

Programming Languages and Types

Exercise 12

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1 Simply-Typed λ -Calculus

1.1 Typing Derivations

1.2 Programming with Extensions

1. Define the subtraction function *sub* in the simply-typed λ -calculus extended with Peano numbers (**0** and **succ**) and fixed point operator **fix**.

```
fix ( $\lambda$  fsub : Nat  $\rightarrow$  Nat  $\rightarrow$  Nat .  
       $\lambda$  m : Nat .  $\lambda$  n : Nat  
      if (iszero m)  
        then 0  
        else (succ (fsub (pred m) n)) )
```

2 System- \mathcal{F}

2.1 Parametric Polymorphism

1. Define the polymorphic function *I*.
2. Define the polymorphic function *K*.
3. Define the polymorphic function *S*.
4. Define *I* in terms of *S* and *K*.

2.2 Typing Church-Encodings

1. Church-numerals
2. Church-booleans
3. Church-pairs