Computer Science Comprehensive Exam—Spring 2005
Programming Languages

Instructions: Do *not* put your name on the exam, please answer all the questions directly on the exam itself. You have 90 minutes. Explain answers as fully as possible; if appropriate give examples or define terms. Answer as many questions as you have time for.

1. What are regular expressions? Where are they used?

2. Consider literals of the same name from different enumerations types. Is this a good idea for the programmer? Why, or why not? Give an example. What possible language design approaches can be used to distinguish the types of literals with the same name?

3. What is polymorphism? What kinds of polymorphism are there? Give an example of each kind of polymorphism in Java.

4. Covariance is when a type operator respects the subtype relation. Contravariance is when a type operator reverses the subtype relation. Are arrays in Java covariant, contravariant, or neither? Illustrate using an example. Is this useful? Explain. Is this type-safe? Explain.

5. What is information hiding? Pick some language in which the representation of a data type can be hidden. Name the language and give an example.

6. In every language since PL/I, exception propagation is essentially the same. Describe exception propagation as in, for example, ML, Ada, C++, Modula-3, and Java.

7. What is the type of the following ML function? How does ML infer the type? Describe in a few words what the function does.

```
fun f x nil    = false |
    f x (h::t) = x=h orelse (f x t);
```

8. Explain how the list data struction may be defined in PROLOG.

9. What is a unifying substitution? Give the most general unifying substitution for each of the following pairs of terms (x, y, and z are variables):

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

10. Consider the following PROLOG program where `A`, `B`, and `C` are unary predicate symbols, `x`, `y`, and `z` are variables:

```
A(y) :- C(y).
B(x) :- A(d).
B(x) :- C(c).
C(a) :- B(b).
C(d).
C(z) :- B(z).
```

Show the entire search space for the query `B(x),C(a)?`. Is the search space finite? Please circle the answer: yes / no. How many solutions are there? [ ]