

## ICS/CSE141: Programming Languages

## Quiz 1

16 August 2004

**1 Language Definition**

Name the three components of a language definition!

(5 Points)

**2 Compilers**

Name the main stages of a compiler!

(10 Points)

**3 Power of Programming Languages**

Your boss tells you to invent a new programming language, which—among other things—should ensure that all programs written in it terminate. What's your answer? (15 Points)

**4 Parse Trees**

Assume the following grammar.

$$e ::= 0|1|e+e|e-e|e*e$$

(a) Draw all possible parse trees for the following expression.

(6 Points)

2

1 - 1 \* 0

(b) Assuming the conventional meaning of arithmetic operations, does parsing matter in this case? Why? (6 Points)

(c) How would you suggest to solve this problem without changing the grammar? (4 Points)

(d) Give a non-ambiguous version of the grammar! (4 Points)

## 5 Abstract Syntax

Why are ASTs the preferred format for a compiler to internally represent the source program? (10 Points)

## 6 $\lambda$ -Calculus

(a) Circle all free variables in (10 Points)

$$(\lambda x. (\lambda x. x) x)(xy)$$

(b) Perform  $\alpha$ -reductions so that all different variables have different names. (5 Points)

(c) Now perform  $\beta$ -reduction to reach normal form. (5 Points)

## 7 Scheme

```
(define (app x y)
  (if (null? x)
      y
      (cons (car x) (app (cdr x) y))))
(define a '(1 2))
(define b '(3 4))
(define c (app a b))
```

Outline the memory (i.e. cons cells and atoms) after the above code has been executed. Start from variables a, b, and c. (20 Points)