Midterm Examination

10:00 – 11:30am, Wednesday, June 19, 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 12 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. Suppose the Java compiler reported an error on the following statement:

```
int num == 10;
```

   At which phase of the compilation process would this occur?

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

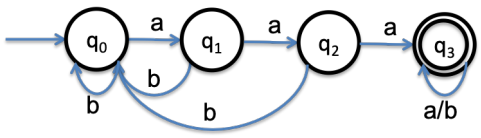
2. Suppose you were asked to create a French version of Java, where all the keywords and operators were in the French language instead of English. Which phase of the Java compiler would you need to modify?

   (a) Scanner
   (b) Parser
   (c) Semantic Analyzer
   (d) Code Generator

3. Which of the following regular expressions specifies the language of all nonempty binary strings that have have exactly three 1s? E.g, 10101, 011100, 0100010010

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

4. What language does the following DFA recognize?



   (a) All strings over the alphabet a, b that have three a's
   (b) All strings over the alphabet a, b that have four a's
   (c) All strings over the alphabet a, b that have no adjacent b's
   (d) All strings over the alphabet a, b that have three adjacent a's

5. Which of the following components differs between DFAs and NFAs?

   (a) Q: The set of states
   (b) Σ: The alphabet
   (c) q_0: the initial state
   (d) δ: the transition function
   (e) F: the set of final states

6. Under which of the following conditions will an NFA M accept a string σ?

   I. There is no path such that M ends up in a final state after reading σ.
   II. There is one path such that M ends up in a final state after reading σ.
   III. There are a finite number of paths such that M ends up in a final state after reading σ.
   IV. There are an infinite number of paths such that M ends up in a final state after reading σ.

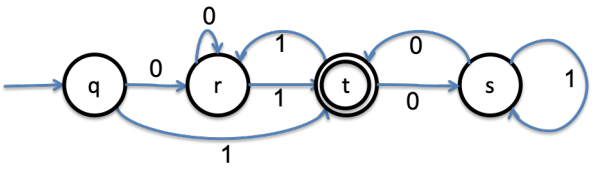
   (a) I
   (b) II
   (c) II or III
   (d) II, III or IV
   (e) II or IV

7. Which of the following statements are true?

   I. For each regular language L, there are many NFAs that recognize L.
   II. For each NFA M, there are many regular languages that M recognizes.
   III. For each regular language L, there are many regular expressions that specify L.
   IV. For each regular expression R, there are many regular languages that R can specify.

   (a) I and III
   (b) I and IV
   (c) 1, II, and IV
   (d) II and III
   (e) II and IV

8. Suppose state r was removed from the following GNFA as part of the procedure to generate a regular expression from an NFA. What would be the regular expression for the transition from q to t?



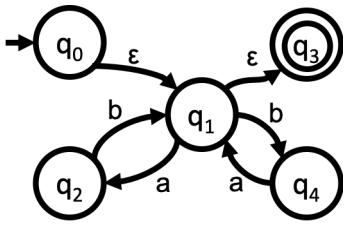
(a) $1 \mid (01)$
(b) $1 \mid (001)$
(c) $1 \mid (00* 1)$
(d) $1 \mid (00* 1*)$
(e) $00* 1*)$

9. Which of the following statements are true?

I. Each regular expression specifies exactly one regular language.
II. Each regular language is recognized by exactly one DFA.
III. Each NFA recognizes eactly one regular language.
IV. Each regular language is specified by exactly one regular expression.

(a) I and II
(b) I and III
(c) II and IV
(d) I, II, and III
(e) I, II, III, and IV

10. Suppose a DFA M was constructed from the following NFA using standard subset construction as discussed in class. What would be the initial state of M?



(a) q_0
(b) $\{q_0\}$
(c) $\{q_0, q_1\}$
(d) $\{q_0, q_1, q_2\}$
(e) $\{q_0, q_1, q_3\}$

11. Suppose a DFA M was constructed from the NFA in the preceding question, using standard subset construction as discussed in class. Which of the following would be final states of M?

I. $\{q_2, q_4\}$
II. $\{q_1, q_3\}$
III. $\{q_0, q_1, q_3\}$
IV. $\{q_0, q_1\}$

(a) I
(b) II and III
(c) II, III, and IV
(d) II and IV
(e) III

12. Suppose that you were told that $L = L_1 \cup L_2$ was not a regular language. We can then conclude that

(a) L_1 and L_2 must be nonregular languages
(b) L_1 or L_2 must be nonregular languages
(c) L_1 or L_2 must be regular languages
(d) None of the above.

13. Suppose you were minimizing a DFA that initially had 10 states and the alphabet $\{0, 1\}$. In the worst case, how many equivalence classes will be created as a result of the minimization process?

(a) 2
(b) 8
(c) 10
(d) 12
(e) 20

14. Which of the following methods is can be used for showing that a language is nonregular.

I. The Pumping Lemma
II. Closure properties of regular languages
III. Constructing an NFA
IV. Constructing a Regular Expression

(a) I
(b) I and II
(c) II
(d) II, III, and IV
(e) I, II, III, and IV

15. When using the Pumping Lemma, which of the following does the prover (you) get to choose?

I. The value of n
II. The word σ
III. The partition of the word σ into $\alpha\beta\gamma$
IV. The power k of β, i.e., β^k.

(a) I and II
(b) I, II, and IV
(c) II and IV
(d) II, III, and IV

16. Suppose you were using the Pumping Lemma to prove that the language $L = \{\sigma \in a, b^* \mid |\sigma|_a > |\sigma|_b\}$ was not regular. What would be the best choice for σ?

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

17. Given the grammar below, how many derivations does it take to derive the string "abac"? the grammar being ambiguous?

$$
\begin{aligned}
S &\rightarrow SS \\
S &\rightarrow AB \\
S &\rightarrow AC \\
A &\rightarrow A\texttt{a} \\
A &\rightarrow \texttt{a} \\
B &\rightarrow \texttt{b}B \\
B &\rightarrow \texttt{b} \\
C &\rightarrow C\texttt{c} \\
C &\rightarrow \epsilon
\end{aligned}
$$

(a) 4
(b) 5
(c) 6
(d) 7
(e) 8

18. Which of the following statements are true about parse trees?

I. Internal nodes are labeled by variables (nonterminals)
II. Internal nodes are labeled by variables (nonterminals) or terminals
III. Leaf nodes are labeled by variables (nonterminals) or terminals
IV. Leaf nodes are labeled by terminals

(a) I and III
(b) I and IV
(c) II and III
(d) II and IV

19. Consider the following grammar.

$$\begin{aligned} S &\rightarrow SS \\ S &\rightarrow 0S1 \\ S &\rightarrow 1S0 \\ S &\rightarrow 01 \\ S &\rightarrow 10 \end{aligned}$$

Which of the following inputs would indicate that this grammar is ambiguous?

(a) 0011
(b) 1010
(c) 1001
(d) 1100

20. What is the purpose of the stack in a top-down (LL(1)) parser?

(a) To store the input that has been read by the parser.
(b) To store the input that will be read by the parser.
(c) To store the current partial sentential form.
(d) To store the derivations that have been performed.

21. Consider the following PREDICT table.

	Production	Predictor Set
1	$S \rightarrow Atoms$	$\{\epsilon, (, ', \texttt{id}, \texttt{int}\}$
2	$Atoms \rightarrow \epsilon$	$\{\epsilon,)\}$
3	$Atoms \rightarrow Atom\ Atoms$	$\{(, ', \texttt{id}, \texttt{int}\}$
4	$Atom \rightarrow '\ Atom$	$\{'\}$
5	$Atom \rightarrow (\ Atoms\ )$	$\{(\}$
6	$Atom \rightarrow \texttt{id}$	$\{\texttt{id}\}$
7	$Atom \rightarrow \texttt{int}$	$\{\texttt{int}\}$

Which statement is most accurate in regards to this grammar?

(a) This grammar is not LL(1) because of productions 1, 2, and 3.
(b) This grammar is not LL(1) because of productions 1 and 3.
(c) This grammar is not LL(1) because of productions 2 and 3.
(d) This grammar is LL(1)

22. When computing the PREDICT table, which of the following productions in the table in question 21 require us to compute the FOLLOW table?

    (a) Production 1
    (b) Production 2
    (c) Productions 1 and 2
    (d) Productions 1, 2, and 3

23. What is the most accurate statement about the following grammar?

$$
\begin{aligned}
E &\rightarrow E + T \\
E &\rightarrow T \\
T &\rightarrow T * F \\
T &\rightarrow \texttt{int}
\end{aligned}
$$

    (a) This grammar is ambiguous.
    (b) This grammar has left recursion.
    (c) This grammar has a common prefix.
    (d) This grammar is LL(1)

24. A recursive descent parser implements a function for each

    (a) Terminal
    (b) Variable
    (c) Production
    (d) Right hand side (RHS) of a production

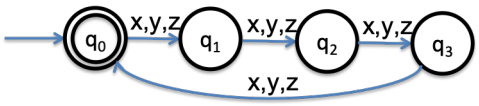
25. A Push-Down Automata can recognize

    I. Regular languages
    II. Languages that have an LL(k) grammar
    III. Languages that have an LR(k) grammar
    IV. Context free languages

    (a) I
    (b) I and II
    (c) I, II, and III
    (d) I, II, III, and IV
    (e) II, III, and IV

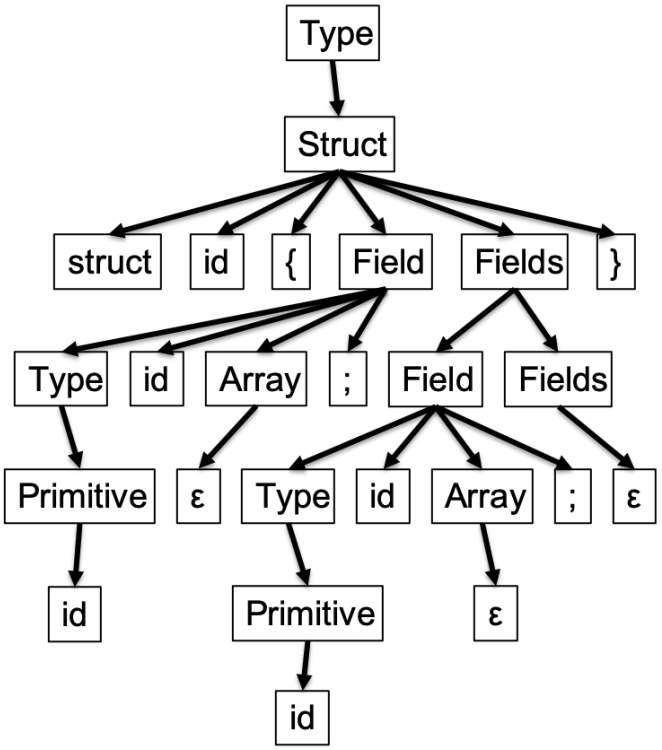
Part 2

1. [5] Give a DFA that recognizes the language over the alphabet $\Sigma = \{x, y, z\}$ of all words whose length is divisable by 4. For example, ϵ, $yyzx$, and $xxxxyyyyzzzz$.



2. [5] Using the grammar on the last page of this test (Figure 1), give a parse tree for the input

```
struct complex {
  float real;
  float img;
}
```



$$
\begin{array}{rcll}
\mathit{Type} & \rightarrow & \mathit{Primitive} & (1) \\
\mathit{Type} & \rightarrow & \mathit{Struct} & (2) \\
\mathit{Struct} & \rightarrow & \text{`}\texttt{struct}\text{'}\ \texttt{id}\ \text{`}\{\text{'}\ \mathit{Field}\ \mathit{Fields}\ \text{`}\}\text{'} & (3) \\
\mathit{Fields} & \rightarrow & \mathit{Field}\ \mathit{Fields} & (4) \\
\mathit{Fields} & \rightarrow & \epsilon & (5) \\
\mathit{Field} & \rightarrow & \mathit{Type}\ \texttt{id}\ \mathit{Array}\ \text{`};\text{'} & (6) \\
\mathit{Array} & \rightarrow & \epsilon & (7) \\
\mathit{Array} & \rightarrow & \text{`}[\text{'}\ \texttt{int}\ \text{`}]\text{'}\ \mathit{Array} & (8) \\
\mathit{Primitive} & \rightarrow & \text{`}\texttt{int}\text{'} & (9) \\
\mathit{Primitive} & \rightarrow & \text{`}\texttt{float}\text{'} & (10) \\
\mathit{Primitive} & \rightarrow & \text{`}\texttt{char}\text{'} & (11)
\end{array}
$$

Figure 1: A simple grammar for C types, with start symbol Type.

SIDE 1

GENERAL PURPOSE ANSWER SHEET

Example

EXAMPLES

WRONG
1 ① ② ③ ④ ⑤

WRONG
2 ① ② ③ ④ ⑤

WRONG
3 ① ② ③ ④ ⑤

RIGHT
4 ① ② ③ ● ⑤

IMPORTANT DIRECTIONS FOR MARKING ANSWERS

- Use a HB pencil only.
- Do NOT use ink or ballpoint pens.
- Make heavy black marks that fill the circle completely.
- Erase cleanly any answer you wish to change.
- Make no stray marks on the answer sheet.

COURSE A B C D E F G H: ESC1211 0

SECTION I J: 01

IDENTIFICATION NUMBER K L M N O P Q R S: B0012345 6

NAME (Last, First, M.I.): Bond James

	A	B	C	D	E
1	①	②	③	④	⑤
2	①	②	③	④	⑤
3	①	②	③	④	⑤
4	①	②	③	④	⑤
5	①	②	③	④	⑤
6	①	②	③	④	⑤
7	①	②	③	④	⑤
8	①	②	③	④	⑤
9	①	②	③	④	⑤
10	①	②	③	④	⑤
11	①	②	③	④	⑤
12	①	②	③	④	⑤
13	①	②	③	④	⑤
14	①	②	③	④	⑤
15	①	②	③	④	⑤
16	①	②	③	④	⑤
17	①	②	③	④	⑤
18	①	②	③	④	⑤
19	①	②	③	④	⑤
20	①	②	③	④	⑤
21	①	②	③	④	⑤
22	①	②	③	④	⑤
23	①	②	③	④	⑤
24	①	②	③	④	⑤
25	①	②	③	④	⑤
26	①	②	③	④	⑤
27	①	②	③	④	⑤
28	①	②	③	④	⑤
29	①	②	③	④	⑤
30	①	②	③	④	⑤
31	①	②	③	④	⑤
32	①	②	③	④	⑤
33	①	②	③	④	⑤
34	①	②	③	④	⑤
35	①	②	③	④	⑤
36	①	②	③	④	⑤
37	①	②	③	④	⑤
38	①	②	③	④	⑤
39	①	②	③	④	⑤
40	①	②	③	④	⑤