

# Programming Languages and Types

## Exercise 11

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- 1  $\lambda$ -Calculus vs.  $\lambda$ -Based Language**
- 2 Nameless  $\lambda$ -Calculus**
  - 2.1  $\alpha$ -Conversion: Pros and Cons**
  - 2.2  $\lambda$ -Calculus Using De-Bruijn Indices**
  - 2.3 Evaluation Semantics for  $\lambda_{bv}$**
- 3 Substitution vs. Environment**
  - 3.1 Substitution-Based Evaluation Semantics for  $\lambda_{ao}$**
  - 3.2 Environment-Based Evaluation Semantics for  $\lambda_{bn}$**
- 4 Computational  $\lambda$ -Calculus**
  - 4.1  $\lambda$ -Calculus Extended with Monads**
  - 4.2 Typing  $\lambda_c$**