1 followed by 2 copies of the same string, such as 0100010001 or 0111.

...............SCRATCH PAPER..................