

Lambda Calculus

Abstract Syntax

$X = \{x, y, z, \dots\}$ — variables

$C = \{X, Y, Z, \dots\}$ — constructors

$\Lambda =$	X	— variable
	$ \quad C$	— constructor
	$ \quad \lambda X. \Lambda$	— abstraction
	$ \quad \Lambda \Lambda$	— application

Normal Order Reductions (Big-Step)

Substitution:

$$x[z \leftarrow B] = \begin{cases} B & , \quad z = x \\ x & , \quad z \neq x \end{cases}$$

$$X[x \leftarrow B] = X$$

$$(M \ N)[x \leftarrow A] = (M[x \leftarrow A])(N[x \leftarrow A])$$

$$(\lambda z. B)[x \leftarrow A] = \begin{cases} \lambda z. B & , \quad z = x \\ \lambda z. (B[x \leftarrow A]) & , \quad z \neq x \end{cases}$$

Reduction rules:

$$x \rightarrow x, \quad x \in X \cup C \qquad [\text{VAR}]$$

$$\frac{A \rightarrow A'}{\lambda x. A \rightarrow \lambda x. A'} \qquad [\text{ABS}]$$

$$\frac{A[x \leftarrow N] \rightarrow K}{(\lambda x. A) \ N \rightarrow K} \qquad [\text{RED}]$$

$$\frac{M \rightarrow \lambda x.A, A[x \leftarrow N] \rightarrow K}{M N \rightarrow K} \quad [\text{APP}]$$

$$\frac{M \rightarrow M', N \rightarrow N'}{M N \rightarrow M' N'}, M' \neq \lambda x.A \quad [\text{ARG}]$$