CMSC330 Fall 2024 Quiz 3

Proctoring TA: _____ **Name:** _____

Section Number: _____ **UID:** _____

Problem 1: Context Free Grammars - Derivations

[Total 6 pts]

Consider the following Grammar:

$$S \rightarrow ASB|c$$
$$A \rightarrow aA|a$$
$$B \rightarrow bbB|\epsilon$$

(a) Derive `aacbb`

[4 pts]

(b) Is this an ambiguous grammar?

[2 pts]

(A) Yes (B) No

Problem 2: Lexing Parsing and Evaluating

[Total 6 pts]

Given the following CFG, and assuming the **Ocaml** type system and semantics, at what stage of language processing would each expression **fail**? Mark **'Valid'** if the expression would be accepted by the grammar and evaluate successfully. Assume the only symbols allowed are those found in the grammar.

$$E \rightarrow M \texttt{ and } E | M \texttt{ or } E | M$$
$$M \rightarrow N + M | N - M | N$$
$$N \rightarrow 1 | 2 | 3 | 4 | \texttt{true} | \texttt{false} | (E)$$

	Lexer	Parser	Evaluator	Valid
`1 + 2 - (true and false)`	(L)	(P)	(E)	(V)
`{2}`	(L)	(P)	(E)	(V)
`3 * 1 - 2`	(L)	(P)	(E)	(V)
`2 and 5`	(L)	(P)	(E)	(V)
`false`	(L)	(P)	(E)	(V)
`true and (false)`	(L)	(P)	(E)	(V)

Problem 3: Operational Semantics

[Total 4 pts]

Consider the following rules for two languages. OCaml will be the meta-language for both. Take note of the order of e_1 and e_2 that is bolded in Language B.

LANGUAGE A

$$\text{(int rule)}\frac{}{A; n \Rightarrow n}$$

$$\frac{A; e_1 \Rightarrow v_1 \qquad A; e_2 \Rightarrow v_2 \qquad v_3 = v_1 * v_2}{A; \text{op1}\ e_1\ e_2 \Rightarrow v_3}$$

$$\frac{A; e_1 \Rightarrow v_1 \qquad A; e_2 \Rightarrow v_2 \qquad v_3 = v_1 + v_2}{A; \text{op2}\ e_1\ e_2 \Rightarrow v_3}$$

LANGUAGE B

$$\text{(int rule)}\frac{}{A; n \Rightarrow n}$$

$$\frac{A; e_1 \Rightarrow v_1 \qquad A; e_2 \Rightarrow v_2 \qquad v_3 = v_1 * v_2}{A; \mathbf{e_2}\ \mathbf{e_1}\ \text{op3} \Rightarrow v_3}$$

$$\frac{A; e_1 \Rightarrow v_1 \qquad A; e_2 \Rightarrow v_2 \qquad v_3 = v_1 + v_2}{A; e_1\ e_2\ \text{op4} \Rightarrow v_3}$$

Assume we derive meaning through operational semantics and read rules left-to-right. Give the Language B sentence that is semantically the same as the Language A sentence:

```
op1 3 op2 6 4
```

Problem 4: Type Checking

[Total 4 pts]

Consider the following type checking rules of OCaml:

$$\frac{}{G \vdash n : int} \qquad \frac{G(x) = t}{G \vdash x : t}$$

$$\frac{G \vdash e_1 : int \qquad G \vdash e_2 : int \qquad (+) : \texttt{int -> int -> int}}{G \vdash e_1\ \texttt{+}\ e_2 : int}$$

$$\frac{G \vdash e_1 : t_1 \qquad G, x : t_1 \vdash e_2 : t_2}{G \vdash let\ x = e_1\ in\ e_2 : t_2}$$

Write a type checking proof for the following expression

```
let x = 5 in x + 7
```