

St. Francis Xavier University
Department of Computer Science
CSCI 356: Theory of Computing
Midterm Examination
October 15, 2021
11:15am–12:05pm

Student Name: _____

Email Address: _____

Instructor: T. J. Smith (Section 10)

Format:

The midterm is fifty minutes long. The midterm consists of 4 questions worth a total of 25 marks. The midterm booklet contains 6 pages, including the cover page and one blank page at the back of the midterm booklet for rough work.

Reference Materials:

None.

Instructions:

1. Write your name and email address in the spaces above.
2. Answer each question either in the space provided or on a blank page. If you use a blank page to write your answer, indicate this clearly in the space provided for the question. Show all of your work.
3. Ensure that your midterm booklet contains 6 pages. Do not detach any pages from your midterm booklet.
4. Do not use any unauthorized reference materials or devices during this midterm.
5. Sign in the space below. Your signature indicates that you understand and agree to these instructions and the university's examination policies.

Question	Marks	Score
1	5	
2	6	
3	6	
4	8	
Total	25	

Signature: _____

Multiple Choice

- [5 marks] 1. For each of the following questions, select exactly one answer by circling the associated letter. Incorrect answers will not be penalized. Answers with more than one letter circled will be marked as incorrect.
- (a) Let L be the language corresponding to the regular expression $a^*b(a+ba^*b)^*$. Which of the following words is in L ?
- A. $aabaababab \in L$
 - B. $aabb \in L$
 - C. $bbaab \in L$
 - D. $bbaabb \in L$
 - E. None of the above.
- (b) Which of the following statements is true?
- A. Every nonregular language is finite.
 - B. Every nonregular language is infinite.
 - C. Every infinite language is regular.
 - D. Every infinite language is nonregular.
 - E. None of the above.
- (c) Consider the language $L = \{a^i b^k \mid i, k \geq 0\}$. Which of the following statements about L is true?
- A. L is regular and context-free.
 - B. L is regular, but not context-free.
 - C. L is context-free, but not regular.
 - D. None of the above.
- (d) Which of the following statements is true?
- A. There exists a language L that is recognized by a pushdown automaton that cannot be recognized by any finite automaton.
 - B. There exists a language L that is recognized by a nondeterministic finite automaton that cannot be recognized by any deterministic finite automaton.
 - C. There exists a regular language L that is not recognized by any pushdown automaton.
 - D. All of the above statements are false.
- (e) Let $V = \{S\}$ and $\Sigma = \{x, y\}$. What language is generated by the following grammar?

$$S \rightarrow xSyyy \mid xS \mid \epsilon$$

- A. $\{x^i y^{3k} \mid 0 \leq i \leq k\}$
- B. $\{x^i y^{3k} \mid 0 \leq k \leq i\}$
- C. $\{x^i y^k \mid 0 \leq i \leq 3k\}$
- D. $\{x^i y^k \mid 0 \leq 3k \leq i\}$

Short Answer

[6 marks] 2. (a) Let $\Sigma = \{\mathbf{a}, \mathbf{b}\}$. Consider the following three languages:

$$L = \{\mathbf{a}, \mathbf{ba}\}, \quad M = \{\epsilon, \mathbf{bbb}\}, \quad N = \{\epsilon\}.$$

List explicitly each element of the following languages.

i. $L \cup M$

ii. $M \cup N$

iii. $L^2 = LL$

iv. \emptyset^*

(b) Let $\Sigma = \{0, 1\}$. Consider the languages $A = \{1, 10, 010\}$ and $B = \{1, 01\}$.

List explicitly each element of the following languages.

i. AB

ii. BA

[6 marks] 3. Let $\Sigma = \{a, b, c, d\}$. Consider the language

$$L = \{a^{2i}b^{3i+1}c^{2k+1}d^{k+2} \mid i \geq 1, k \geq 1\}.$$

(a) Is the language L regular or context-free? Briefly explain your answer.

(b) If you said in part (a) that L was regular, give a regular expression for L .
If you said in part (a) that L was context-free, give a context-free grammar for L .

This blank page may be used for rough work.