Programming Languages and Compilers

Midterm Exam

Complete the exam, and submit it as a plain text email under the subject "CISC 7120 Midterm" to nzhou@brooklyn.cuny.edu by midnight on Wednesday, October 20.

Question 1

Consider ternary (base-3) numbers over the alphabet $\Sigma = \{0, 1, 2\}$. Give a regular expression for each of the following languages:

1. All 3-digit numbers with no repeating digits. For example, `"012"` is valid, but `"12"` and `"100"` is not.

2. All numbers in which the digits are increasing. For example, `"02"` is valid, but `"0210"` is not.

3. All numbers with at least two repeating digits. For example, `0101` and `1122` are valid, but `0` and `020` are invalid.

Question 2

The following DFAs define three languages over $\Sigma = \{a, b\}$. Describe each of the languages, and give a regular expression for it.

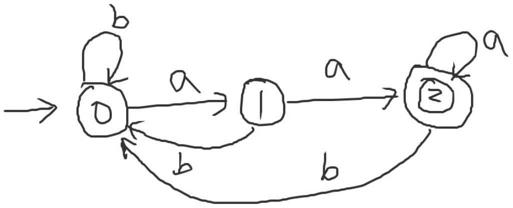

Figure 1: (DFA-1)

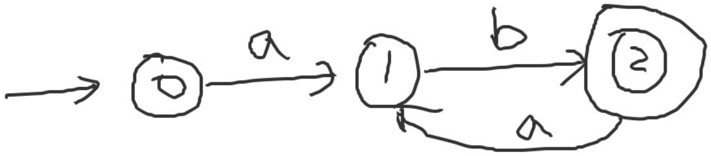

Figure 2: (DFA-2)

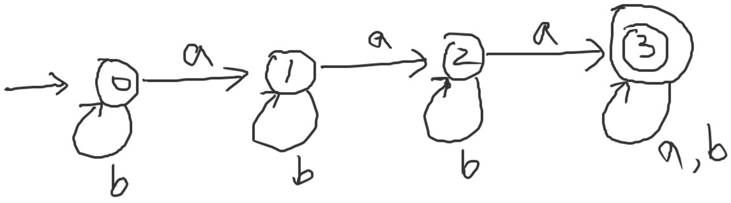

Figure 3: (DFA-3)

Question 3

Write a function in a programming language of your choice that takes a string and returns true if and only if the string is accepted by DFA-3 given above.

Question 4

Give a context-free grammar for each of the following languages over $\Sigma = \{a, b, c\}$.

1. $\{a^n b^{2n} : n \geq 0\}$.

2. Strings of a's and b's with twice as many a's as b's.

3. $\{a^n b^m c^k : k = n + m\}$

Question 5

Consider the following grammar.

```
E  -> E o T | T
T  -> T a NF | NF
NF -> n NF | F
F  -> ( E ) | t | f
```

where E, T, NF, and F are non-terminals, and o, a, n, (,), t, and f are terminals.

1. Give a leftmost derivation for the following expression.

   ```
   n (t o n f) a t
   ```

2. Describe the associability (left-associative or right-associative) of the operators: o, a, and n.

3. Eliminate left-recursion from the grammar.

4. (extra 10 points) Write a top-down recursive descent parser in a programming language of your choice for the grammar obtained after the above transformation.