What's in Main

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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 https://isabelle.in.tum.de/library/HOL/HOL.

HOL

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

$\mathit{undefined}$	$::\ 'a$
$\mathit{default}$	$::\ 'a$

Syntax

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

Orderings

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

$(\leq)$	$:: 'a \Rightarrow 'a \Rightarrow bool$	(<=)
$(<)$	$:: 'a \Rightarrow 'a \Rightarrow bool$	
Least	$:: ('a \Rightarrow bool) \Rightarrow 'a$	
Greatest	$:: ('a \Rightarrow bool) \Rightarrow 'a$	
min	$:: 'a \Rightarrow 'a \Rightarrow 'a$	
max	$:: 'a \Rightarrow 'a \Rightarrow 'a$	
top	$:: 'a$	
bot	$:: 'a$	

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 $>$

$LEAST\ x.\ P$	$\equiv$	$Least\ (\lambda x.\ P)$
$GREATEST\ x.\ P$	$\equiv$	$Greatest\ (\lambda x.\ P)$

Lattices

Classes semilattice, lattice, distributive lattice and complete lattice (the latter in theory *HOL.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 via **unbundle** *lattice_syntax*.

$x \sqsubseteq y$	$\equiv$	$x \leq y$
$x \sqsubset y$	$\equiv$	$x < y$
$x \sqcap y$	$\equiv$	$inf\ x\ y$
$x \sqcup y$	$\equiv$	$sup\ x\ y$
$\bigsqcap A$	$\equiv$	$Inf\ A$
$\bigsqcup A$	$\equiv$	$Sup\ A$
$\top$	$\equiv$	top
$\bot$	$\equiv$	bot

Set

$\{\}$	$:: {'a}\ set$	
$insert$	$:: {'a} \Rightarrow {'a}\ set \Rightarrow {'a}\ set$	
$Collect$	$:: ({'a} \Rightarrow bool) \Rightarrow {'a}\ set$	
$(\in)$	$:: {'a} \Rightarrow {'a}\ set \Rightarrow bool$	(`:`)
$(\cup)$	$:: {'a}\ set \Rightarrow {'a}\ set \Rightarrow {'a}\ set$	(`Un`)
$(\cap)$	$:: {'a}\ set \Rightarrow {'a}\ set \Rightarrow {'a}\ set$	(`Int`)
$\bigcup$	$:: {'a}\ set\ set \Rightarrow {'a}\ set$	
$\bigcap$	$:: {'a}\ set\ set \Rightarrow {'a}\ set$	
Pow	$:: {'a}\ set \Rightarrow {'a}\ set\ set$	
$UNIV$	$:: {'a}\ set$	
$(`)$	$:: ({'a} \Rightarrow {'b}) \Rightarrow {'a}\ set \Rightarrow {'b}\ set$	
$Ball$	$:: {'a}\ set \Rightarrow ({'a} \Rightarrow bool) \Rightarrow bool$	
Bex	$:: {'a}\ set \Rightarrow ({'a} \Rightarrow bool) \Rightarrow bool$	

Syntax

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

Fun

id	$:: 'a \Rightarrow 'a$	
$(\circ)$	$:: ('a \Rightarrow 'b) \Rightarrow ('c \Rightarrow 'a) \Rightarrow 'c \Rightarrow 'b$	$(\circ)$
inj_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_betw	$:: ('a \Rightarrow 'b) \Rightarrow 'a\ set \Rightarrow 'b\ set \Rightarrow bool$	
monotone_on	$:: 'a\ set \Rightarrow ('a \Rightarrow 'a \Rightarrow bool) \Rightarrow ('b \Rightarrow 'b \Rightarrow bool) \Rightarrow ('a \Rightarrow 'b) \Rightarrow bool$	
monotone	$:: ('a \Rightarrow 'a \Rightarrow bool) \Rightarrow ('b \Rightarrow 'b \Rightarrow bool) \Rightarrow ('a \Rightarrow 'b) \Rightarrow bool$	
mono_on	$:: 'a\ set \Rightarrow ('a \Rightarrow 'b) \Rightarrow bool$	
mono	$:: ('a \Rightarrow 'b) \Rightarrow bool$	
strict_mono_on	$:: 'a\ set \Rightarrow ('a \Rightarrow 'b) \Rightarrow bool$	
strict_mono	$:: ('a \Rightarrow 'b) \Rightarrow bool$	
antimono	$:: ('a \Rightarrow 'b) \Rightarrow bool$	
fun_upd	$:: ('a \Rightarrow 'b) \Rightarrow 'a \Rightarrow 'b \Rightarrow 'a \Rightarrow 'b$	

Syntax

$f(x := y)$	$\equiv$	*fun_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: *HOL.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 $+$.

$Inl \quad :: \ 'a \Rightarrow \ 'a + \ 'b$
$Inr \quad :: \ 'a \Rightarrow \ 'b + \ 'a$
$(<\!+\!>) :: \ 'a \ set \Rightarrow \ 'b \ set \Rightarrow (\ 'a + \ 'b) \ set$

Product_Type

Types *unit* and $\times$.

$() \quad :: unit$
$Pair \quad :: \ 'a \Rightarrow \ 'b \Rightarrow \ 'a \times \ 'b$
$fst \quad :: \ 'a \times \ 'b \Rightarrow \ 'a$
$snd \quad :: \ 'a \times \ 'b \Rightarrow \ 'b$
$case\_prod :: (\ 'a \Rightarrow \ 'b \Rightarrow \ 'c) \Rightarrow \ 'a \times \ 'b \Rightarrow \ 'c$
$curry \quad :: (\ 'a \times \ 'b \Rightarrow \ 'c) \Rightarrow \ 'a \Rightarrow \ 'b \Rightarrow \ 'c$
$Sigma \quad :: \ 'a \ set \Rightarrow (\ 'a \Rightarrow \ 'b \ set) \Rightarrow (\ 'a \times \ 'b) \ set$

Syntax

$(a,\ b) \quad \equiv \quad Pair \ a \ b$
$\lambda(x,\ y).\ t \quad \equiv \quad case\_prod \ (\lambda x \ y.\ t)$
$A \times B \quad \equiv \quad Sigma \ A \ (\lambda\_.\ B)$

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

$converse \quad :: (\ 'a \times \ 'b) \ set \Rightarrow (\ 'b \times \ 'a) \ set$
$(O) \quad :: (\ 'a \times \ 'b) \ set \Rightarrow (\ 'b \times \ 'c) \ set \Rightarrow (\ 'a \times \ 'c) \ set$
$(``) \quad :: (\ 'a \times \ 'b) \ set \Rightarrow \ 'a \ set \Rightarrow \ 'b \ set$
$inv\_image :: (\ 'a \times \ 'a) \ set \Rightarrow (\ 'b \Rightarrow \ 'a) \Rightarrow (\ 'b \times \ 'b) \ set$
$Id\_on \quad :: \ 'a \ set \Rightarrow (\ 'a \times \ 'a) \ set$
$Id \quad :: (\ 'a \times \ 'a) \ set$
$Domain \quad :: (\ 'a \times \ 'b) \ set \Rightarrow \ 'a \ set$
$Range \quad :: (\ 'a \times \ 'b) \ set \Rightarrow \ 'b \ set$

$$
\begin{array}{ll}
\mathit{Field} & :: ('a \times 'a)\ \mathit{set} \Rightarrow 'a\ \mathit{set} \\
\mathit{refl\_on} & :: 'a\ \mathit{set} \Rightarrow ('a \times 'a)\ \mathit{set} \Rightarrow \mathit{bool} \\
\mathit{refl} & :: ('a \times 'a)\ \mathit{set} \Rightarrow \mathit{bool} \\
\mathit{sym} & :: ('a \times 'a)\ \mathit{set} \Rightarrow \mathit{bool} \\
\mathit{antisym} & :: ('a \times 'a)\ \mathit{set} \Rightarrow \mathit{bool} \\
\mathit{trans} & :: ('a \times 'a)\ \mathit{set} \Rightarrow \mathit{bool} \\
\mathit{irrefl} & :: ('a \times 'a)\ \mathit{set} \Rightarrow \mathit{bool} \\
\mathit{total\_on} & :: 'a\ \mathit{set} \Rightarrow ('a \times 'a)\ \mathit{set} \Rightarrow \mathit{bool} \\
\mathit{total} & :: ('a \times 'a)\ \mathit{set} \Rightarrow \mathit{bool}
\end{array}
$$

Syntax

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

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

Equiv_Relations

$$
\begin{array}{ll}
\mathit{equiv} & :: 'a\ \mathit{set} \Rightarrow ('a \times 'a)\ \mathit{set} \Rightarrow \mathit{bool} \\
(//) & :: 'a\ \mathit{set} \Rightarrow ('a \times 'a)\ \mathit{set} \Rightarrow 'a\ \mathit{set}\ \mathit{set} \\
\mathit{congruent} & :: ('a \times 'a)\ \mathit{set} \Rightarrow ('a \Rightarrow 'b) \Rightarrow \mathit{bool} \\
\mathit{congruent2} & :: ('a \times 'a)\ \mathit{set} \Rightarrow ('b \times 'b)\ \mathit{set} \Rightarrow ('a \Rightarrow 'b \Rightarrow 'c) \Rightarrow \mathit{bool}
\end{array}
$$

Syntax

$$
\begin{array}{lcl}
f\ \mathit{respects}\ r & \equiv & \mathit{congruent}\ r\ f \\
f\ \mathit{respects2}\ r & \equiv & \mathit{congruent2}\ r\ r\ f
\end{array}
$$

Transitive_Closure

$$
\begin{array}{ll}
\mathit{rtrancl} & :: ('a \times 'a)\ \mathit{set} \Rightarrow ('a \times 'a)\ \mathit{set} \\
\mathit{trancl} & :: ('a \times 'a)\ \mathit{set} \Rightarrow ('a \times 'a)\ \mathit{set} \\
\mathit{reflcl} & :: ('a \times 'a)\ \mathit{set} \Rightarrow ('a \times 'a)\ \mathit{set} \\
\mathit{acyclic} & :: ('a \times 'a)\ \mathit{set} \Rightarrow \mathit{bool} \\
(\frown\frown) & :: ('a \times 'a)\ \mathit{set} \Rightarrow \mathit{nat} \Rightarrow ('a \times 'a)\ \mathit{set}
\end{array}
$$

Syntax

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

Algebra

Theories *HOL.Groups*, *HOL.Rings*, *HOL.Euclidean_Rings* and *HOL.Fields* 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	$:: 'a$	
$(+)$	$:: 'a \Rightarrow 'a \Rightarrow 'a$	
$(-)$	$:: 'a \Rightarrow 'a \Rightarrow 'a$	
uminus	$:: 'a \Rightarrow 'a$	`(-)`
$(*)$	$:: 'a \Rightarrow 'a \Rightarrow 'a$	
inverse	$:: 'a \Rightarrow 'a$	
(div)	$:: 'a \Rightarrow 'a \Rightarrow 'a$	
abs	$:: 'a \Rightarrow 'a$	
sgn	$:: 'a \Rightarrow 'a$	
(dvd)	$:: 'a \Rightarrow 'a \Rightarrow bool$	
(div)	$:: 'a \Rightarrow 'a \Rightarrow 'a$	
(mod)	$:: 'a \Rightarrow 'a \Rightarrow 'a$	

Syntax

$\lvert x\rvert$	$\equiv$	*abs x*

Nat

datatype *nat* = *0* | *Suc nat*

$(+)$	$(-)$	$(*)$	$(\widehat{\ })$	(div)	(mod)	(dvd)
$(\le)$	$(<)$	*min*	*max*	*Min*	*Max*	

of_nat $:: nat \Rightarrow 'a$
$(\widehat{\widehat{\ }})$ $:: ('a \Rightarrow 'a) \Rightarrow nat \Rightarrow 'a \Rightarrow 'a$

Int

Type *int*

$(+)$	$(-)$	*uminus*	$(*)$	$(\hat{\ })$	(div)	(mod)	(dvd)
$(\leq)$	$(<)$	*min*	*max*	*Min*	*Max*		
abs	*sgn*						

$nat :: int \Rightarrow nat$
$of\_int :: int \Rightarrow 'a$
$\mathbb{Z} :: 'a\ set$ (`Ints`)

Syntax

$int \quad \equiv \quad of\_nat$

Finite_Set

$finite :: 'a\ set \Rightarrow bool$
$card :: 'a\ set \Rightarrow nat$
$Finite\_Set.fold :: ('a \Rightarrow 'b \Rightarrow 'b) \Rightarrow 'b \Rightarrow 'a\ set \Rightarrow 'b$

Lattices_Big

$Min :: 'a\ set \Rightarrow 'a$
$Max :: 'a\ set \Rightarrow 'a$
$arg\_min :: ('a \Rightarrow 'b) \Rightarrow ('a \Rightarrow bool) \Rightarrow 'a$
$is\_arg\_min :: ('a \Rightarrow 'b) \Rightarrow ('a \Rightarrow bool) \Rightarrow 'a \Rightarrow bool$
$arg\_max :: ('a \Rightarrow 'b) \Rightarrow ('a \Rightarrow bool) \Rightarrow 'a$
$is\_arg\_max :: ('a \Rightarrow 'b) \Rightarrow ('a \Rightarrow bool) \Rightarrow 'a \Rightarrow bool$

Syntax

$ARG\_MIN\ f\ x.\ P \quad \equiv \quad arg\_min\ f\ (\lambda x.\ P)$
$ARG\_MAX\ f\ x.\ P \quad \equiv \quad arg\_max\ f\ (\lambda x.\ P)$

Groups_Big

$sum :: ('a \Rightarrow 'b) \Rightarrow 'a\ set \Rightarrow 'b$
$prod :: ('a \Rightarrow 'b) \Rightarrow 'a\ set \Rightarrow 'b$

Syntax

$\sum A$	$\equiv$	$sum\ (\lambda x.\ x)\ A$	(SUM)
$\sum x{\in}A.\ t$	$\equiv$	$sum\ (\lambda x.\ t)\ A$	
$\sum x{\mid}P.\ t$	$\equiv$	$\sum x \mid P.\ t$	
Similarly for $\prod$ instead of $\sum$			(PROD)

Wellfounded

wf	$::\ ('a \times 'a)\ set \Rightarrow bool$
$Wellfounded.acc$	$::\ ('a \times 'a)\ set \Rightarrow 'a\ set$
$measure$	$::\ ('a \Rightarrow nat) \Rightarrow ('a \times 'a)\ set$
$(<*lex*>)$	$::\ ('a \times 'a)\ set \Rightarrow ('b \times 'b)\ set \Rightarrow (('a \times 'b) \times 'a \times 'b)\ set$
$(<*mlex*>)$	$::\ ('a \Rightarrow nat) \Rightarrow ('a \times 'a)\ set \Rightarrow ('a \times 'a)\ set$
$less\_than$	$::\ (nat \times nat)\ set$
$pred\_nat$	$::\ (nat \times nat)\ set$

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

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

Power

$(\hat{\ }) :: 'a \Rightarrow nat \Rightarrow 'a$

Option

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

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

List

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

$(@) :: 'a\ list \Rightarrow 'a\ list \Rightarrow 'a\ list$

$butlast$ :: $'a\ list \Rightarrow 'a\ list$
$concat$ :: $'a\ list\ list \Rightarrow 'a\ list$
$distinct$ :: $'a\ list \Rightarrow bool$
$drop$ :: $nat \Rightarrow 'a\ list \Rightarrow 'a\ list$
$dropWhile$ :: $('a \Rightarrow bool) \Rightarrow 'a\ list \Rightarrow 'a\ list$
$filter$ :: $('a \Rightarrow bool) \Rightarrow 'a\ list \Rightarrow 'a\ list$
$find$ :: $('a \Rightarrow bool) \Rightarrow 'a\ list \Rightarrow 'a\ option$
$fold$ :: $('a \Rightarrow 'b \Rightarrow 'b) \Rightarrow 'a\ list \Rightarrow 'b \Rightarrow 'b$
$foldr$ :: $('a \Rightarrow 'b \Rightarrow 'b) \Rightarrow 'a\ list \Rightarrow 'b \Rightarrow 'b$
$foldl$ :: $('a \Rightarrow 'b \Rightarrow 'a) \Rightarrow 'a \Rightarrow 'b\ list \Rightarrow 'a$
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 :: $('a \times 'a)\ set \Rightarrow ('a\ list \times 'a\ list)\ set$
$lexn$ :: $('a \times 'a)\ set \Rightarrow nat \Rightarrow ('a\ list \times 'a\ list)\ set$
$lexord$ :: $('a \times 'a)\ set \Rightarrow ('a\ list \times 'a\ list)\ set$
$listrel$ :: $('a \times 'b)\ set \Rightarrow ('a\ list \times 'b\ list)\ set$
$listrel1$ :: $('a \times 'a)\ set \Rightarrow ('a\ list \times 'a\ list)\ set$
$lists$ :: $'a\ set \Rightarrow 'a\ list\ set$
$listset$ :: $'a\ set\ list \Rightarrow 'a\ list\ set$
$list\_all2$ :: $('a \Rightarrow 'b \Rightarrow bool) \Rightarrow 'a\ list \Rightarrow 'b\ list \Rightarrow bool$
$list\_update$ :: $'a\ list \Rightarrow nat \Rightarrow 'a \Rightarrow 'a\ list$
map :: $('a \Rightarrow 'b) \Rightarrow 'a\ list \Rightarrow 'b\ list$
$measures$ :: $('a \Rightarrow nat)\ list \Rightarrow ('a \times 'a)\ set$
$(!)$ :: $'a\ list \Rightarrow nat \Rightarrow 'a$
$nths$ :: $'a\ list \Rightarrow nat\ set \Rightarrow 'a\ list$
$prod\_list$ :: $'a\ list \Rightarrow 'a$
$remdups$ :: $'a\ list \Rightarrow 'a\ list$
$removeAll$ :: $'a \Rightarrow 'a\ list \Rightarrow 'a\ list$
$remove1$ :: $'a \Rightarrow 'a\ list \Rightarrow 'a\ list$
$replicate$ :: $nat \Rightarrow 'a \Rightarrow 'a\ list$
rev :: $'a\ list \Rightarrow 'a\ list$
$rotate$ :: $nat \Rightarrow 'a\ list \Rightarrow 'a\ list$
$rotate1$ :: $'a\ list \Rightarrow 'a\ list$
set :: $'a\ list \Rightarrow 'a\ set$
$shuffles$ :: $'a\ list \Rightarrow 'a\ list \Rightarrow 'a\ list\ set$
$sort$ :: $'a\ list \Rightarrow 'a\ list$
$sorted$ :: $'a\ list \Rightarrow bool$

$sorted\_wrt$	::	$('a \Rightarrow 'a \Rightarrow bool) \Rightarrow 'a\ list \Rightarrow bool$
$splice$	::	$'a\ list \Rightarrow 'a\ list \Rightarrow 'a\ list$
sum_list	::	$'a\ list \Rightarrow 'a$
$take$	::	$nat \Rightarrow 'a\ list \Rightarrow 'a\ list$
$takeWhile$	::	$('a \Rightarrow bool) \Rightarrow 'a\ list \Rightarrow 'a\ list$
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

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

Filter input syntax $[pat \leftarrow e.\ b]$, where pat is a tuple pattern, which stands for $filter\ (\lambda pat.\ b)\ e$.

List comprehension input syntax: $[e.\ q_1,\ \ldots,\ q_n]$ 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.

$Map.empty$	::	$'a \Rightarrow 'b\ option$
$(++)$	::	$('a \Rightarrow 'b\ option) \Rightarrow ('a \Rightarrow 'b\ option) \Rightarrow 'a \Rightarrow 'b\ option$
$(\circ_m)$	::	$('a \Rightarrow 'b\ option) \Rightarrow ('c \Rightarrow 'a\ option) \Rightarrow 'c \Rightarrow 'b\ option$
$(\|`)$	::	$('a \Rightarrow 'b\ option) \Rightarrow 'a\ set \Rightarrow 'a \Rightarrow 'b\ option$
dom	::	$('a \Rightarrow 'b\ option) \Rightarrow 'a\ set$
ran	::	$('a \Rightarrow 'b\ option) \Rightarrow 'b\ set$
$(\subseteq_m)$	::	$('a \Rightarrow 'b\ option) \Rightarrow ('a \Rightarrow 'b\ option) \Rightarrow bool$
map_of	::	$('a \times 'b)\ list \Rightarrow 'a \Rightarrow 'b\ option$
map_upds	::	$('a \Rightarrow 'b\ option) \Rightarrow 'a\ list \Rightarrow 'b\ list \Rightarrow 'a \Rightarrow 'b\ option$

Syntax

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

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
	^^	80	right
Numbers	$+$, $-$	65	left
	$*$, $/$	70	left
	div, *mod*	70	left
	^	80	right
	dvd	50	
Lists	#, @	65	right
	!	100	left