York University- Department of Computer Science and Engineering

SC/CSE 3401 3.00 – Functional and Logic Programming

Assignment 3

Notes:

1- This assignment is due on Monday, July 19 at 2:30pm.

2- To do this assignment, you can use what we covered in Lambda calculus plus Chap. 1-4 of Wilensky.

3- Please check the website regularly for updates.

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1) (5 marks) What is the order of evaluation of arguments in Common LISP? Are the arguments evaluated from left to right, or right to left? Under what circumstances does the order make a difference? Write two expressions (one for each of above methods) to test LISP's strategy. [refer to exercise 7 of Chapter 1- Wilensky]

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2) (10 marks) In a certain application, we want to be able to call a function **dist** that can find the Euclidean distance between two points for which the coordinates are given as a list of numbers. In addition, we want to be able to call this function with one (or two) nil argument(s) indicating that we want to find the distance to a reference point, the coordinates of which are saved in a global variable **ref**. See the following for examples:

```
> (dist '(1  2) '(4  -2))
5
> (setq ref '(0 1))
(0 1)
> (dist '(0 2) nil)
1
> (dist nil nil)
0
```

Write the function definition for dist. The efficiency and readability of your code is important. Do not use setq in the function definition.

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3) (6 marks) Assume you have evaluated the following in LISP:

```
(setq v1 '((a b) (x d)))
(setq v2 '((a b) . (x d)))
(setq v3 (append (car v1) (car (cdr v1)) ))
```

Use car and cdr to return X when applied to

(a) V1
(b) V2
(c) V3

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4) (8 marks) Do Exercise 3 on page 12 of Selinger's lecture notes (both parts a and b). In addition, for part b, (iii) show the term calculation.

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5) (8 marks) Assume that true (T) is defined as $\lambda xy.x$ and false (F) is defined as $\lambda xy.y$. Prove that the function $\lambda pq.ppq$ can implement OR($\vee$) in logic.(Hint: Show evaluation of OR for all four cases of the truth table of OR).

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6) (8 marks) Do the following λ-terms have a β-normal form? If yes, how many? Show reduction steps. Note: In λ-calculus, instead of the infix operators such as x + y, the prefix operator is used e.g. (+ x y).

(a) $(\lambda x.* \; x \; 4)5$
(b) $(\lambda fx.f(fx))(\lambda y.+ \; y \; 3)4$
(c) $(\lambda x.xx)(\lambda y.yy)$
(d) $(\lambda xy.xy)y$

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7) (10 marks) [ref: A short introduction to the Lambda Calculus- by A. Jung] Let S be the term $\lambda xyz.(xz)(yz)$ and K the term $\lambda xy.x$.

(a) Reduce SKK to β-normal form. (Hint: To keep things manageable, keep the abbreviations S and K as long as you can; replace them with their corresponding lambda terms only when needed.)
(b) Find the set of free variables of SKK. Show steps. Is your answer in accordance with part (a)?