

Final Exam for CS 320

Follow These Rules: These rules help prevent difficulties I have suffered in the past. I often deduct points for failure to follow instructions.

(1) **Do not use books or notes.** Explanation: when I allow books, I have to ask harder questions since you can look up the easy ones right in the book. Also, I want you to memorize some things so you can remember and use them later.

(2) **Only pens, pencils, erasers, and paper should be on your desk.** Keep all backpacks, papers, notes, and books on the floor. Explanation: this reduces the risk of cheating, or of others believing that you are cheating.

(3) **Use the paper that I provide.** Explanation: student-provided paper is often oddly shaped, recycled (printed on one side), has rough edges, or is an odd size, color, or texture. These factors and more make it difficult to work with. Uniformity makes grading easier. Use my paper instead.

(4a) **Label each answer page** with your ID number, dash, and problem number, in a box in the top left corner (↖) of the answer sheet. For example, if your id number is 1234567 and the problem number is 12, write 1234567-12 in the upper left corner, **one inch down** from the top of the paper, and **one inch in** from the left edge of the paper. Do not write your NAME anywhere on the answer sheet. Explanation: For fairness and uniformity I try to grade all problems without being aware of the person who wrote the answer.

(4b) **Keep?** If you want me to keep your answer sheets and return them to you, write the word KEEP inside or near the ID box. Otherwise I will feel free to throw your test away after final grades have been posted.

(5) **Leave the edges of your paper blank**, at least as much as the edges of this sheet are blank (one inch, or 25 mm, on all four sides).

Explanation: I need room to write comments, and room to staple things. I don't like to feel crowded.

(6) **Answer on separate sheets.** Explanation: For fairness and uniformity I typically grade problems separately in random order. I shuffle the answer sheets. Assume each sheet will be graded in

total isolation from the other sheets you submit. Do not split an answer across two sheets. If you do, they will likely become separated. Do not staple, fold, or tear your pages. Write one answer per sheet, so I can have one pile for problem 1, another for problem 2, and so forth. Try to use just the front of the sheet, leaving the other side empty. Do not refer to other answers you have written (as in: see problem 3) since I will not have problem 3 handy. Also, do not write two different answers to a question. (I will ignore the second answer.)

(7a) **Use an easy-to-read writing method.** Write neatly and clearly. Use good contrast (e.g., dark pencil or ink). Explanation: Light (faint) pencil can be very hard for me to read. Light (faint) pencil on top of erasures can be almost impossible to read. Very small handwriting is hard for me to read. Help my eyes find your answer easily. Cross out things you don't want me to grade.

(7b) **Do not use red ink.** Explanation: I use it for grading.

(8) **Avoid sitting directly next to another student.** Spread out around the room. Explanation: this reduces the risk of cheating.

Each problem is worth the same number of points.

Discuss: Some questions ask you to discuss a word or phrase. Write briefly the most important things about it. Explain it (in the context of this course) as though to someone who is interested but does not yet understand.

Problem 1: Discuss Palindrome

Problem 2: Discuss Languages

Problem 3: Discuss Intractable

Problem 4: Discuss Nondeterminism

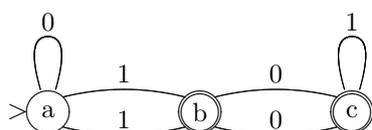
Problem 5: Discuss the Pumping Lemma for regular languages.

Problem 6: Discuss the Pumping Lemma for context-free languages.

Problem 7: Discuss Ambiguity
Give an example of an ambiguous grammar.

Problem 8: Discuss Turing Machines

Figure 1: Finite Automaton



Problem 9: Trace a FA

Trace the finite automaton in figure 1 above for the following inputs. At each step, identify the state in which the FA is. Tell whether the input is accepted.

(a) 10101 (b) 111000

(c) For extra credit, explain what language is accepted by this finite automaton.

Problem 10: Convert FA to Regex

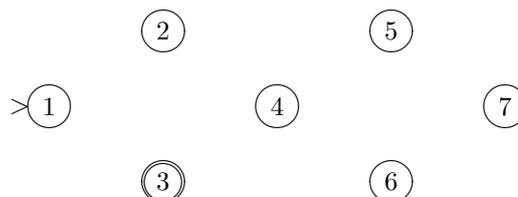
Convert the finite automaton in figure 1 above into a regular expression that matches the same language.

Problem 11: Convert Regex to NFA

Convert the following regular expression a finite automaton (either DFA or NFA is okay, GTG is not okay) that matches the same language.

$((ab^*a)^+ | (ba+b)^*)abab^*$

Figure 2: Nondeterministic Finite Automaton



Problem 12: Convert NFA to FA

Convert the nondeterministic finite automaton in figure 2 above to a (deterministic) finite automaton that matches the same language.

Problem 13: NFA Trace

Trace the NFA in figure 2 above for the following inputs. At each step, identify the set of states in which the NFA could be. Tell whether the input is accepted.

(a) ababab (b) bbbabbb

(c) Give two examples of words that are accepted by this NFA.

Figure 3: Context Free Grammar

$$\begin{aligned} S &\longrightarrow X \mid Y \mid a \mid b \\ X &\longrightarrow aXa \mid bYb \mid \Lambda \\ Y &\longrightarrow bXb \mid aYa \end{aligned}$$

Problem 14: CFG Generate

Given the CFG in figure 3 above, generate the five shortest words in its language. (If the language has less than five words, generate all of them.)

Problem 15: CFG Parse

Given the CFG in figure 3 above and each of the following words, show how to generate the word or tell why it is impossible. Use either a leftmost derivation or a parse tree.

(a) babbab (c) abaaba

(b) abbbba (d) aabbaa

Problem 16: Convert CFG to CNF

Convert the CFG in figure 3 above into Chomsky Normal Form. Explain your solution to make it easy to verify that you are right.