

CS3342 – Assignment 3
due Mar. 24, 2022
2-day no-penalty extension until: Mar. 26, 11:55pm
(SRA's cannot be used to extend the due date further)

1. (25pt) Consider the following program:

```
int a;
s(n) { a = n; }
p() { print a; }
f() { s(1); p(); }
g() { int a; s(2); p(); }
s(0); f(); p(); g(); p();
```

- (a) (10pt) Give the output of the program if static scoping is used
(b) (15pt) Give the output of the program if dynamic scoping is used.

Run the program step by step to explain the output.

2. (25pt) Consider the Python program:

```
def A(I, P):
    def B():
        print(I)
    if I > 3:
        P()
    elif I > 2:
        A(4, P)
    elif I > 1:
        A(3, B)
    else:
        A(2, B)
def C():
    print(0)
A(1, C)
```

What does this program print? Explain your answer. Draw the run-time stack. You can use in Python `print(P)` and `print(B)` from within `A` to identify the procedures uniquely.

3. (25pt) We have modelled the non-negative integers and operations with λ -expressions:

$$\begin{aligned}
 n &\equiv \lambda f c. \underbrace{f(f \dots (f(f c)) \dots)}_{nf's} \\
 + &\equiv \lambda m n a b. m a (n a b) \\
 \times &\equiv \lambda m n a. m (n a)
 \end{aligned}$$

Prove, using both call-by-value and call-by-name reduction, that:

- (a) (10pt) $1 + 3 \Rightarrow_{\beta}^* 4$
(b) (15pt) $0 * 2 \Rightarrow_{\beta}^* 0$

4. (25pt) We modelled also boolean logic: $T \equiv \lambda xy.x$, $F \equiv \lambda xy.y$. We define a new operator, **xor**, that computes the exclusive or of two boolean values, as follows:

$$\mathbf{xor} \equiv \lambda xy.x (y F T) y$$

Prove, using both call-by-value and call-by-name reduction, that:

$$\mathbf{xor} T T \Longrightarrow_{\beta}^* F$$

Q3,4 note: For all computations you perform, indicate clearly the reduction being done by underlying the abstraction used and the argument it is applied to: $(\lambda x.M)\underline{N}$. Do not use anything already computed in the notes; compute everything from scratch.

READ ME! Submit your answers as a *single pdf file* in OWL. Solutions should be typed but readable (by others!) hand-written solutions are acceptable. Source code, if required, is submitted as separate files.

L^AT_EX: For those interested, the best program for scientific writing is L^AT_EX. It is far superior to all the other programs, it is free, and you can start using it in minutes; here is an introduction: <https://tobi.oetiker.ch/lshort/lshort.pdf>