

## CMSC330 Fall 2009 Quiz #3

Name \_\_\_\_\_

Discussion Time (circle one):      10am   11am   12pm   1pm   2pm   3pm

### Instructions

- You have 20 minutes for this quiz.
- For partial credit, show all of your work and clearly indicate your answers.
- Write neatly. Credit cannot be given for illegible answers.

Circle all free (unbound) variables in the following  $\lambda$ -expression

1. (2 pts)  $((\lambda a. b \lambda b. a b c) b a)$

Evaluate the following  $\lambda$ -expressions as much as possible. Show each beta-reduction.

2. (2 pts)  $(\lambda x. \lambda y. x x) a b$

3. (3 pts)  $(\lambda x. \lambda y. y x y) y$

4. (3 pts)  $(\lambda x. x a) (\lambda y. \lambda z. b z y) c$

5. (10 pts) Using encodings, show  $\text{iszero } 2 \Rightarrow^* \text{false}$ . Show each beta-reduction.

You do not need to expand true & false.

$\Rightarrow^*$  indicates 0 or more steps of beta-reduction.

$\text{iszero } 2 \Rightarrow$

<pre>true = <math>\lambda x. \lambda y. x</math> false = <math>\lambda x. \lambda y. y</math> if a then b else c = <math>a b c</math> not = <math>\lambda x. ((x \text{ false}) \text{ true})</math> and = <math>\lambda x. \lambda y. ((x y) \text{ false})</math> or = <math>\lambda x. \lambda y. ((x \text{ true}) y)</math> iszero = <math>\lambda g. g (\lambda y. \text{false}) \text{ true}</math> succ = <math>\lambda z. \lambda f. \lambda y. f (z f y)</math> 1 = <math>\lambda f. \lambda y. f y</math> 2 = <math>\lambda f. \lambda y. f (f y)</math> 3 = <math>\lambda f. \lambda y. f (f (f y))</math> 4 = <math>\lambda f. \lambda y. f (f (f (f y)))</math></pre>
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