STALGCM Final Exam Reviewer

Prepared By:
Ryan Austin Fernandez (ryan.fernandez@dlsu.edu.ph)
Academic Year and Term: Term 2, A.Y. 2024 - 2025
Total Points: 50
REMINDERS. READ BEFORE YOU START ANSWERING!

---

1. This is a closed notes exam. No notes are allowed. However, it is also a reviewer, so I cannot police you. You might as well practice answering this without notes. In fact, if you are reading this, especially if you are superstitious, I am cursing you with final exam failure if you use notes to answer this reviewer.
2. This reviewer is worth 50 points, of which none will be credited because it is a reviewer. Life is too short for unnecessary masochism.
3. Write your name AND section on the questionnaire and answer sheet/bubble sheet. After finishing the reviewer, please do not submit the questionnaire and the filled-out bubble sheet to me because it is only a reviewer. You may compare answers with a classmate, but please do not escalate your inevitable disagreements beyond academic discourse and debate. This is a reviewer, not a battle royale.
4. For each item, choose the **BEST ANSWER**. If none of the choices are appropriate, shade **E** for that item. It will also be like this in the final exam because sometimes, life wants you to have a 20% probability of success instead of 25%.
5. Cheating in any form is punishable with a grade of 0.0 for the course and a disciplinary offense. This includes but is not limited to passing notes during the exam or communicating with other people. However, since this is a reviewer, I literally could not care less.

Part I: Turing Machines and Computability

Consider the following as facts, given the languages $L_1, L_2, L_3, L_4,$ and L_5:

- L_1 is Turing-recognizable.
- L_2 is Turing-decidable.
- $L_2 \cup \overline{L_3}$ is Turing-decidable.
- $\overline{L_1} \cup L_4$ is Turing-recognizable.
- L_5 is regular.

1. Which of the following can we conclude about L_3?
   A. L_3 is context-free.
   B. L_3 is regular.
   C. L_3 is Turing-decidable
   D. $L_3 \subseteq L_1$
2. Which of the following can we conclude about $L_1 \cup L_2$?
   A. $L_1 \cup L_2$ is Turing-complete.
   B. $L_1 \cup L_2$ is an empty set.
   C. $L_1 \cup L_2$ is Turing-recognizable.
   D. $L_1 \cup L_2$ is regular.
3. Which of the following can we conclude about $L_5 - L_3$?
   A. $L_5 - L_3$ is Turing-decidable.
   B. $L_5 - L_3$ is Turing-recognizable.
   C. $L_5 - L_3$ is context free.
   D. $L_5 - L_3$ is an empty set.
4. Which of the following can we conclude about $L_2 \cap L_3$?
   A. $L_1 \cap L_2$ is Turing-recognizable.
   B. $L_1 \cap L_2$ is Turing-decidable.
   C. $L_1 \cap L_2$ is context-free.
   D. $L_1 \cap L_2$ is regular.
5. Which of the following can we conclude about $L_2 \cup \overline{L_4}$?
   A. $L_2 \cup \overline{L_4}$ is Turing-decidable.
   B. $L_2 \cup \overline{L_4}$ is Turing-recognizable.
   C. $L_2 \cup \overline{L_4}$ is context-free.
   D. $L_2 \cup \overline{L_4}$ is an empty set.

6. Which of the following can we conclude about $L_2 \cup L_5$?
   A. $L_2 \cup L_5$ is Turing-decidable.
   B. $L_2 \cup L_5$ is Turing-recognizable.
   C. $L_2 \cup L_5$ is context-free.
   D. $L_2 \cup L_5$ is an empty set.

   Consider the following Turing Accepter M given by:

   $M = (Q, \Sigma, \Gamma, \delta, A, \sqcup, E)$
   $Q = \{A, B, C, D, E\}$
   $\Sigma = \{0, 1\}$
   $\Gamma = \{0, 1, \sqcup, X, Y\}$
   $\delta(A, 0) = (B, X, R)$
   $\delta(A, Y) = (D, Y, R)$
   $\delta(B, 0) = (B, 0, R)$
   $\delta(B, 1) = (C, Y, L)$
   $\delta(C, 0) = (C, 0, L)$
   $\delta(C, X) = (A, X, R)$
   $\delta(D, Y) = (D, Y, R)$
   $\delta(D, \sqcup) = (E, \sqcup, L)$

   This machine must recognize the language $L = \{\omega \in \{0, 1\} \mid \omega = 0^n 1^n, n \geq 1\}$.

7. State B is missing a transition. What is the appropriate transition to add?
   A. $\delta(B, X) = (B, X, L)$
   B. $\delta(B, Y) = (B, Y, L)$
   C. $\delta(B, X) = (B, X, R)$
   D. $\delta(B, Y) = (B, Y, R)$

8. State C is missing a transition. What is the appropriate transition to add?
   A. $\delta(C, X) = (C, X, L)$
   B. $\delta(C, X) = (C, X, R)$
   C. $\delta(C, Y) = (C, Y, L)$
   D. $\delta(C, Y) = (C, Y, R)$

9. Including the correct missing transitions from the previous three items, what are the contents of the final tape when the machine takes the string 0011 as input?
   A. $\sqcup XXYY\sqcup$
   B. $\sqcup XXXX\sqcup$
   C. $\sqcup 0011\sqcup$
   D. $\sqcup YYXX\sqcup$

10. Which of the following strings are accepted by M?
    A. 000111
    B. 00011
    C. 00111
    D. 0111

    Consider the Turing transducer M given by:

    $M = (Q, \Sigma, \Gamma, \delta, A, \sqcup, J)$
    $Q = \{A, B, C, D, E, F, G, H, I, J, K\}$
    $\Sigma = \{1\}$
    $\Gamma = \{1, \sqcup, X, Y\}$
    $\delta(A, 1) = (A, 1, L)$
    $\delta(A, \sqcup) = (B, Y, R)$
    $\delta(B, 1) = (C, X, R)$
    $\delta(B, \sqcup) = (F, \sqcup, L)$
    $\delta(C, 1) = (C, 1, R)$
    $\delta(C, \sqcup) = (D, \sqcup, L)$
    $\delta(D, 1) = (E, \sqcup, L)$
    $\delta(E, 1) = (E, 1, L)$
    $\delta(E, X) = (B, X, R)$
    $\delta(F, X) = (F, 1, L)$
    $\delta(F, Y) = (G, Y, R)$
    $\delta(G, 1) = (H, 1, R)$
    $\delta(H, \sqcup) = (I, \sqcup, L)$
    $\delta(H, 1) = (K, 1, L)$
    $\delta(I, 1) = (I, \sqcup, L)$
    $\delta(I, Y) = (I, 1, L)$
    $\delta(I, \sqcup) = (J, \sqcup, R)$
    $\delta(K, 1) = (K, 1, L)$
    $\delta(K, Y) = (K, Y, L)$

$\delta(K, \sqcup) = (B, Y, R)$

This transducer converts the input $1^{2^n}, n \geq 1$, to an output 1^n.

11. State B is missing a transition. Which of the following is the best transition to add?
    A. $\delta(B, 1) = (B, 1, L)$
    B. $\delta(B, Y) = (B, Y, L)$
    C. $\delta(B, 1) = (B, 1, R)$
    D. $\delta(B, Y) = (B, Y, R)$

12. What are the contents of the final tape when machine M takes 1111 as input?
    A. $\sqcup 11 \sqcup$
    B. $\sqcup 1111111111111111 \sqcup$
    C. $\sqcup 1 \sqcup$
    D. $\sqcup 111 \sqcup$

13. Which of the following is the output for when 11 is the input?
    A. 1
    B. 11
    C. 111
    D. 1111

14. Which of the following best describes the purpose/task/responsibility of state D?
    A. Mark a 1 to match with another 1 at the end.
    B. Delete the rightmost 1.
    C. Add another Y to the counter on the left of the tape.
    D. Restore the marked 1s.

15. Which of the following best describes the purpose/task/responsibility of state F?
    A. Mark a 1 to match with another 1 at the end.
    B. Delete the rightmost 1.
    C. Add another Y to the counter on the left of the tape.
    D. Restore the marked 1s.

Part II: Context-Free Languages

Consider the CNF Grammar below:

$G = (N, T, P, \Sigma)$
$N = \{A, B, C, D, E\}$
$T = \{0, 1\}$
P :
$\Sigma \to CA \mid AD \mid 0 \mid 1$
$A \to CA \mid 0 \mid 1 \mid CE \mid CB \mid DB$
$B \to DB \mid 1$
$C \to 0$
$D \to 1$
$E \to AB$

Given the input string 00111, refer to the CYK parsing table below:

Σ, A, E				
Σ, A, E	**(4)**			
Σ, A, E	Σ, A, E	**(3)**		
(2)	Σ, A, E	Σ, B, E	Σ, B, E	
Σ, A, C	Σ, A, C	**(1)**	Σ, A, B, D	Σ, A, B, D
0	0	1	1	1

Table 1: CYK Parsing Table for string 00111 under grammar G

16. What should be the contents of cell **(1)**? A. $\varnothing$ B. Σ, B, D C. Σ, A, B, D D. Σ, A, B

17. What should be the contents of cell **(2)**? A. Σ, B, E B. $\varnothing$ C. Σ, A, E D. Σ, A, B, E

18. What should be the contents of cell **(3)**? A. Σ, A, B, E B. $\varnothing$ C. A, B, E D. Σ, A, E

19. What should be the contents of cell **(4)**? A. Σ, A, E B. Σ, A C. Σ, E D. $\varnothing$

Consider the context-free grammar G defined as:

$G = (N, T, P, \Sigma)$
$N = \{A\}$
$T = \{0, 1\}$
P :
$\Sigma \to A \mid \lambda$
$A \to 0A \mid A1 \mid 0 \mid 1$

20. The production $A \to A1$ is left-recursive. Which of the following is the correct modified form of As productions, assuming we move the recursive behavior to a new nonterminal B?

A. $A \to 0A \mid 0 \mid 1$
B. $A \to 0A \mid 0 \mid 1 \mid 0AB \mid 0B \mid 1B$
C. $A \to 0AB \mid 0B \mid 1B$
D. $A \to 0A \mid 1B0 \mid 1$

21. Continuing from the previous item, which of the following is the correct production set for B?

A. $B \to 1B \mid 1$
B. $B \to B1 \mid 1$
C. $B \to 1B \mid 0B \mid 1$
D. $B \to 1B \mid 0B \mid 0 \mid 1$

22. How many productions are in CNF in the original grammar?

A. 0
B. 1
C. 4
D. 5

23. In the CNF version of grammar G, how many productions are in GNF?

A. 5
B. 6
C. 7
D. 8

24. How many productions are in the GNF version of grammar G?

A. 13
B. 25
C. 26
D. 27

Consider the following formal definition of a Pushdown Automata:

$M = (Q, \Sigma, \Gamma, \delta, A, Z, C)$
$Q = \{A, B, C\}$
$\Sigma = \{0, 1\}$
$\Gamma = \{Z, X\}$
$\delta(A, 0, \lambda) = \{(A, X)\}$
$\delta(A, 0, \lambda) = \{(A, \lambda)\}$
$\delta(A, \lambda, \lambda) = \{(B, \lambda)\}$
$\delta(B, 1, X) = \{(B, \lambda)\}$
$\delta(B, 1, \lambda) = \{(B, \lambda)\}$
$\delta(B, \lambda, Z) = \{(C, \lambda)\}$

Consider the partial conversion of machine M into the CFG G as follows:

$G = (N, T, P, \Sigma)$
$N = \{[AA], [AB], [BA], [BB]\}$
$T = \{0, 1\}$
P :
$[AA] \to [AA][AA] \mid [AB][BA] \mid \lambda$
$[AB] \to [AA][AB] \mid [AB][BB] \mid$
$[BA] \to [BA][AA] \mid [BB][BA] \mid$
$[BA] \to [BA][AA] \mid [BB][BA] \mid \lambda$

25. How will the transition $\delta(A, 0, \lambda) = \{(A, \lambda)\}$ be represented in G?

A. Add the production $[AA] \to 0$ to P.
B. Add the production $[AA] \to \lambda$ to P.
C. Add the production $[AC] \to 0$ to P.
D. Add the production $[AC] \to \lambda$ to P.

26. How will the transitions $\delta(A, 0, \lambda) = \{(A, X)\}$ and $\delta(B, 1, X) = \{(B, \lambda)\}$ be represented in G

    A. Add the production $[AA] \to 0[AB]1$ to P.

    B. Add the production $[AA] \to 0[AA]1$ to P.

    C. Add the production $[AB] \to 0[AB]1$ to P.

    D. Add the production $[AB] \to 0[AA]1$ to P.

27. What should be the productions for Σ?

    A. $\Sigma \to [AA] \mid [AB]$

    B. $\Sigma \to [AA]$

    C. $\Sigma \to [AB]$

    D. $\Sigma \to \lambda$

28. If we add the transition $\delta(A, \lambda, Z) = (C, \lambda)$ to the machine, which of the following productions must be added?

    A. $[AB] \to [BA]$

    B. $\Sigma \to [AA]$

    C. $[AB] \to \lambda$

    D. All of the above

    Consider the context-free grammar G given by:

    $G = (N, T, P, \Sigma)$
    $N = \{A\}$
    $T = \{0, 1\}$
    P :
    $\Sigma \to A \mid \lambda$
    $A \to 0A1A \mid 01A \mid 0A1 \mid 01$

29. Which of the following strings is generated by G?

    A. 00101101

    B. 110010

    C. 101010

    D. 01010

30. Which of the following strings is not generated by G?

    A. 00110

    B. 0011

    C. 0101

    D. λ

    Consider the pushdown accepter M given by:

    $M = (Q, \Sigma, \Gamma, \delta, A, Z, B)$
    $Q = \{A, B\}$
    $\Sigma = \{0, 1\}$
    $\Gamma = \{Z, X\}$
    $\delta(A, 0, \lambda) = \{(A, X)\}$
    $\delta(A, 1, X) = \{(A, \lambda)\}$
    $\delta(A, \lambda, Z) = \{(B, \lambda)\}$

31. Which of the following strings is accepted by M?

    A. 100111

    B. 01001111

    C. 0000111

    D. 0001001111

32. Which of the following strings is not accepted by M?

    A. 010011

    B. 001101

    C. 10010

    D. 01001011

Part III: Regular Languages

Consider the language $L = \{\omega \in \{0,1\}^* \mid \omega = 0^*(10)^*\}$

When demonstrating the pumping lemma for regular languages, let $p = 4$.

33. For the string $\omega = 001010$, which of the following is a valid partitioning of ω?
    A. $x = \lambda, y = 001, z = 010$
    B. $x = 0010, y = 10, z = \lambda$
    C. $x = \lambda, y = 0, z = 01010$
    D. $x = \lambda, y = 001010, z = \lambda$

34. For the string $\omega = 101010$, which of the following is not a valid partitioning of ω?
    A. $x = \lambda, y = 10, z = 1010$
    B. $x = 10, y = 10, z = 10$
    C. $x = 10, y = 1010, z = \lambda$
    D. $x = \lambda, y = 1010, z = 10$

Given the following two languages:

- $L_1 = \{\omega \in \{a,b,c\}^* \mid \omega = a^*(b \cup c)(a \cup c \cup ba^*(b \cup c))^*\}$
- $L_2 = \{\omega \in \{a,b,c\}^* \mid \omega = (a(a \cup b)^*c \cup b \cup c)^*\}$

represented by the following DFA's:

	a	b	c
$\rightarrow A$	A	B	B
B^*	B	A	B

Table 2: DFA for L_1

	a	b	c
$\rightarrow C^*$	D	C	C
D	D	D	C

Table 3: DFA for L_2

And their joint machine given by the following transition table:

	a	b	c
$\rightarrow AC$	AD	BC	BC
AD	AD	BD	BC
BC	BD	AC	BC
BD	BD	AD	BC

Table 4: Joint/Product Machine for the DFAs of L_1 and L_2

35. Which of the following choices best represents the final states for $L_1 \cap L_2$?
    A. $F = \{BC\}$
    B. $F = \{BC, BD\}$
    C. $F = \{AC, BC, BD\}$
    D. $F = \{BD\}$

36. Which of the following choices best represents the final states for $\overline{L_1} \cup \overline{L_2}$?
    A. $F = \{AC, AD, BD\}$
    B. $F = \{BC\}$
    C. $F = \{BC, AD, BD\}$
    D. $F = \{BC, AC, BD\}$

Consider the DFA RM given by Table 5.

	e	f	c
$\rightarrow Q1^*$	Q2		Q3
$Q2^*$	Q1	Q3	
$Q3^*$		Q2	Q3

Table 5: Transition Table for DFA RM

37. Refer to Table 5. Any string that matches the regex $e^*f^*c^*$ is accepted by DFA RM.
    A. True
    B. False

38. Refer to Table 5. Any string that matches the regex $(efc)^*$ is accepted by DFA RM.
    A. True
    B. False

39. The string $ffce$ is in the language described by RegEx $f^*(ce)(ce)^*$
    A. True
    B. False

40. The string $ffecffec$ is in the language described by RegEx $((ff \cup e)^*c)^*$
    A. True
    B. False

Consider the NFA NM given by Table 6.

	e	f
$\rightarrow Q1^*$	Q2	
$Q2$	Q1, Q2	Q1

Table 6: Transition Table for NFA NM

41. Refer to NFA NM. How many states will the converted DFA have?
    A. 2
    B. 3
    C. 4
    D. 5

42. Refer to NFA NM. How many final states will the converted DFA have?
    A. 2
    B. 3
    C. 4
    D. 5

Consider the DFA DM given by Table 7.

	e	f	c
$\rightarrow Q1$	Q1	Q2	Q4
$Q2^*$	Q3	Q1	Q2
$Q3$	Q4	Q4	Q1
$Q4^*$	Q2	Q2	Q2

Table 7: Transition Table for DFA DM

43. Refer to DFA DM. The DFA does not accept an empty string as input.
    A. True
    B. False

44. Refer to DFA DM. The DFA is also an NFA.
    A. True
    B. False

Consider the DFA SM given by Table 8 and the DFA EM given by Table 9.

	e	f
$\rightarrow A^*$	D	C
B^*	C	F
C	C	C
D^*	C	A
E^*	D	C
F^*	B	C

Table 8: Transition Table for DFA SM

	e	f
$\rightarrow G^*$	H	I
H	H	H
I^*	J	H
J^*	H	I

Table 9: Transition Table for DFA EM

45. Refer to DFAs SM and EM. When testing for machine equivalence, the two machines are not equivalent.
    A. True

B. False

46. Refer to DFAs SM and EM. When testing for machine equivalence, state A will be in the same group as state I.
    A. True
    B. False

47. Refer to DFA SM. Which state, if any, is unreachable?
    A. A
    B. B
    C. C
    D. D

48. Refer to DFA SM. How many states does the minimized DFA have?
    A. 3
    B. 4
    C. 5
    D. 6

Consider the Moore Machine M given by

	0	1
$\rightarrow A : 0$	A	B
$B : 1$	B	A

Table 10: Transition Table for Mealy Machine M

49. Which of the following is a valid output of machine M for strings that follow the regular expression $0(10)^*$?
    A. 01100110
    B. 011001100
    C. 11001100
    D. 100

50. Which of the following is a valid output of machine M for strings that follow the regular expression $(11)^*$?
    A. 10
    B. 1001
    C. 011
    D. 0110

- - END OF FINAL EXAMINATION REVIEWER - -

STALGCM Final Examination Reviewer Answer Key

1.) E	2.) C	3.) E	4.) B	5.) E
6.) A	7.) D	8.) C	9.) A	10.) A
11.) D	12.) A	13.) A	14.) B	15.) D
16.) C	17.) E	18.) A	19.) A	20.) B
21.) A	22.) E	23.) D	24.) C	25.) A
26.) C	27.) C	28.) B	29.) A	30.) A
31.) D	32.) C	33.) C	34.) C	35.) A
36.) A	37.) B	38.) B	39.) A	40.) A
41.) C	42.) A	43.) A	44.) A	45.) A
46.) A	47.) B	48.) A	49.) B	50.) E

- - END OF FINAL EXAMINATION REVIEWER ANSWER KEY - -