Midterm Exam
CS 314, Fall 2021
Section 05-07

1 Quick Identifications (16 pts)

Specify true (T) or false (F) for each of the following statements.

(a) In dynamically typed languages, a type error is unnoticed if the statement containing the error is never executed.

Answer: | true | | false |

(b) In OCaml fold_right is tail recursive while fold_left is not.

Answer: | true | | false |

(c) Immutability fits the functional programming paradigm. Mutability fits the imperative programming paradigm.

Answer: | true | | false |

(d) Higher order functions are the functions that run with higher than O(n) time complexity.

Answer: | tree | | false |

(e) In every programming language, code must be compiled before it is run.

Answer: | true | | false |

(f) Every language that is a regular language is also a context-free language.

Answer: | true | | false |

(g) Regular expression and finite state automaton are equivalently powerful.

Answer: | true | | false |

(h) Lambda calculus is Turing-complete.

Answer: | true | | false |

2 Regular Expression and Languages (9 pts)

(a) Given the language A = {"a", "bb"} and B = {"d"}, what is the language AB?

(b) Given the language A = {"a", "bb"} and B = {"d"}, what is the language A|B?

(c) Given the language C = {"aa", "b"}, what is the language C^0? C^0 means that C appears zero times.

3 DFA (15 pts)

3.1 Accept or Reject a String by Simulating a DFA

Consider the DFA in Fig. 1, determine whether the given strings can be accepted or rejected. S is the start state, and R is the accepting state.
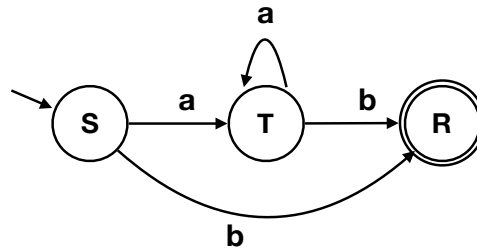

Figure 1: Simulating a DFA

(a) aaab (Accept or Reject?)

(b) abb (Accept or Reject?)

(c) b (Accept or Reject?)

3.2 Convert a DFA to a RE

Give a regular expression that describes the DFA above.

4 Context Free Grammar (26 pts)

Consider the language consisting of all strings of properly balanced square brackets. The context free grammar G is defined as follows:

1. <Goal>   ::= < List >
2. <List>   ::= < Pair > < List >
3. <List>   ::= ϵ
4. <Pair>   ::= [<List>]

Note that **EOF** is the token that immediately follows the start symbol <**Goal**> and it means *end of file* (EOF), representing the end of an input sentence. Therefore you can assume FOLLOW{<Goal>} = {EOF}.

(a) Give the FIRST sets of <List>, <Goal>, and <Pair>.

(b) Give the FOLLOW set of <List>.

(b) Please provide the parse table below. **Insert a rule number or leave an entry empty**.

	[	]	EOF
<Goal>			
<List>			
<Pair>			

5   Lambda Calculus (12 pts)

Apply β-reduction (and α-reduction if necessary) to the following lambda expressions as much as possible.

(a) $(\lambda x.x)$ z

(b) $(\lambda x.x$ y$)$ $(\lambda z.z)$

(c) $((\lambda x.x)$ $(\lambda y.y))$ $(\lambda y.y)$

(d) $(\lambda x.(\lambda y.(x$ y$))$ y $)$ z

6   OCaml (12 pts)

Write OCaml functions that has the following types:

(a) bool ->bool -> bool list

(b) (int * 'a) -> int

7   Closure Implementation (10 pts)

Show the contents of the closure for "f" after executing the following code in Scheme.

```
(define mul (lambda (x) (lambda (y) (* x y) ) ) )
(define f (mul 3) )
```

You need to specify the code and the environment of this closure.