Banner number: Name:

Midterm Exam

CSCI 3136: Principles of Programming Languages

March 2, 2018

Question 1.1		Question 2.1		Question 3.1		$\sum$
Question 1.2		Question 2.2		Question 3.2		
$\sum$		$\sum$		$\sum$		

Instructions:

- Provide your answer in the box after each question. If you absolutely need extra space, use the backs of the pages; but try to avoid it. Keep your answers short and to the point.
- You are not allowed to use a cheat sheet.
- Make sure your answers are clear and legible. If I can't decipher an answer or follow your train of thought with reasonable effort, you'll receive 0 marks for your answer.
- Read every question carefully before answering.
- Do not forget to write your banner number and name on the top of this page.
- This exam has 7 pages, including this title page. Notify me immediately if your copy has fewer than 7 pages.

1 Programming Languages

Question 1.1 — 10 marks

(a) Why doesn't a purely functional language have any loop constructs?

(b) Without loops, how do you express iterative computations in a purely functional language? How do you ensure that this uses no more space than the corresponding loop would use.

Question 1.2 — 10 marks

Consider the following Prolog database:

```
a(1).  a(2).  a(3).  b(1,1).  b(1,2).  b(2,3).  b(2,4).  b(5,5).
```

and the following two implementations of a Prolog predicate `f`:

(a)
```
f(X,Y) :- g(X,Y).
f(3,3).
g(X,Y) :- a(X), b(X,Y).
g(4,4).
```

(b)
```
f(X,Y) :- g(X,Y).
f(3,3).
g(X,Y) :- a(X), !, b(X,Y).
g(4,4).
```

Provide the output the query `?- f(X,Y).` produces for each definition of `f`:

(a)

(b)

2 Regular Languages

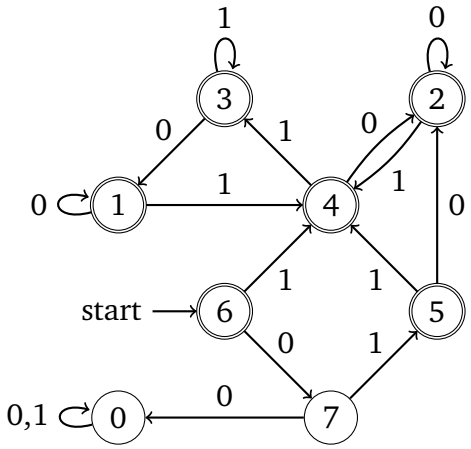
Question 2.1 — 10 marks

(a) Formally define what a DFA is.

(b) Formally define the language decided by a DFA.

Question 2.2 **10 marks**

Consider the following DFA. Construct another DFA that decides the same language and has the minimum possible number of states.



3 Context-Free Languages

Question 3.1 — 10 marks

(a) Formally define what a context-free grammar is.

(b) Formally define the language defined by a context-free grammar.

Question 3.2 **10 marks**

Consider the following grammar G (only the productions are shown; the start symbol is *FunCall*):

$$\begin{aligned} \mathit{FunCall} &\rightarrow \mathit{id}\ (\ \mathit{Args}\ ) \\ \mathit{Args} &\rightarrow \varepsilon \\ \mathit{Args} &\rightarrow \mathit{Arg}\ \mathit{MoreArgs} \\ \mathit{MoreArgs} &\rightarrow \varepsilon \\ \mathit{MoreArgs} &\rightarrow ,\ \mathit{Arg}\ \mathit{MoreArgs} \\ \mathit{Arg} &\rightarrow \mathit{id} \\ \mathit{Arg} &\rightarrow \mathit{num} \\ \mathit{Arg} &\rightarrow \mathit{FunCall} \end{aligned}$$

and the following strings:

$$\mathit{id}\,(\,\mathit{num}\,,\mathit{id}\,(\,\mathit{id}\,,)\,) \qquad \mathit{id}\,(\,\mathit{id}\,,\mathit{id}\,(\,\mathit{num}\,,\mathit{id}\,)\,,\mathit{num}\,) \qquad \mathit{id}\,(\,\mathit{id}\,\mathit{num}\,)$$

(a) Exactly one of the strings is in the language defined by this grammar. Which one?

(b) For the string σ you provided in answer to question (a), provide a parse tree using the grammar G that has σ as its yield.

(c) Provide a left-most derivation for the string σ in (a) using G.