Programming Languages and Compilers Midterm Exam

April 2, 2025

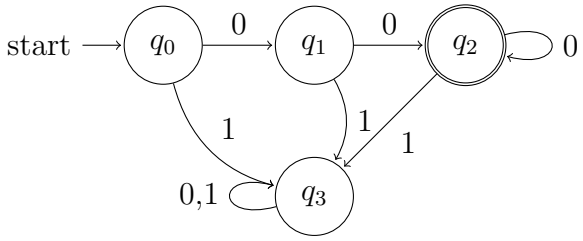
Name:_____

Part 1: Regular Expressions

1. (20 points) Write a regular expression for each of the following languages over the alphabet $\Sigma = \{a, b\}$:
   (a) All strings that contain at least two a's. For example, aa, and aba are valid.
   (b) All strings that do not end with aa.

Part 2: Deterministic Finite Automata

1. (10 points) Given the regular expression $r = (0|1)^*1(0|1)$:
   (a) Construct a deterministic finite automaton (DFA) that recognizes this language.
2. (20 points) Consider the following DFA:



   (a) Describe the language recognized by this DFA.
   (b) Convert this DFA to an equivalent regular expression.
   (c) Write a function in a programming language of your choice, which takes a string and checks if the string is accepted by the DFA.

Part 4: Context-Free Grammars

1. (20 points) Give a context-free grammar for each of the following languages over $\Sigma = \{a, b\}$.
   (a) $\{a^n b^m : n \geq 2, m > n\}$.

   (b) Strings where the number of a's is twice as many as the number of b's, including ϵ.

2. (30 points) Given the grammar:

$$E \rightarrow E + T \mid T$$
$$T \rightarrow T * F \mid F$$
$$F \rightarrow (E) \mid \text{id}$$

   (a) Draw a parse tree for "id + id * id + id".

   (b) Eliminate left recursion from this grammar.

   (c) Write pseudocode for a recursive descent parser for the non-terminal E in the modified grammar (extra 5 points).