

Mid-Term Exam 2

CS 3520, Fall 2000 *Edited for Fall 2001*

Name: _____

Instructions: You have one hour and twenty minutes to complete this open-book, open-note, closed-computer exam. Please write all answers in the provided space, plus the back of the exam if necessary.

1) Given the following expression in the language we have been implementing:

```
letrec g = proc(y)(g -(y, 1))
in let x = f
    f = g
    in let f = proc(z)(f +(x, z))
        in (g (f m))
```

- Draw arrows on the above expression from each bound variable to its binding occurrence.
- List the free variables: _____ and bound variables: _____
- Re-write the above expression, replacing each bound variable with its lexical address. A lexical address is of the form $@(d, o)$ where d is the lexical depth and o is the offset at that depth.

2) Given the following expression for the call-by-value variant of our language:

```
let g = proc(z)z
    x = 10
    in let f = proc(w)(g w)
        in (f x)
```

- Describe the closure bound to **f** at the point where **(f x)** is the current expression.
 - * Argument variables:
 - * Body expression:
 - * Environment:
- Describe the environment at the point during evaluation where **(g w)** is the current expression.

3) Given the following expression:

```
let f = let y = 7
        in proc(x)+(x,y)
in (f 3)
```

Describe a trace of the evaluation in terms of arguments to an `eval-expression` interpreter function for every call. For literal, variable, and `proc` expressions, show the result.

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4) Given the following expression:

```
let x = 0
  in let f = proc(y)+(y,y)
      in (f { set x = +(x,7) ; x } )
```

- a) What is the value of the expression in a **call-by-value** language?
- b) What is the value of the expression in a **call-by-name** language?
- c) What is the value of the expression in a **call-by-need** language?

5) Find and justify a type for the following expression:

```
((proc(int y)proc(bool b)if b then 0 else y 8) false)
```

6) In the typed expression

```
proc( $T_1$  a,  $T_2$  b)if a then proc(int y)y else b
```

what types must replace T_1 and T_2 so that the expression has a type?

$T_1 =$

$T_2 =$