

CSE 130 Midterm Solution, Fall 2019

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Part I. Lambda Calculus [20 pts]

Q1: Reductions [10 pts]

1.1 [5 pts]

Check the box next to **each** term that contains **exactly one** redex.

- (A) $(\lambda x \rightarrow x) (\lambda x \rightarrow x)$
- (B) $\lambda x \rightarrow x (\lambda x \rightarrow x)$
- (C) $f (\lambda x \rightarrow x) (\lambda x \rightarrow x)$
- (D) $(\lambda x \rightarrow x) f (\lambda x \rightarrow x)$
- (E) $(\lambda f x \rightarrow f (f x)) y z$

1.2 [5 pts]

Check the box next to **each** valid reduction.

$(\lambda x y \rightarrow (\lambda x y \rightarrow x) y x)$ apple banana

(A) =b> $(\lambda x y \rightarrow (\lambda y \rightarrow y) x)$ apple banana []

(B) =a> $(\lambda x y \rightarrow (\lambda x x \rightarrow x) y x)$ apple banana []

(C) =a> $(\lambda x y \rightarrow (\lambda x z \rightarrow x) y x)$ apple banana [X]

(D) =b> $(\lambda y \rightarrow (\lambda x y \rightarrow x) y \text{ apple})$ banana [X]

(E) =b> $(\lambda y \rightarrow (\lambda x y \rightarrow \text{apple}) y \text{ apple})$ banana []

Q2: 2048 [10 pts]

(ADD FIVE SIX) (MUL TWO) ONE

Part II. Datatypes and Recursion [30 pts]

Q3: Reverse Polish Notation [30 pts]

3.1 To RPN [10 pts]

```
toRPN :: Expr -> [Token]
toRPN (Num x)          = [Operand x]
toRPN (Bin op e1 e2) = toRPN e1 ++ toRPN e2 ++ [Operation op]
```

3.2 From RPN [20 pts]

```
fromRPN :: [Token] -> Expr
fromRPN toks = loop [] toks
  where
    loop :: [Expr] -> [Token] -> Expr
    loop [e]          []
      = e
    loop stack      (Operand x : toks)
      = loop (Num x : stack) toks
    loop (e2:e1:rest) (Operation op : toks)
      = loop (Bin op e1 e2 : rest) toks
    loop _           _
      = error "Invalid RPN"
```