

Exercise 1

- a) \textcircled{x} Variable
- b) $\lambda \overline{x}. x$ Abstraction
- c) $(\lambda \overline{a}. \overline{a}) \overline{a}$ Application
- d) $\lambda \overline{a}. \overline{a}$ Abstraction
- e) $(\lambda \overline{n}. \overline{n}) \overline{a}$ Application
- f) $\lambda \overline{z}. (\lambda \overline{y}. (\lambda \overline{x}. x) y) z$ Abstraction
- g) $(\lambda \overline{t}. ((\lambda \overline{t}. (\lambda \overline{t}. t) t) t)) \overline{t}$ Application

Exercise 2

- a) $\lambda x. x(\lambda z. z)$
- b) $\lambda w. w(\lambda z. zx)$
- c) $(f(\lambda x. yx)y(fy))$
- d) $\lambda w. w(\lambda x. yx)y(fy)$

Exercise 3

- a) $(\lambda w. y)x - 1$ redex
- b) $(\lambda y. z)(\lambda x. x) - 1$ redex
- c) $\lambda w. w(\lambda x. xy) - 1$ redex
- d) $(\lambda x. xx)(\lambda x. x) - 2$ redexes
 $((\lambda y. y)(\lambda x. x))((\lambda y. y)(\lambda x. x))$
- e) $(\lambda y. y)(\lambda y. y)(\lambda x. x) - 1$ redex
- f) $(\lambda x. xx)(\lambda x. xx)((\lambda y. y)(\lambda x. x)) - 2$ redexes
 $(\lambda x. xx)(\lambda x. xx)(\lambda x. x)$

Exercise 4

- a) $M = (\lambda x. x)(\lambda x. x)$
 $N = (\lambda y. \lambda x. x)x$
- b) $M = ((\lambda x. x)(\lambda x. x))((\lambda y. x)(\lambda z. z))((\lambda x. xx)(\lambda z. z))$
 $N = (\lambda x. x)((\lambda y. x)(\lambda z. z))((\lambda x. xx)(\lambda z. z))$
 $P = ((\lambda x. x)(\lambda x. x))x((\lambda x. xx)(\lambda z. z))$
 $Q = ((\lambda x. x)(\lambda x. x))((\lambda y. x)(\lambda z. z))((\lambda z. z)(\lambda z. z))$