Computer Science & Engineering 505 – Final

December 10, 1993

Open papers and notes – 110 minutes – 100 points total

Name: _____

Please write any long answers on a separate piece of paper.

1. (15 points) Suppose that the following Miranda script has been filed in. (This is the same script that was on the midterm. Recall that \/ is the "or" operator, and ++ is an infix append.)

```
tree * ::= EmptyTree | Node * (tree *) (tree *)

sample = Node 1 (Node 10 EmptyTree EmptyTree) EmptyTree

compose f g x = f (g x)

my_map f [] = []
my_map f (a:x) = f a : my_map f x

double x = 2*x

my_foldr op r = f
                where
                f [] = r
                f (a:x) = op a(f x)

my_sum = my_foldr (+) 0

tree_map f EmptyTree = EmptyTree
tree_map f (Node x left right) = Node (f x) (tree_map f left) (tree_map f right)

tree_fold op r = f
                 where
                 f EmptyTree = r
                 f (Node x left right) = op x (op (f left) (f right))

tree_sum = tree_fold (+) 0

tree_or = tree_fold (\/) False

tree_member tree x = tree_or (tree_map (= x) tree)

many_numbers n = Node n (many_numbers (n+1)) (many_numbers (n+1))
```

What is the result of evaluating the following Miranda expressions? If there is a compile-time type error, or a run-time error, or a non-terminating computation, say so. If the result is an infinite structure, give some initial parts of it. If the expression is followed by `::`, then give the type, instead of the value.

(a) `double compose ::`

(b) `my_map many_numbers ::`

(c) `tree_fold (++) ::`

(d) `tree_fold (++) [] ::`

(e) `compose double double 10`

2. (20 points) Compare the way arguments are passed to functions (or rules) in Algol-60, Miranda, Prolog, CLP($\mathcal{R}$), and Strand. Hint: here are some terms that should be in your answer: lazy evaluation, unification, call by value, call by name, one-way pattern matching, equality constraint, logic variable.

3. (10 points) Miranda, CLP($\mathcal{R}$), and Strand all allow multiple definitions of a function or rule. Compare how the appropriate function or rule is selected in each language. What sorts of criteria can be used to choose which is which? Is it possible to backtrack if an incorrect choice has been made?

4. (5 points) When does does CLP($\mathcal{R}$) return the answer "maybe"? What does it mean?

5. (10 points) Compare "inner" in Beta and "super" in Smalltalk-80.

6. (5 points) In Strand, when two different processes P1 and P2 are sending messages to an object, it is necessary to give each of the processes a separate message stream and merge them. Why? What would happen if P1 and P2 shared the same stream?

7. (5 points) Which of the following are correct difference list representations of the list `[1,2,3]`? (Circle the correct ones.)

   (a) `[1,2,3,4|X]\[4|X]`

   (b) `[1,2,3]\Y`

   (c) `[1,2,3|Z]\Z`

8. (15 points) Consider the following CLP($\mathcal{R}$) clauses to find the length of a list:

```
mylength([],0).

mylength([H|T],N) :-
  N > 0,
  mylength(T,N-1).
```

   What would be the answer(s) to the following queries? If there is more than one answer, give them all (or the first several if there are an infinite number). If the system goes into an infinite search at some point, say so.

   (a) `?- mylength([a,b,c,d],N).`

   (b) `?- mylength([a,b,c|X],N).`

   (c) `?- mylength(L,N), N<=3.`

   (d) `?- N<=3, mylength(L,N).`

   (e) `?- mylength(L,3).`

9. (5 points) What does it mean for a Strand rule to have a "process reading"? Give a simple example.

10. (10 points) True or false?

    (a) In Cecil, multi-methods are selected based on the abstract types of *each* argument, not just the first.

    (b) In Cecil, closures play an essential role in implementing control structures.

    (c) In standard Prolog, arithmetic is handled in an ad hoc manner. A Prolog statement such as `A is B+2` can be used to find a value for `A` if `B` is unified with a number, but cannot be used to find a value for `B` if `A` is unified with a number.

    (d) Shared logic variables are used for process synchronization and communication in Strand.

    (e) Using the "cut" operator in Prolog and CLP($\mathcal{R}$) destroys the declarative reading of a rule.