

CMPSC464

Fall 2021

Midterm Exam 1

09/30/2021

Time Limit: 75 Minutes

Name: _____

This exam contains 9 pages (including this cover page, double-sided) and 6 questions.

Total of points is 100.

This will contribute to 25 % of your total grade

Grade Table (for grader use only)

Question	Points	Score
1	10	
2	10	
3	20	
4	30	
5	10	
6	20	
Total:	100	

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1. (10 points) True or False Questions (Leaving an empty box will result in 0 pt)

(a) (1 point) A regular language is accepted by some Turing Machine.

(b) (1 point) A decidable language is accepted by some NFA.

(c) (1 point) If there exists a Nondeterministic Turing Machine (NTM) which accepts some language A , then there exists a Deterministic Turing Machine which accepts A .

(d) (1 point) The set of even numbers (viewed as a binary string) is decidable.

(e) (1 point) If A is recognizable and \bar{A} is recognizable then A is decidable.

(f) (1 point) There exists some language A where A is decidable but \bar{A} is not decidable.

(g) (1 point) If A is regular, then \bar{A} is regular.

(h) (1 point) If A is decidable and B is decidable, then $A \circ B$ (concatenation) is decidable.

(i) (1 point) If B is regular and $A \leq_m B$, then A is regular.

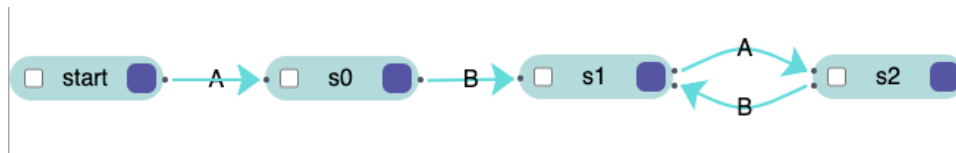
(j) (1 point) If A is decidable by a Turing Machine, then it is decidable by a wordRAM.

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2. (10 points) Fill in the blank. For runtime questions, points will be only given to the simplest asymptotic form. (Leaving an empty box will result in 0 pt)



- (a) (3 points) Suppose $F = \{s_1\}$. Give an example of string in $\{A, B\}^*$ that is accepted by this DFA.

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- (b) (3 points) Suppose $F = \{s_0, s_1, s_2\}$. Give an example of string in $\{A, B\}^*$ that is rejected by this DFA.

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- (c) (4 points) Suppose $F = \{s_1, s_2\}$. Give a full description of strings in $\{A, B\}^*$ that is accepted by this DFA.

3. (20 points) Consider $A = \{w \in \{0,1\}^* \mid w \text{ has equal number of zeroes and ones}\}$. Leaving Blank will result in 2 pts per part.
- (a) (10 points) Use the pumping lemma to show that A is not regular.

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- (b) (10 points) Suppose we have a Turing machine for A . Suppose we have $B = \{w \in \{0, 1\}^* \mid w \text{ has exactly one more zeroes than ones}\}$. Show that $B \leq_m A$. (Hint: exhibit the computable function f)

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4. (30 points) Let $a \in \{0, 1\}^*$. Define $binary(a)$ as

$$binary(a) = \sum_i \frac{a_i}{2^i}$$

Note that this is equivalent to having a as a binary representation of some real number between 0 and 1. Leaving Blank will result in 3 pts per part.

- (a) (15 points) With some fixed a (thereby a having some finite length), consider

$$A_a := \{x \in \{0, 1\}^* \mid binary(x) < a\}.$$

Show that A_a is regular.

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(b) (15 points) Let A be defined as

$$A := \{x\#y \mid x, y \in \{0, 1\}^* \text{ binary}(x) + \text{binary}(y) < 1\}$$

Is A regular? Why or why not?

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5. (10 points) Let $x, y \in \{0, 1\}$. Design a Boolean circuit that computes

$$f(x, y) := \begin{cases} 0 & \text{if } x \neq y \\ 1 & \text{if } x = y \end{cases}$$

using *AND*, *NOT*, *OR* gates of fan-in at most 2. Leaving Blank will result in 2 pts.

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6. (20 points) Suppose we define EQ_{DFA} as the following.

$$EQ_{DFA} := \{(M_1, M_2) : M_1, M_2 \text{ are DFA, } L(M_1) = L(M_2)\}$$

Show that EQ_{DFA} is decidable. Leaving Blank will result in 4 pts.

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