

Assignment 6

CAS CS 320: Concepts of Programming Languages

Due Thursday 3/5 by 8:00PM

1 Written(100%)

1.

```
<s> ::= A <s> B | <a>
<a> ::= A <a> | A <b>
<b> ::= B B <b> | B B
```

- (a) Demonstrate that the sentence `A A A B B B` is recognized by the above grammar by providing a parse tree for it.
- (b) Demonstrate that the above grammar is ambiguous by determining the *shortest* sentence which has multiple parse trees. Include both parse trees in your solution.

2.

```
<e> ::= match <e> with <cs> | x | true | false | (<e>)
<cs> ::= <c> | <c> <cs>
<c> ::= | <p> -> <e>
<p> ::= x | true | false
```

- (a) Demonstrate that the sentence `match x with | true -> false | false -> true` is recognized by the above grammar by providing a parse tree for it.
- (b) Demonstrate that the above grammar is ambiguous by determining a sentence which has multiple parse trees. Include both parse trees in your solution.

3.

```
<e> ::= if <e> then <e> else <e> | <e> + <e2> | <e2>
<e2> ::= true | false | 1 | (<e>)
```

- (a) Demonstrate that the sentence `if true then 1 + 1 else 1` is recognized by the above grammar by providing a parse tree for it.
- (b) Demonstrate that the above grammar is ambiguous by determining a sentence which has multiple parse trees. Include both parse trees in your solution.

4. The following grammar expresses that a program ($\langle p \rangle$) is a sequence of assignment statements ($\langle w \rangle = \langle e \rangle$) ending with an optional expression ($\langle e \rangle$).¹ For example, $x = 1 \ y = \&x \ x + *y$ is a well-formed program. Note that it can be written more naturally as:²

```
x = 1
y = &x
x + *y
```

$$\langle p \rangle ::= \langle w \rangle = \langle e \rangle \langle p \rangle \mid \langle w \rangle = \langle e \rangle \mid \langle e \rangle$$
$$\langle e \rangle ::= \langle e_2 \rangle \langle o \rangle \langle e \rangle \mid \langle e_2 \rangle$$
$$\langle e_2 \rangle ::= \& \langle w \rangle \mid \langle w \rangle \mid (\langle e \rangle) \mid 1 \mid 2 \mid 3$$
$$\langle o \rangle ::= + \mid - \mid * \mid /$$
$$\langle w \rangle ::= * \langle w \rangle \mid x \mid y \mid z$$

- (a) Demonstrate that the sentence $x = 1 \ y = \&x \ x + *y$ is recognized by the above grammar by providing a parse tree for it.
- (b) Demonstrate that the above grammar is ambiguous by determining a sentence which has multiple parse trees. Include both parse trees in your solution.

¹This is similar to how Rust works.

²The meaning of this program doesn't matter for this problem, but we might understand this program to be saying: x is assigned to 1, and then y is assigned to a reference to x , and then the output of the program is x plus the value that y refers to, i.e., y is *dereferenced*.