

### Problem 1

$$\left[ (\lambda f. \lambda g. f(g\ 1)) (\lambda x. x + 4) \right] (\lambda y. 3 - y)$$

$$(a) \left[ \lambda g. (\lambda x. x + 4) (g\ 1) \right] (\lambda y. 3 - y)$$

$$= \left[ (\lambda x. x + 4) ((\lambda y. 3 - y)\ 1) \right]$$

$$= [(\lambda y. 3 - y)\ 1] + 4$$

$$= [2] + 4$$

$$= 6$$

$$(b) \left[ \lambda f. f ((\lambda y. 3 - y)\ 1)) \lambda x. x + 4 \right]$$

$$= \left[ (\lambda f. f\ (2)) (\lambda x. x + 4) \right]$$

$$= (\lambda x. x + 4)\ (2)$$

$$= 6$$

## Problem 2

$$\lambda \text{compose. } (\lambda h \text{ compose } h \ h \ 3) \ \lambda x. x+x) \ \lambda f. \lambda g. \lambda x. f(g(x))$$

$$= \lambda h. \left[ ((\lambda f. \lambda g. \lambda x. f(g(x))) (h)) (h) \right] 3 \ \lambda x. x+x$$

$$= \left[ ((\lambda f. \lambda g. \lambda x. f(g(x))) (\lambda x. x+x)) (\lambda x. x+x) \right] 3$$

$$= \left[ (\lambda g. \lambda x. (\lambda x. x+x)(g(x))) (\lambda x. x+x) \right] 3$$

$$= \left[ \lambda x. (\lambda x. x+x)((\lambda x. x+x) (x)) \right] 3$$

$$= 12$$

## Problem 3

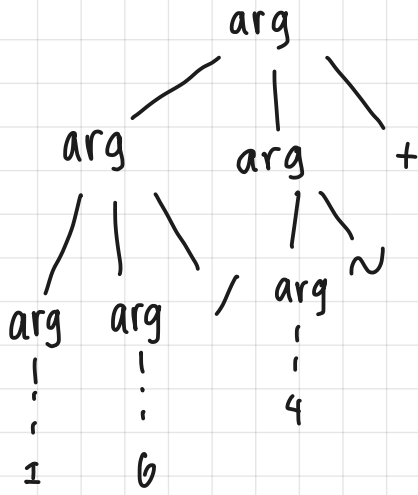
$$\langle \text{binary} \rangle := \langle \text{unit} \rangle \mid \langle \text{bit} \rangle \langle \text{binary} \rangle \mid \langle \text{binary} \rangle \langle \text{bit} \rangle$$

$$\langle \text{bit} \rangle := 0 \mid 1$$

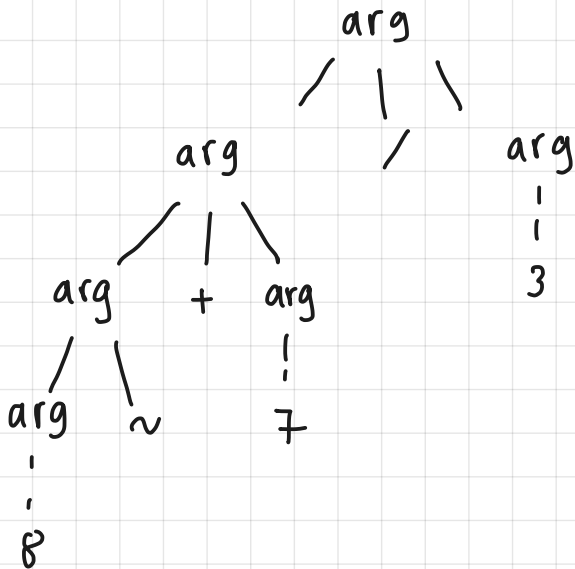
$$\langle \text{unit} \rangle := 1 \mid 1 \mid 1$$

# Problem 4

(a)  $1 \ 6 \ / \ 4 \ \sim \ +$



(b)  $8 \ \sim \ 7 \ + \ 3 \ /$



## Problem 5

$$\langle s \rangle \rightarrow \langle x \rangle$$

$$\langle x \rangle \rightarrow \langle x \rangle * \langle x \rangle \mid \langle y \rangle$$

$$\langle y \rangle \rightarrow a \mid b \mid c$$

## Equivalent Unambiguous grammar

$$\langle s \rangle \rightarrow \langle x \rangle$$

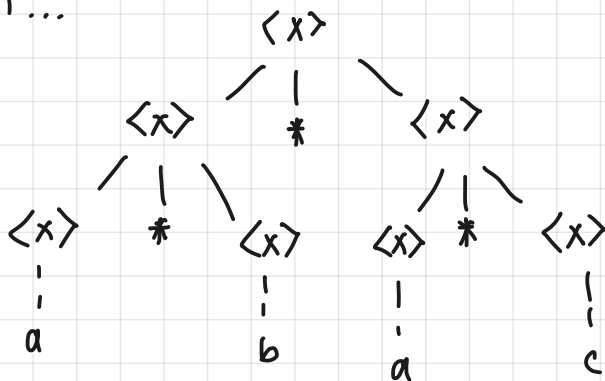
$$\langle x \rangle \rightarrow \langle y \rangle * \langle x \rangle \mid \langle y \rangle$$

$$\langle y \rangle \rightarrow a \mid b \mid c$$

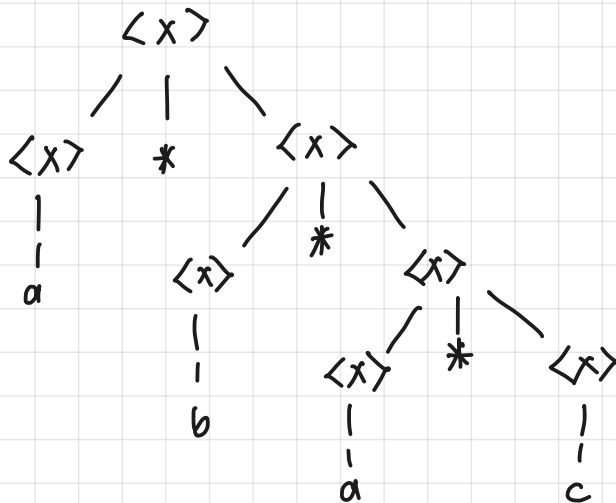
right  
associativity  
imposed

Let expression be ...  $a * b * a * c$

Parse tree 1...



Parse tree 2...



Since there exist  
more than one parse  
tree for an expression,  
this grammar is  
ambiguous.