Midterm Test

July 6, 2000

Duration: 50 minutes
Aids allowed: None
Weight: 15% of your course grade

This exam contains a total of 7 pages (including this one). Write your answers clearly in the spaces provided. Use the back pages for your rough work.

Surname: ____________________________
First name: ____________________________
Student #: ____________________________

Tutor (circle one):

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# 0: ____/2
# 1: ____/6
# 2: ____/6
# 3: ____/6
# 4: ____/6
# 5: ____/6
# 6: ____/12
# 7: ____/10
# 8: ____/10

TOTAL: ____/64

Good Luck!
Question 0. [2 marks]
Write your name (or your initials if your name is long) and student number legibly at the top of every page of this test.

Question 1. Parameter Passing [6 marks]
Considering static scoping and three of the four possible parameter-passing methods (call by value, call by reference, and call by name), what will be the value of x, and y at the end of the following program?

```c
int x, y;
procedure P(int a, int b, int c) {
    int x;
    x = 3;
    b = b+x+6;
    c = c+a;
}

x = 5;
y = 10;
P(y,x,x);
```

<table>
<thead>
<tr>
<th>passing method</th>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Call by value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Call by reference</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Call by name</td>
<td></td>
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</tbody>
</table>

Question 2. List Representation [6 marks]
Draw a tree showing Scheme's internal representation for `let` after the following expression is evaluated:

```
(define let '((1 2) () (3 . 4)))
```

Question 3. Unification [6 marks]
What is the result of unifying the following expression? Write the answer in the appropriate box, or “cannot” if the two expressions cannot be unified.

<table>
<thead>
<tr>
<th>[a,b,X]</th>
<th>[X,Y,[a]]</th>
</tr>
</thead>
<tbody>
<tr>
<td>[X,b</td>
<td>X]</td>
</tr>
<tr>
<td>p(a,x)</td>
<td>p(Y,[c,d])</td>
</tr>
</tbody>
</table>
Question 4. \textbf{sum-all [6 marks]}
Write a Scheme function \texttt{(sum-all L)} that finds the sum of all the numbers in a list that may contain nested sublists of numbers. For example,

\begin{verbatim}
1 ]=> (sum-all '())
;Value: 0

1 ]=> (sum-all 7)
;Value: 7

1 ]=> (sum-all '((5 6) 9 (7 8)))
;Value: 42

1 ]=> (sum-all '(5 6 9 7 7 8))
;Value: 42

(define (sum-all L))
\end{verbatim}
Question 5. Scheme Interpretation [6 marks]

Part (a) [3 marks]
Given the following Scheme function f:

```
(define f
  (lambda (item ls)
    (cond
      ((null? ls) '())
      ((equal? (car ls) item) (cdr ls))
      (else (cons (car ls) (f item (cdr ls)))))
  ))
```

What is the result of the following calls:

1. (f 'a '())
2. (f '4 '(2 3 4 3 9 4))
3. (f 'ian '(joe jack ian jack ian ian))

Part (b) [3 marks]
Given the following Scheme function g:

```
(define g L)
  (cond
    ((number? L) '())
    ((number? (car L)) (cdr L))
    (else (cons (g (car L)) (cdr L)))
  )
```

What is the result of the following calls:

1. (g '((9 8 9 (7) 4)))
2. (g '((9 8 (5 6)) 9 (7) 4))
3. (g '((9 5) 9) 7))

Note that number? is a built-in predicate that returns true if its argument is a number and false otherwise.
Question 6. Mystery Function [12 marks]
Consider the following mystery function:

```
(define (foo M L)
  (cond ((null? L) '())
        ((number? L) (M L))
        (else (cons (foo M (car L)) (foo M (cdr L))))
  )
)
```

(a) [4 marks] For each of the following expressions, indicate if the expression is legal and if so, what it is going to return. Note that zero? is a built-in predicate that tests if its argument is 0.

1. `(foo zero? '(1 2 3 0))`
2. `(foo (lambda (x y) (+ x y)) '(1 2 3 4))`
3. `(foo (lambda (x) (+ 1 x)) '(1 (2 (3 4) 5) 6))`

(b) [2 marks] What does `foo` do, in general?

(c) [6 marks] Rewrite `foo` using `map`. 
Question 7. Prolog [10 marks]
Consider the following Prolog facts and rules:

\[
\text{male(john).} \\
\text{male(philip).} \\
\text{female(suzanne).} \\
\text{female(janette).} \\
\text{parent(suzanne,john).} \\
\text{parent(suzanne,janette).} \\
\text{parent(philip,john).} \\
\text{parent(philip,janette).} \\
\text{father(X,Y) :- male(X), parent(X,Y).} \\
\text{sibling(X,Y) :- parent(Z,X), parent(Z,Y).}
\]

(a) [2 marks] Write a Prolog rule \text{uncle(X,Y)} which holds if \(X\) is an uncle of \(Y\).

(b) [2 marks] Express the \text{sibling} rule in logic.

(c) [2 marks] What will be Prolog’s first answer to the query \text{father(X,Y)}?

(d) [2 marks] What will be Prolog’s first answer to the query \text{sibling(john,X)}?

(e) [2 marks] What will be Prolog’s first answer to the query \text{sibling(X,john)}?
Question 8. Short Questions  [10 marks]
Answer the following short questions.
(a)  [2 marks] List three language evaluation criteria that affect readability.

(b)  [2 marks] What is pseudo-compilation?

(c)  [2 marks] What characterizes functional programming?

(d)  [2 marks] What is lexical scoping?

(e)  [2 marks] What is a Horn clause?

Total Marks = 64