

CMSC 330 Quiz 4 Fall 2021 Solutions

Q1. Explicit Parenthesis

Make the parentheses in the following lambda expressions explicit:

$\lambda x. x y \lambda y. y y z$

Note: You may use λ , \backslash , or L to denote the lambda symbol.

$(\lambda x. ((x y) (\lambda y. (y y) z)))$

Q2. Alpha Conversion

Select the valid alpha conversions of the following lambda expression:

$(\lambda x. x (\lambda a. x a b)) y$

B: $(\lambda x. x (\lambda c. x c b)) y$

C: $(\lambda c. c (\lambda w. c w b)) y$

Q3. Free Variables

Select the following lambda expressions that **contain** free variables.

A: $(\lambda b. a (\lambda a. a) b)$

D: $(\lambda c. \lambda b. c \lambda b. a \lambda a. a) (\lambda b. b)$

Q4. β -Reduction

Solve the following beta reductions. Show all steps with **explicit parentheses** to receive full points.

$(\lambda a. a) ((\lambda x. \lambda y. x y) (\lambda b. b) (\lambda c. c))$

You may solve this using either call-by-value or call-by-name.

$= (\lambda a. a) (((\lambda x. \lambda y. x y) (\lambda b. b)) (\lambda c. c))$

$= (((\lambda x. \lambda y. x y) (\lambda b. b)) (\lambda c. c))$

$= (\lambda y. (\lambda b. b) y) (\lambda c. c)$

$= (\lambda b. b) (\lambda c. c)$

$= (\lambda c. c)$

– Explicit Parenthesis

– Using call-by-name

– Substitute x with $(\lambda b. b)$

– Substitute y with $(\lambda c. c)$

– Substitute b with $(\lambda c. c)$

Q5. Call-by-Name vs. Call-by-Value

Q5.1. Show the β -Reduction of the expression $(\lambda a. \lambda b. b) ((\lambda c. c) (\lambda d. d))$ using **call-by-name**. Show all steps with **explicit parentheses** for full credit.

$= (\lambda b. b)$

– Substitute a with $((\lambda c. c) (\lambda d. d))$

Q5.2. Show the β -Reduction of the expression $(\lambda a. \lambda b. b) ((\lambda c. c) (\lambda d. d))$ using **call-by-value**. Show all steps with **explicit parentheses** for full credit.

$= (\lambda a. \lambda b. b) (\lambda d. d)$

– Substitute c with $(\lambda d. d)$

$= (\lambda b. b)$

– Substitute a with $(\lambda d. d)$