Midterm Examination

1:00 – 2:30pm, Wednesday, June 20, 2018 Instructor: Alex Brodsky

Name: ______________________

Student Number: ______________________

Student Signature: ______________________

Duration: 75 minutes
Aids allowed: None

1. Place your student card on the table beside you. An invigilator will check your ID and register you during the exam.
2. This examination has 8 pages. Ensure that you have a complete paper.
3. The use of calculators, computers, books, papers, memoranda, cell phones, or any other electronic device is strictly prohibited.
4. Place your book-bags, coats, and books at the front of the room.
5. You may not reenter the examination once you leave.
6. You may not leave the examination after 65 minutes into the exam.
7. You must hand in the exam. You may not remove the exam from the room.
8. You may not ask questions of invigilators, except in cases of supposed errors or ambiguities in examination questions.
9. Answer the multiple choice questions on the bubble sheet and on your paper. (just in case)
10. Answer the short answer questions directly on the exam
11. No smoking is permitted.
12. Write legibly and neatly.
13. Complete as much of the exam as you can.
14. Good Luck!

Question	Value
1	/25
2	/10
Total	/35

Part 1

1. What is the order of the first three stages of a compiler or interpreter?

    (a) Lexical analysis, syntax analysis, semantic analysis
    (b) Semantic analysis, syntax analysis, lexical analysis
    (c) Syntax analysis, lexical analysis, semantic analysis
    (d) Lexical analysis, semantic analysis, syntax analysis

2. Suppose the Java compiler reported an error on the following statement:

    ```
    int num = "";
    ```

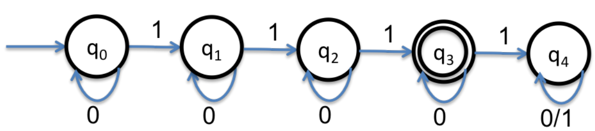
    At which phase of the compilation process would this occur?

    (a) Intermediate code generation
    (b) Lexical analysis
    (c) Semantic analysis
    (d) Syntax analysis

3. Which of the following regular expressions specifies the language of all nonempty binary strings that start and end with the same digit? E.g, 1001, 01100, 0

    (a) $(01)(01)(01)$
    (b) $(0\,(0|1)*\,0)\,|\,(1\,(0|1)*\,1)$
    (c) $0\,|\,1\,|\,(0\,(0|1)*\,1)\,|\,(1\,(0|1)*\,0)$
    (d) $(0\,(0|1)*\,0)\,|\,(1\,(0|1)*\,1)\,|\,0\,|\,1$

4. What language does the following DFA recognize?



    (a) $0{*}10{*}10{*}10{*}$
    (b) $0{*}10{*}10{*}1(01){*}$
    (c) $0{*}10{*}10{*}1$
    (d) $010101(01){*}$

5. Which characteristic is shared by both NFAs and DFAs

    (a) Epsilon transitions
    (b) Multiple transitions on the same symbol from the same state
    (c) Multiple paths through the automata for the same input string
    (d) Multiple final states

6. Which of the following statements is false?
   (a) If L is recognized by a DFA then L is finite.
   (b) If L is finite it can be specified by a regular expression.
   (c) If R is a regular expression, then it specifies exactly one regular language.
   (d) If L can be recognized by an NFA, it can also be recognized by an DFA.

7. Which of the following statements is true?
   (a) An NFA that recognizes L will always have fewer states than a DFA that recognizes the same language.
   (b) An NFA that recognizes L will always have no more states than a DFA that recognizes the same language.
   (c) A DFA that recognizes L will always have fewer states than an NFA that recognizes the same language.
   (d) None of the above.

8. Suppose you were minimizing a DFA with n states. At most how many iterations of the minimization algorithm would you need to perform to minimize the DFA?
   (a) $n - 2$
   (b) $n - 1$
   (c) n
   (d) $n + 1$

9. Which of the following statements is false?
   (a) For each regular expression there is exactly one regular language.
   (b) For each regular language there is exactly one minimal DFA.
   (c) For each minimal DFA that recognizes L there is exaclty one NFA that recognizes L.
   (d) None of the above.

10. Suppose that you were told that $L = L_1 \cap L_2$ was a regular language. We can then conclude that
   (a) L_1 and L_2 must be regular languages
   (b) L_1 or L_2 must be regular languages
   (c) L_1 and L_2 must be nonregular languages
   (d) None of the above.

11. Which of the following methods is **not** recommended for showing that a language is regular.

    (a) The Pumping Lemma
    (b) Closure properties of regular languages
    (c) Constructing an NFA
    (d) Constructing a Regular Expression

12. Suppose you were using the Pumping Lemma to prove that the language $L = \{0^i 1^j \mid i < j\}$ was not regular. What would be the best choice for σ?

    (a) $\sigma = 0^n 1^n$
    (b) $\sigma = 0^n 1^{n+1}$
    (c) $\sigma = 1^n 0^n$
    (d) $\sigma = 1^n 0^{n+1}$

13. Suppose you had a parse tree with n internal nodes and m leaf nodes. How many derivations did it take to generate the parse tree?

    (a) m
    (b) $n - m$
    (c) n
    (d) $n + m$

14. In the following grammar, which of the productions is responsible for the grammar being ambiguous?

$$\begin{array}{lcl} S & \rightarrow & S : S \\ S & \rightarrow & AB \\ S & \rightarrow & AC \\ A & \rightarrow & A\texttt{a} \\ A & \rightarrow & \texttt{a} \\ B & \rightarrow & \texttt{b}B \\ B & \rightarrow & \texttt{b}B \\ C & \rightarrow & C\texttt{c} \\ C & \rightarrow & \epsilon \end{array}$$

    (a) $S \rightarrow S : S$
    (b) $A \rightarrow A\texttt{a}$
    (c) $B \rightarrow \texttt{b}B$
    (d) $C \rightarrow \epsilon$

15. How would you prove to someone that a grammar is LL(1)?

    (a) Show that all productions have unique left-hand-sides (LHS).
    (b) Show that all productions with the same LHS have different right-hand-sides.
    (c) Show that all productions have disjoint predictor sets.
    (d) Show that all productions with the same LHS have disjoint predictor sets.

16. Suppose $E+E+E$ is a partial sentential form of a right-most derivation of `1 + 2 + 3` using the grammar below.

$$
\begin{array}{lcl}
E & \rightarrow & E+E \\
E & \rightarrow & (\,E\,) \\
E & \rightarrow & \texttt{Int}
\end{array}
$$

    What is the next derivation?

    (a) $1+E+E$
    (b) $E+2+E$
    (c) $E+E+3$
    (d) $1+2+3$

17. Which of the following conditions must hold for an LL(1) parser to push something onto its stack?

    (a) The parser popped a terminal from the stack.
    (b) The parser popped a variable from the stack.
    (c) The parser selected a production.
    (d) The parser selected a production with a non-empty right-hand-side (RHS).

18. A grammar G is an S-Grammar if and only if

    (a) For all variables X, $\epsilon \notin FIRST(X)$
    (b) The predictor sets of all productions with the same LHS are disjoint.
    (c) The predictor set for each production contains a single terminal
    (d) None of the above

19. For which variables in the grammar on the last page of this test (Figure 1) is a $FOLLOW(X)$ needed to compute the predictor table?

    (a) *S* and *Atom*
    (b) *S* and *Atoms*
    (c) *Atom* and *Atoms*
    (d) *S*, *Atom*, and *Atoms*

20. Which of the following productions in the grammar on the last page of this test (Figure 1) will need to be refactored to create an LL(1) grammar?

    (a) Production (1)
    (b) Production (2)
    (c) Production (3)
    (d) Production (5)

21. If you were writing a recursive descent parser for the grammar on the last page of this test (Figure 1), how many parse functions would you need to implement?

    (a) 1
    (b) 3
    (c) 5
    (d) 7

22. A Push-Down Deterministic Automata can recognize

    (a) Only regular languages
    (b) Only LL(k) languages
    (c) Botk LL(k) and LR(k) languages
    (d) Only Context Free languages

23. The language $L = \{0^n 1 0^{2n} \mid n \geq 0\}$ can be recognized by

    (a) A DFA or DPDA
    (b) An NFA or DPDA
    (c) A DPDA or PDA
    (d) Only a PDA

24. In order to be useful, an attribute grammar must have

    (a) Attributes associated with the variables
    (b) Semantic rules associated with the productions
    (c) Both attributes and semantic rules
    (d) None of the above

25. In an attribute grammar with only synthesized attributes,

    (a) Information flows down the parse tree.
    (b) Information flows up the parse tree.
    (c) Information flows from left to right on the parse tree.
    (d) Information flows from right to left on the parse tree.

Part 2

1. [5] Give a DFA that recognizes the language over the alphabet $\Sigma = \{0, 1, 2\}$ of all words the end in 012. E.g., 012, 1112012, 010101200121012.

2. [5] Using the grammar on the last page of this test (Figure 1), give a parse tree for the expression `( car ( cdr ' ( list 1 2 3 ) ) )`

$$
\begin{aligned}
S &\rightarrow Atoms && (1)\\
Atoms &\rightarrow \epsilon && (2)\\
Atoms &\rightarrow Atoms\ Atom && (3)\\
Atom &\rightarrow {}'\ Atom && (4)\\
Atom &\rightarrow (Atoms\ ) && (5)\\
Atom &\rightarrow \mathtt{id} && (6)\\
Atom &\rightarrow \mathtt{int} && (7)
\end{aligned}
$$

Figure 1: A simple grammar for Scheme, with start symbol S.