

# LC.index

November 29, 2025

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## 1 LC.Definitions

```
module LC.Definitions where  
  
import LC.Variables  
import LC.Terms  
import LC.Domains  
import LC.Environments  
import LC.Semantics
```

## 2 LC.Domains

```
module LC.Domains where

open import Function
  using (Inverse; _↔_ ) public
open Inverse {{ ... }}
  using (to; from) public

postulate
  Domain : Set1
  ⟨⟨ _ ⟩⟩ : Domain → Set
  D∞ : Domain
postulate
  instance iso : ⟨⟨ D∞ ⟩⟩ ↔ (⟨⟨ D∞ ⟩⟩ → ⟨⟨ D∞ ⟩⟩)
variable d : ⟨⟨ D∞ ⟩⟩
```

The PCF example illustrates declaration of a domain of functions.

### 3 LC.Environments

```
module LC.Environments where

open import LC.Variables
open import LC.Domains
open import Data.Bool using (if_ _ then_ _ else_ _)

Env = Var → ⌘ D∞ ⌘

variable ρ : Env

_ [ _ / _ ] : Env → ⌘ D∞ ⌘ → Var → Env
ρ [ d / v ] = λ v' → if v == v' then d else ρ v'
```

## 4 LC.Semantics

```
module LC.Semantics where

open import LC.Variables
open import LC.Terms
open import LC.Domains
open import LC.Environments

 $\llbracket \_ \rrbracket : \text{Exp} \rightarrow \text{Env} \rightarrow \langle\langle \text{D}\infty \rangle\rangle$ 
--  $\llbracket e \rrbracket \rho$  is the value of  $e$  with  $\rho$  giving the values of free variables

 $\llbracket \text{var } v \rrbracket \rho = \rho v$ 
 $\llbracket \text{lam } v e \rrbracket \rho = \text{from}(\lambda d \rightarrow \llbracket e \rrbracket (\rho[d/v]))$ 
 $\llbracket \text{app } e_1 e_2 \rrbracket \rho = \text{to}(\llbracket e_1 \rrbracket \rho)(\llbracket e_2 \rrbracket \rho)$ 
```

## 5 LC.Terms

```
module LC.Terms where

open import LC.Variables

data Exp : Set where
  var_ : Var → Exp      -- variable value
  lam_ : Var → Exp → Exp -- lambda abstraction
  app_ : Exp → Exp → Exp -- application

variable e : Exp
```

## 6 LC.Tests

```
{-# OPTIONS --rewriting --confluence-check #-}

open import Agda.Builtin.Equality
open import Agda.Builtin.Equality.Rewrite

module LC.Tests where

open import LC.Domains
open import LC.Variables
open import LC.Terms
open import LC.Semantics

open import Relation.Binary.PropositionalEquality using (refl)
open Inverse using (inversel; inverser)

to-from-elim : ∀ {f} → to (from f) ≡ f
to-from-elim = inversel iso refl

from-to-elim : ∀ {d} → from (to d) ≡ d
from-to-elim = inverser iso refl

{-# REWRITE to-from-elim #-}

-- The following proofs are potentially unsound,
-- due to rewriting using the postulated iso

-- (λx1.x1)x42 = x42
check-id :
  [[ app (lam (x 1) (var x 1))
    (var x 42) ]] ≡ [[ var x 42 ]]
check-id = refl

-- (λx1.x42)x0 = x42
check-const :
  [[ app (lam (x 1) (var x 42))
    (var x 0) ]] ≡ [[ var x 42 ]]
check-const = refl

-- (λx0.x0 x0)(λx0.x0 x0) = ...
-- check-divergence :
--   [[ app (lam (x 0) (app (var x 0) (var x 0)))
--     (lam (x 0) (app (var x 0) (var x 0))) ]]
--   ≡ [[ var x 42 ]]
-- check-divergence = refl

-- (λx1.x42)((λx0.x0 x0)(λx0.x0 x0)) = x42
check-convergence :
  [[ app (lam (x 1) (var x 42))
    (app (lam (x 0) (app (var x 0) (var x 0)))
      (lam (x 0) (app (var x 0) (var x 0)))) ]]

```

```

≡ [[ var x 42 ]]
check-convergence = refl

-- (λx1.x1)(λx1.x42) = λx2.x42
check-abs :
[[ app (lam (x 1) (var x 1))
  (lam (x 1) (var x 42)) ]]
≡ [[ lam (x 2) (var x 42) ]]
check-abs = refl

-- (λx1.(λx42.x1)x2)x42 = x42
check-free :
[[ app (lam (x 1)
  (app (lam (x 42) (var x 1))
    (var x 2)))
  (var x 42) ]] ≡ [[ var x 42 ]]
check-free = refl

```

## 7 LC.Variables

```
module LC.Variables where

open import Data.Bool using (Bool)
open import Data.Nat using (N; _ $\equiv^b$  _)

data Var : Set where
  x : N  $\rightarrow$  Var -- variables

variable v : Var

_ == _ : Var  $\rightarrow$  Var  $\rightarrow$  Bool
x n == x n' = (n  $\equiv^b$  n')
```

## 8 LC.index

```
{-# OPTIONS --rewriting --confluence-check #-}

module LC.index where

import LC.Definitions
import LC.Domains
import LC.Environments
import LC.Semantics
import LC.Terms
import LC.Tests
import LC.Variables
```