What's in Main

Tobias Nipkow

November 11, 2013

Abstract

This document lists the main types, functions and syntax provided by theory *Main*. It is meant as a quick overview of what is available. For infix operators and their precedences see the final section. The sophisticated class structure is only hinted at. For details see http://isabelle.in.tum.de/library/HOL/.

HOL

The basic logic: $x = y$, *True*, *False*, $\neg\ P$, $P \wedge Q$, $P \vee Q$, $P \longrightarrow Q$, $\forall x.\ P$, $\exists x.\ P$, $\exists!x.\ P$, *THE* $x.\ P$.

$undefined :: 'a$
$default :: 'a$

Syntax

$x \neq y$	$\equiv$	$\neg\ (x = y)$	(~=)
$P \longleftrightarrow Q$	$\equiv$	$P = Q$	
if x *then* y *else* z	$\equiv$	*If* $x\ y\ z$	
let $x = e_1$ *in* e_2	$\equiv$	*Let* $e_1\ (\lambda x.\ e_2)$	

Orderings

A collection of classes defining basic orderings: preorder, partial order, linear order, dense linear order and wellorder.

$op \leq :: 'a \Rightarrow 'a \Rightarrow bool$ (<=)
$op < :: 'a \Rightarrow 'a \Rightarrow bool$
$Least :: ('a \Rightarrow bool) \Rightarrow 'a$
$min :: 'a \Rightarrow 'a \Rightarrow 'a$
$max :: 'a \Rightarrow 'a \Rightarrow 'a$

top :: $'a$
bot :: $'a$
$mono$ :: $('a \Rightarrow 'b) \Rightarrow bool$
$strict\text{-}mono$ :: $('a \Rightarrow 'b) \Rightarrow bool$

Syntax

$x \geq y$ $\equiv$ $y \leq x$ (>=)
$x > y$ $\equiv$ $y < x$
$\forall x{\leq}y.\ P$ $\equiv$ $\forall x.\ x \leq y \longrightarrow P$
$\exists x{\leq}y.\ P$ $\equiv$ $\exists x.\ x \leq y \wedge P$
Similarly for $<$, $\geq$ and $>$
$LEAST\ x.\ P$ $\equiv$ $Least\ (\lambda x.\ P)$

Lattices

Classes semilattice, lattice, distributive lattice and complete lattice (the latter in theory *Set*).
inf :: $'a \Rightarrow 'a \Rightarrow 'a$
sup :: $'a \Rightarrow 'a \Rightarrow 'a$
Inf :: $'a\ set \Rightarrow 'a$
Sup :: $'a\ set \Rightarrow 'a$

Syntax

Available by loading theory *Lattice-Syntax* in directory *Library*.
$x \sqsubseteq y$ $\equiv$ $x \leq y$
$x \sqsubset y$ $\equiv$ $x < y$
$x \sqcap y$ $\equiv$ $inf\ x\ y$
$x \sqcup y$ $\equiv$ $sup\ x\ y$
$\bigsqcap A$ $\equiv$ $Sup\ A$
$\bigsqcup A$ $\equiv$ $Inf\ A$
$\top$ $\equiv$ top
$\bot$ $\equiv$ bot

Set

$\{\}$ :: $'a\ set$
$insert$ :: $'a \Rightarrow 'a\ set \Rightarrow 'a\ set$
$Collect$ :: $('a \Rightarrow bool) \Rightarrow 'a\ set$
$op \in$ :: $'a \Rightarrow 'a\ set \Rightarrow bool$ (:)
$op \cup$ :: $'a\ set \Rightarrow 'a\ set \Rightarrow 'a\ set$ (Un)
$op \cap$ :: $'a\ set \Rightarrow 'a\ set \Rightarrow 'a\ set$ (Int)

$UNION :: 'a\ set \Rightarrow ('a \Rightarrow 'b\ set) \Rightarrow 'b\ set$
$INTER :: 'a\ set \Rightarrow ('a \Rightarrow 'b\ set) \Rightarrow 'b\ set$
$Union :: 'a\ set\ set \Rightarrow 'a\ set$
$Inter :: 'a\ set\ set \Rightarrow 'a\ set$
$Pow :: 'a\ set \Rightarrow 'a\ set\ set$
$UNIV :: 'a\ set$
$op\ `\ :: ('a \Rightarrow 'b) \Rightarrow 'a\ set \Rightarrow 'b\ set$
$Ball :: 'a\ set \Rightarrow ('a \Rightarrow bool) \Rightarrow bool$
$Bex :: 'a\ set \Rightarrow ('a \Rightarrow bool) \Rightarrow bool$

Syntax

$\{a_1,\ldots,a_n\}$	$\equiv$	$insert\ a_1\ (\ldots\ (insert\ a_n\ \{\})\ldots)$	
$a \notin A$	$\equiv$	$\neg(x \in A)$	
$A \subseteq B$	$\equiv$	$A \leq B$	
$A \subset B$	$\equiv$	$A < B$	
$A \supseteq B$	$\equiv$	$B \leq A$	
$A \supset B$	$\equiv$	$B < A$	
$\{x.\ P\}$	$\equiv$	$Collect\ (\lambda x.\ P)$	
$\{t \mid x_1\ \ldots\ x_n.\ P\}$	$\equiv$	$\{v.\ \exists x_1\ \ldots\ x_n.\ v = t \wedge P\}$	
$\bigcup x{\in}I.\ A$	$\equiv$	$UNION\ I\ (\lambda x.\ A)$	(UN)
$\bigcup x.\ A$	$\equiv$	$UNION\ UNIV\ (\lambda x.\ A)$	
$\bigcap x{\in}I.\ A$	$\equiv$	$INTER\ I\ (\lambda x.\ A)$	(INT)
$\bigcap x.\ A$	$\equiv$	$INTER\ UNIV\ (\lambda x.\ A)$	
$\forall x{\in}A.\ P$	$\equiv$	$Ball\ A\ (\lambda x.\ P)$	
$\exists x{\in}A.\ P$	$\equiv$	$Bex\ A\ (\lambda x.\ P)$	
$range\ f$	$\equiv$	$f\ `\ UNIV$	

Fun

$id :: 'a \Rightarrow 'a$
$op\ \circ :: ('a \Rightarrow 'b) \Rightarrow ('c \Rightarrow 'a) \Rightarrow 'c \Rightarrow 'b$ (o)
$inj\text{-}on :: ('a \Rightarrow 'b) \Rightarrow 'a\ set \Rightarrow bool$
$inj :: ('a \Rightarrow 'b) \Rightarrow bool$
$surj :: ('a \Rightarrow 'b) \Rightarrow bool$
$bij :: ('a \Rightarrow 'b) \Rightarrow bool$
$bij\text{-}betw :: ('a \Rightarrow 'b) \Rightarrow 'a\ set \Rightarrow 'b\ set \Rightarrow bool$
$fun\text{-}upd :: ('a \Rightarrow 'b) \Rightarrow 'a \Rightarrow 'b \Rightarrow 'a \Rightarrow 'b$

Syntax

$f(x := y)$	$\equiv$	$fun\text{-}upd\ f\ x\ y$
$f(x_1{:=}y_1,\ldots,x_n{:=}y_n)$	$\equiv$	$f(x_1{:=}y_1)\ldots(x_n{:=}y_n)$

Hilbert_Choice

Hilbert's selection (ε) operator: *SOME* $x.$ $P.$

inv-into :: $'a$ *set* $\Rightarrow$ $('a \Rightarrow 'b) \Rightarrow 'b \Rightarrow 'a$

Syntax

inv $\equiv$ *inv-into UNIV*

Fixed Points

Theory: *Inductive*.

Least and greatest fixed points in a complete lattice $'a$:

lfp :: $('a \Rightarrow 'a) \Rightarrow 'a$

gfp :: $('a \Rightarrow 'a) \Rightarrow 'a$

Note that in particular sets ($'a \Rightarrow$ *bool*) are complete lattices.

Sum_Type

Type constructor $+$.

Inl :: $'a \Rightarrow 'a + 'b$

Inr :: $'a \Rightarrow 'b + 'a$

op <+> :: $'a$ *set* $\Rightarrow$ $'b$ *set* $\Rightarrow$ $('a + 'b)$ *set*

Product_Type

Types *unit* and $\times$.

() :: *unit*

Pair :: $'a \Rightarrow 'b \Rightarrow 'a \times 'b$

fst :: $'a \times 'b \Rightarrow 'a$

snd :: $'a \times 'b \Rightarrow 'b$

split :: $('a \Rightarrow 'b \Rightarrow 'c) \Rightarrow 'a \times 'b \Rightarrow 'c$

curry :: $('a \times 'b \Rightarrow 'c) \Rightarrow 'a \Rightarrow 'b \Rightarrow 'c$

Sigma :: $'a$ *set* $\Rightarrow$ $('a \Rightarrow 'b$ *set*$) \Rightarrow ('a \times 'b)$ *set*

Syntax

(a, b) $\equiv$ *Pair a b*

$\lambda(x, y).\ t$ $\equiv$ *split* $(\lambda x\ y.\ t)$

$A \times B$ $\equiv$ *Sigma A* $(\lambda\_.\ B)$ (<*>)

Pairs may be nested. Nesting to the right is printed as a tuple, e.g. (a, b, c) is really $(a, (b, c))$. Pattern matching with pairs and tuples extends to all binders, e.g.

$\forall\,(x,\ y){\in}A.\ P$, $\{(x,\ y).\ P\}$, etc.

Relation

converse :: $('a \times 'b)\ set \Rightarrow ('b \times 'a)\ set$
op O :: $('a \times 'b)\ set \Rightarrow ('b \times 'c)\ set \Rightarrow ('a \times 'c)\ set$
op `` :: $('a \times 'b)\ set \Rightarrow 'a\ set \Rightarrow 'b\ set$
inv-image :: $('a \times 'a)\ set \Rightarrow ('b \Rightarrow 'a) \Rightarrow ('b \times 'b)\ set$
Id-on :: $'a\ set \Rightarrow ('a \times 'a)\ set$
Id :: $('a \times 'a)\ set$
Domain :: $('a \times 'b)\ set \Rightarrow 'a\ set$
Range :: $('a \times 'b)\ set \Rightarrow 'b\ set$
Field :: $('a \times 'a)\ set \Rightarrow 'a\ set$
refl-on :: $'a\ set \Rightarrow ('a \times 'a)\ set \Rightarrow bool$
refl :: $('a \times 'a)\ set \Rightarrow bool$
sym :: $('a \times 'a)\ set \Rightarrow bool$
antisym :: $('a \times 'a)\ set \Rightarrow bool$
trans :: $('a \times 'a)\ set \Rightarrow bool$
irrefl :: $('a \times 'a)\ set \Rightarrow bool$
total-on :: $'a\ set \Rightarrow ('a \times 'a)\ set \Rightarrow bool$
total :: $('a \times 'a)\ set \Rightarrow bool$

Syntax

$r^{-1} \equiv converse\ r$ (`^-1`)

Type synonym $'a\ rel = ('a \times 'a)\ set$

Equiv_Relations

equiv :: $'a\ set \Rightarrow ('a \times 'a)\ set \Rightarrow bool$
op // :: $'a\ set \Rightarrow ('a \times 'a)\ set \Rightarrow 'a\ set\ set$
congruent :: $('a \times 'a)\ set \Rightarrow ('a \Rightarrow 'b) \Rightarrow bool$
congruent2 :: $('a \times 'a)\ set \Rightarrow ('b \times 'b)\ set \Rightarrow ('a \Rightarrow 'b \Rightarrow 'c) \Rightarrow bool$

Syntax

f respects r $\equiv$ *congruent r f*
f respects2 r $\equiv$ *congruent2 r r f*

Transitive_Closure

$rtrancl :: ('a \times 'a)\ set \Rightarrow ('a \times 'a)\ set$
$trancl :: ('a \times 'a)\ set \Rightarrow ('a \times 'a)\ set$
$reflcl :: ('a \times 'a)\ set \Rightarrow ('a \times 'a)\ set$
$acyclic :: ('a \times 'a)\ set \Rightarrow bool$
$op\ \hat{}\hat{} :: ('a \times 'a)\ set \Rightarrow nat \Rightarrow ('a \times 'a)\ set$

Syntax

r^* $\equiv$ $rtrancl\ r$ (`^*`)
r^+ $\equiv$ $trancl\ r$ (`^+`)
$r^=$ $\equiv$ $reflcl\ r$ (`^=`)

Algebra

Theories *Groups*, *Rings*, *Fields* and *Divides* define a large collection of classes describing common algebraic structures from semigroups up to fields. Everything is done in terms of overloaded operators:

$0 :: 'a$
$1 :: 'a$
$op + :: 'a \Rightarrow 'a \Rightarrow 'a$
$op - :: 'a \Rightarrow 'a \Rightarrow 'a$
$uminus :: 'a \Rightarrow 'a$ (-)
$op * :: 'a \Rightarrow 'a \Rightarrow 'a$
$inverse :: 'a \Rightarrow 'a$
$op / :: 'a \Rightarrow 'a \Rightarrow 'a$
$abs :: 'a \Rightarrow 'a$
$sgn :: 'a \Rightarrow 'a$
$op\ dvd :: 'a \Rightarrow 'a \Rightarrow bool$
$op\ div :: 'a \Rightarrow 'a \Rightarrow 'a$
$op\ mod :: 'a \Rightarrow 'a \Rightarrow 'a$

Syntax

$|x|$ $\equiv$ $abs\ x$

Nat

datatype $nat = 0 \mid Suc\ nat$

$op +$ $op -$ $op *$ $op\ \hat{}$ $op\ div$ $op\ mod$ $op\ dvd$
$op \leq$ $op <$ min max Min Max

$of\text{-}nat :: nat \Rightarrow 'a$
$op\ \hat{}\hat{} :: ('a \Rightarrow 'a) \Rightarrow nat \Rightarrow 'a \Rightarrow 'a$

Int

Type *int*

op + *op −* *uminus* *op ∗* *op ^* *op div* *op mod* *op dvd*
op ≤ *op <* *min* *max* *Min* *Max*
abs *sgn*

nat :: *int ⇒ nat*
of-int :: *int ⇒ 'a*
ℤ :: *'a set* (Ints)

Syntax

int ≡ *of-nat*

Finite_Set

finite :: *'a set ⇒ bool*
card :: *'a set ⇒ nat*
Finite-Set.fold :: *('a ⇒ 'b ⇒ 'b) ⇒ 'b ⇒ 'a set ⇒ 'b*
setsum :: *('a ⇒ 'b) ⇒ 'a set ⇒ 'b*
setprod :: *('a ⇒ 'b) ⇒ 'a set ⇒ 'b*

Syntax

$\sum A$ ≡ *setsum* (λ*x*. *x*) *A* (SUM)
$\sum x{\in}A.\ t$ ≡ *setsum* (λ*x*. *t*) *A*
$\sum x|P.\ t$ ≡ $\sum x \mid P.\ t$
Similarly for $\prod$ instead of $\sum$ (PROD)

Wellfounded

wf :: *('a × 'a) set ⇒ bool*
acc :: *('a × 'a) set ⇒ 'a set*
measure :: *('a ⇒ nat) ⇒ ('a × 'a) set*
op <∗lex∗> :: *('a × 'a) set ⇒ ('b × 'b) set ⇒ (('a × 'b) × 'a × 'b) set*
op <∗mlex∗> :: *('a ⇒ nat) ⇒ ('a × 'a) set ⇒ ('a × 'a) set*
less-than :: *(nat × nat) set*
pred-nat :: *(nat × nat) set*

Set_Interval

$lessThan$ :: $'a \Rightarrow 'a\ set$
$atMost$ :: $'a \Rightarrow 'a\ set$
$greaterThan$ :: $'a \Rightarrow 'a\ set$
$atLeast$ :: $'a \Rightarrow 'a\ set$
$greaterThanLessThan$ :: $'a \Rightarrow 'a \Rightarrow 'a\ set$
$atLeastLessThan$ :: $'a \Rightarrow 'a \Rightarrow 'a\ set$
$greaterThanAtMost$ :: $'a \Rightarrow 'a \Rightarrow 'a\ set$
$atLeastAtMost$ :: $'a \Rightarrow 'a \Rightarrow 'a\ set$

Syntax

$\{..<y\}$ $\equiv$ $lessThan\ y$
$\{..y\}$ $\equiv$ $atMost\ y$
$\{x<..\}$ $\equiv$ $greaterThan\ x$
$\{x..\}$ $\equiv$ $atLeast\ x$
$\{x<..<y\}$ $\equiv$ $greaterThanLessThan\ x\ y$
$\{x..<y\}$ $\equiv$ $atLeastLessThan\ x\ y$
$\{x<..y\}$ $\equiv$ $greaterThanAtMost\ x\ y$
$\{x..y\}$ $\equiv$ $atLeastAtMost\ x\ y$
$\bigcup\ i{\leq}n.\ A$ $\equiv$ $\bigcup\ i \in \{..n\}.\ A$
$\bigcup\ i{<}n.\ A$ $\equiv$ $\bigcup\ i \in \{..<n\}.\ A$
Similarly for $\bigcap$ instead of $\bigcup$
$\sum x = a..b.\ t$ $\equiv$ $setsum\ (\lambda x.\ t)\ \{a..b\}$
$\sum x = a..<b.\ t$ $\equiv$ $setsum\ (\lambda x.\ t)\ \{a..<b\}$
$\sum x{\leq}b.\ t$ $\equiv$ $setsum\ (\lambda x.\ t)\ \{..b\}$
$\sum x{<}b.\ t$ $\equiv$ $setsum\ (\lambda x.\ t)\ \{..<b\}$
Similarly for $\prod$ instead of $\sum$

Power

$op\ \hat{}\ ::\ 'a \Rightarrow nat \Rightarrow 'a$

Option

datatype $'a\ option = None \mid Some\ 'a$

the :: $'a\ option \Rightarrow 'a$
$Option.map$ :: $('a \Rightarrow 'b) \Rightarrow 'a\ option \Rightarrow 'b\ option$
$Option.set$ :: $'a\ option \Rightarrow 'a\ set$
$Option.bind$ :: $'a\ option \Rightarrow ('a \Rightarrow 'b\ option) \Rightarrow 'b\ option$

List

datatype $'a\ list = [] \mid op\ \#\ 'a\ ('a\ list)$

$op\ @$ :: $'a\ list \Rightarrow 'a\ list \Rightarrow 'a\ list$
$butlast$ :: $'a\ list \Rightarrow 'a\ list$
$concat$ :: $'a\ list\ list \Rightarrow 'a\ list$
$distinct$ :: $'a\ list \Rightarrow bool$
$drop$ :: $nat \Rightarrow 'a\ list \Rightarrow 'a\ list$
$dropWhile$ :: $('a \Rightarrow bool) \Rightarrow 'a\ list \Rightarrow 'a\ list$
$filter$ :: $('a \Rightarrow bool) \Rightarrow 'a\ list \Rightarrow 'a\ list$
$List.find$ :: $('a \Rightarrow bool) \Rightarrow 'a\ list \Rightarrow 'a\ option$
$fold$ :: $('a \Rightarrow 'b \Rightarrow 'b) \Rightarrow 'a\ list \Rightarrow 'b \Rightarrow 'b$
$foldr$ :: $('a \Rightarrow 'b \Rightarrow 'b) \Rightarrow 'a\ list \Rightarrow 'b \Rightarrow 'b$
$foldl$ :: $('a \Rightarrow 'b \Rightarrow 'a) \Rightarrow 'a \Rightarrow 'b\ list \Rightarrow 'a$
hd :: $'a\ list \Rightarrow 'a$
$last$ :: $'a\ list \Rightarrow 'a$
$length$ :: $'a\ list \Rightarrow nat$
$lenlex$ :: $('a \times 'a)\ set \Rightarrow ('a\ list \times 'a\ list)\ set$
lex :: $('a \times 'a)\ set \Rightarrow ('a\ list \times 'a\ list)\ set$
$lexn$ :: $('a \times 'a)\ set \Rightarrow nat \Rightarrow ('a\ list \times 'a\ list)\ set$
$lexord$ :: $('a \times 'a)\ set \Rightarrow ('a\ list \times 'a\ list)\ set$
$listrel$ :: $('a \times 'b)\ set \Rightarrow ('a\ list \times 'b\ list)\ set$
$listrel1$ :: $('a \times 'a)\ set \Rightarrow ('a\ list \times 'a\ list)\ set$
$lists$ :: $'a\ set \Rightarrow 'a\ list\ set$
$listset$ :: $'a\ set\ list \Rightarrow 'a\ list\ set$
$listsum$ :: $'a\ list \Rightarrow 'a$
$list\text{-}all2$ :: $('a \Rightarrow 'b \Rightarrow bool) \Rightarrow 'a\ list \Rightarrow 'b\ list \Rightarrow bool$
$list\text{-}update$ :: $'a\ list \Rightarrow nat \Rightarrow 'a \Rightarrow 'a\ list$
map :: $('a \Rightarrow 'b) \Rightarrow 'a\ list \Rightarrow 'b\ list$
$measures$ :: $('a \Rightarrow nat)\ list \Rightarrow ('a \times 'a)\ set$
$op\ !$ :: $'a\ list \Rightarrow nat \Rightarrow 'a$
$remdups$ :: $'a\ list \Rightarrow 'a\ list$
$removeAll$ :: $'a \Rightarrow 'a\ list \Rightarrow 'a\ list$
$remove1$ :: $'a \Rightarrow 'a\ list \Rightarrow 'a\ list$
$replicate$ :: $nat \Rightarrow 'a \Rightarrow 'a\ list$
rev :: $'a\ list \Rightarrow 'a\ list$
$rotate$ :: $nat \Rightarrow 'a\ list \Rightarrow 'a\ list$
$rotate1$ :: $'a\ list \Rightarrow 'a\ list$
set :: $'a\ list \Rightarrow 'a\ set$
$sort$ :: $'a\ list \Rightarrow 'a\ list$
$sorted$ :: $'a\ list \Rightarrow bool$
$splice$ :: $'a\ list \Rightarrow 'a\ list \Rightarrow 'a\ list$
$sublist$ :: $'a\ list \Rightarrow nat\ set \Rightarrow 'a\ list$
$take$ :: $nat \Rightarrow 'a\ list \Rightarrow 'a\ list$

$takeWhile :: ('a \Rightarrow bool) \Rightarrow 'a\ list \Rightarrow 'a\ list$
$tl :: 'a\ list \Rightarrow 'a\ list$
$upt :: nat \Rightarrow nat \Rightarrow nat\ list$
$upto :: int \Rightarrow int \Rightarrow int\ list$
$zip :: 'a\ list \Rightarrow 'b\ list \Rightarrow ('a \times 'b)\ list$

Syntax

$[x_1,\ldots,x_n]$	$\equiv$	$x_1 \# \ldots \# x_n \# []$
$[m..<n]$	$\equiv$	$upt\ m\ n$
$[i..j]$	$\equiv$	$upto\ i\ j$
$[e.\ x \leftarrow xs]$	$\equiv$	$map\ (\lambda x.\ e)\ xs$
$[x \leftarrow xs\ .\ b]$	$\equiv$	$filter\ (\lambda x.\ b)\ xs$
$xs[n := x]$	$\equiv$	$list\text{-}update\ xs\ n\ x$
$\sum x \leftarrow xs.\ e$	$\equiv$	$listsum\ (map\ (\lambda x.\ e)\ xs)$

List comprehension: $[e.\ q_1,\ \ldots,\ q_n]$ where each qualifier q_i is either a generator $pat \leftarrow e$ or a guard, i.e. boolean expression.

Map

Maps model partial functions and are often used as finite tables. However, the domain of a map may be infinite.

$Map.empty :: 'a \Rightarrow 'b\ option$
$op\ ++ :: ('a \Rightarrow 'b\ option) \Rightarrow ('a \Rightarrow 'b\ option) \Rightarrow 'a \Rightarrow 'b\ option$
$op\ \circ_m :: ('a \Rightarrow 'b\ option) \Rightarrow ('c \Rightarrow 'a\ option) \Rightarrow 'c \Rightarrow 'b\ option$
$op\ |` :: ('a \Rightarrow 'b\ option) \Rightarrow 'a\ set \Rightarrow 'a \Rightarrow 'b\ option$
$dom :: ('a \Rightarrow 'b\ option) \Rightarrow 'a\ set$
$ran :: ('a \Rightarrow 'b\ option) \Rightarrow 'b\ set$
$op\ \subseteq_m :: ('a \Rightarrow 'b\ option) \Rightarrow ('a \Rightarrow 'b\ option) \Rightarrow bool$
$map\text{-}of :: ('a \times 'b)\ list \Rightarrow 'a \Rightarrow 'b\ option$
$map\text{-}upds :: ('a \Rightarrow 'b\ option) \Rightarrow 'a\ list \Rightarrow 'b\ list \Rightarrow 'a \Rightarrow 'b\ option$

Syntax

$Map.empty$	$\equiv$	$\lambda x.\ None$
$m(x \mapsto y)$	$\equiv$	$m(x{:=}Some\ y)$
$m(x_1 \mapsto y_1,\ldots,x_n \mapsto y_n)$	$\equiv$	$m(x_1 \mapsto y_1)\ldots(x_n \mapsto y_n)$
$[x_1 \mapsto y_1,\ldots,x_n \mapsto y_n]$	$\equiv$	$Map.empty(x_1 \mapsto y_1,\ldots,x_n \mapsto y_n)$
$m(xs\ [\mapsto]\ ys)$	$\equiv$	$map\text{-}upds\ m\ xs\ ys$

Infix operators in Main

	Operator	precedence	associativity
Meta-logic	$\Longrightarrow$	1	right
	$\equiv$	2	
Logic	$\wedge$	35	right
	$\vee$	30	right
	$\longrightarrow$, $\longleftrightarrow$	25	right
	$=$, $\neq$	50	left
Orderings	$\leq$, $<$, $\geq$, $>$	50	
Sets	$\subseteq$, $\subset$, $\supseteq$, $\supset$	50	
	$\in$, $\notin$	50	
	$\cap$	70	left
	$\cup$	65	left
Functions and Relations	$\circ$	55	left
	‘	90	right
	O	75	right
	“	90	right
Numbers	$+$, $-$	65	left
	$*$, $/$	70	left
	div, *mod*	70	left
	^	80	right
	^^	80	right
	dvd	50	
Lists	#, @	65	right
	!	100	left