

1. Circle the correct parenthesization (of the two options on the right) for each expression (on the left)

(a)	$\lambda a. \lambda b. b b$	$(\lambda a. \lambda b. b) b$	$\lambda a. (\lambda b. (b b))$
(b)	$\lambda a. \lambda b. b + a$	$(\lambda a. \lambda b. b) + a$	$\lambda a. (\lambda b. (b + a))$
(c)	$a b b$	$(a b) b$	$a (b b)$
(d)	$\lambda a. f a + a$	$\lambda a. ((f a) + a)$	$\lambda a. (f (a + a))$

2. Given the following evaluation rules

$$\frac{}{z \Downarrow z} \quad \frac{}{\lambda x. t \Downarrow \lambda x. t} \quad \frac{t_1 \Downarrow \lambda x. t \quad t_2 \Downarrow w \quad t[w/x] \Downarrow v}{t_1 t_2 \Downarrow v}$$

where substitution is defined as usual, give the derivation tree for “ $(\lambda a. a) ((\lambda b. b) 3) \Downarrow 3$ ”.

$$\frac{\lambda a. a \Downarrow \lambda a. a \quad \frac{\lambda b. b \Downarrow \lambda b. b \quad 3 \Downarrow 3 \quad b[3/b] \Downarrow 3}{(\lambda b. b) 3 \Downarrow 3} \quad a[3/a] \Downarrow 3}{(\lambda a. a) ((\lambda b. b) 3) \Downarrow 3}$$

Call by value; have 3 terms
call by name: have two terms