

Computer Science Comprehensive Exam—Fall 2001

Programming Languages

Instructions: Do *not* put your name on the exam, please answer all the questions directly on the exam itself. Answer **all** the questions. Explain answers as fully as possible, give examples if appropriate, define terms. Answer first, the questions you know best.

1. What is aliasing? Give examples of constructs in two different languages that give rise to aliasing. Explain why aliasing is harmful.

2. Consider two separate, independent executions of the following Ada-like program. Assuming that X is passed by copy-in/copy-out, what are the values of I and A after the call? Assuming that X is passed by reference, what are the values of I and A after the call?

```
PP: declare
  -- declare an array of 5 elements
  A: array (1..5) of Integer := (1,2,3,4,5);
  I: Integer := 1;
  procedure P (X: Integer) is
  begin
    X := 0;  I := 2;  X := 6;
  end P;
begin
  P (A[I]); -- call P
  -- value of "I", values of "A"?
end PP;
```

3. In regard to subtyping, what is the law of contravariance and why is it important?

4. Although exception handling is pretty much the same in ML, Ada, C++, Modula-3, and Java, describe some of the differences.

5. What are the types of the following ML function?

```
fun a (nil,ys) = ys
  | a (x::xs,ys) = x :: a(xs,ys)

fun f g ie nil = ie
  | f g ie (x::xs) = g (x, f g ie xs);
```

What are the values of the following expressions?

```
a ([1,2,3],[1,2,3]);
f a nil [[1],[2,3],[4,5,6],[],[7,8,9,0]];
```

6. Give the most general unifying substitution, if any, for each of the following pairs of terms (x , y , and z are variables):

$f(a, b)$	z
$k(x, a, b)$	$k(c, a, y)$
$f(a, b)$	$f(a, b)$
$g(y, x)$	$g(h(a, x), f(z, b))$
$g(y, x)$	$g(h(a, x), y)$
$f(g(a, b), h(x, y))$	$f(g(z, b), h(y, b))$

7. Given the relations

Father(x,y)	x is the father of y
Mother(x,y)	x is the mother of y
Female(x)	x is female
Male(x)	x is male

define PROLOG relations for the following notions:

- (a) x is a sister of y (same parents)
- (b) x and y are siblings (brother or sister)
- (c) x is a grandson of y
- (d) x is a descendant of y