

Basic Haskell Cheat Sheet

Structure

```
func :: type -> type
func x = expr
```

```
fung :: type -> [type] -> type
fung x xs = expr
```

```
main = do code
      code
      ...
```

Function Application

```
f x y      ≡ (f x) y      ≡ ((f) (x)) (y)
f x y z    ≡ ((f x) y) z ≡ (f x y) z
f $ g x    ≡ f (g x)     ≡ f . g $ x
f $ g $ h x ≡ f (g (h x)) ≡ f . g . h $ x
f $ g x y  ≡ f (g x y)   ≡ f . g x $ y
f g $ h x  ≡ f g (h x)
```

Values and Types

```
has type      expr      :: type
boolean       True || False :: Bool
character     'a'         :: Char
fixed-precision integer 1           :: Int
integer (arbitrary sz.) 31337       :: Integer
               31337^10          :: Integer
single precision float  1.2         :: Float
double precision float  1.2         :: Double
list              []             :: [a]
                  [1,2,3]         :: [Integer]
                  ['a','b','c']    :: [Char]
                  "abc"           :: [Char]
string           [[1,2],[3,4]]     :: [[Integer]]
tuple            (1,2)             :: (Int,Int)
                  ([1,2], 'a')     :: ([Int],Char)
ordering relation LT, EQ, GT      :: Ordering
function (λ)     \x -> e          :: a -> b
maybe (just something or nothing) Just 10 :: Maybe Int
                                         Nothing :: Maybe a
```

Values and Typeclasses

```
given context, has type  expr :: context => type
Numeric (+,-,*)         137  :: Num a => a
Fractional (/)          1.2  :: Fractional a => a
Floating                1.2  :: Floating a => a
Equatable (==)          'a'  :: Eq a => a
Ordered (<=, >=, >, <)  731  :: Ord a => a
```

Declaring Types and Classes

```
type synonym      type MyType = Type
                  type UserId = Integer
                  type UserName = String
                  type User = (UserId,UserName)
                  type UserList = [User]
data (single constructor) data MyData = MyData Type Type Type
                           deriving (Class,Class)
data (multi constructor) data MyData = Simple Type |
                           Duple Type Type |
                           Nople
newtype            newtype MyNewType = MyNewType Type
                  deriving (Class,Class)
typeclass          class MyClass a where
                  foo :: a -> a -> b
                  goo :: a -> a
typeclass instance instance MyClass MyType where
                  foo x y = ...
                  goo x = ...
```

Operators (grouped by precedence)

List index, function composition	!!, .
raise to: Non-neg. Int, Int, Float	^, ^^, **
multiplication, fractional division	*, /
integral division (⇒ -∞), modulus	'div', 'mod'
integral quotient (⇒ 0), remainder	'quot', 'rem'
addition, subtraction	+, -
list construction, append lists	:, ++
list difference	\\
comparisons:	>, >=, <, <=, ==, /=
list membership	'elem', 'notElem'
boolean and	&&
boolean or	
sequencing: bind and then	>>=, >>
application, strict apl., sequencing	\$, \$!, 'seq'

NOTE: Highest precedence (first line) is 9, lowest precedence is 0. Those aligned to the right are right associative, all others left associative: except comparisons, list membership and list diff. which are non-associative.

```
Defining fixity: non associative      infix 0-9 'op'
                  left associative   infixl 0-9 +--+
                  right associative  infixr 0-9 -!-
                  default (when none given) infixl 9
```

Functions ≡ Infix operators

```
f a b ≡ a 'f' b
a + b ≡ (+) a b
(a +) b ≡ ((+) a) b
(+ b) a ≡ (\x -> x + b) a
```

Expressions / Clauses

```
if expression      ≈ guarded equations
if boolExpr        foo ... | boolExpr = exprA
                   then exprA   | otherwise = exprB
                   else exprB
nested if expression ≈ guarded equations
if boolExpr1       foo ... | boolExpr1 = exprA
                   then exprA   | boolExpr2 = exprB
                   else if boolExpr2 | otherwise = exprC
                       then exprB
                       else exprC
case expression     ≈ function pattern matching
case x of pat1 -> exA
          pat2 -> exB
          _ -> exC
foo pat1 = exA
foo pat2 = exB
foo _ = exC
2-variable case expression ≈ function pattern matching
case (x,y) of
  (pat1,patA) -> exprA
  (pat2,patB) -> exprB
  _ -> exprC
foo pat1 patA = exprA
foo pat2 patB = exprB
foo _ _ = exprC
let expression      ≈ where clause
let nameA=exprA
    nameB=exprB
in mainExpression
foo ... = mainExpression
where nameA=exprA
      nameB=exprB
do notation         ≈ desugared do notation
do patA <- action1
  action2
  patB <- action3
  action4
action1 >>= \patA ->
  action2 >>
  action3 >>= \patB ->
  action4
```

Pattern Matching (function declaration, lambda, case, let, where)

```
fixed      number 3      3      character 'a' 'a'
           ignore value -      empty string ""
list       empty        []
           head x and tail xs (x:xs)
           tail xs (ignore head) (.:xs)
           list with 3 elements: a, b and c [a,b,c]
           list with 3 elements: a, b and c (a:b:c:[])
           list where 2nd element is 3 (x:3:xs)
tuple      pair values a and b (a,b)
           ignore second element of tuple (a,_)
           triple values a, b and c (a,b,c)
mixed      first tuple on list ((a,b):xs)
maybe     just constructor Just a
           nothing constructor Nothing
custom     user-defined type MyData a b c
           ignore second field MyData a _ c
as-pattern tuple s and its values a and b s@(a,b)
           list a, its head x and tail xs a@(x:xs)
```

Prelude functions

Misc

```
id      :: a -> a           id x ≡ x  -- identity
const  :: a -> b -> a     (const x) y ≡ x
undefined :: a           undefined ≡ ⊥ (lifts error)
error  :: String -> a     error cs ≡ ⊥ (lifts error cs)
not    :: Bool -> Bool    not True ≡ False
flip   :: (a -> b -> c) -> (b -> a -> c)
      flip f $ x y ≡ f y x
```

Lists

```
null :: [a] -> Bool      null [] ≡ True  -- empty?
length :: [a] -> Int     length [x,y,z] ≡ 3
elem :: a -> [a] -> Bool  y `elem` [x,y] ≡ True  -- ∈?
head :: [a] -> a         head [x,y,z,w] ≡ x
tail :: [a] -> [a]       tail [x,y,z,w] ≡ [y,z,w]
init :: [a] -> [a]       init [x,y,z,w] ≡ [x,y,z]
reverse :: [a] -> [a]    reverse [x,y,z] ≡ [z,y,x]
take :: Int -> [a] -> [a] take 2 [x,y,z] ≡ [x,y]
drop :: Int -> [a] -> [a] drop 2 [x,y,z] ≡ [z]
takeWhile, dropWhile :: (a -> Bool) -> [a] -> [a]
takeWhile (/= z) [x,y,z,w] ≡ [x,y]
zip :: [a] -> [b] -> [(a, b)]
      zip [x,y,z] [a,b] ≡ [(x,a),(y,b)]
zipWith :: [a] -> [b] -> [(a, b)]
      zipWith f [x,y,z] [a,b] ≡ [f x a, f y b]
```

Infinite Lists

```
repeat :: a -> [a]      repeat x ≡ [x,x,x,x,x,...]
cycle  :: [a] -> [a]    cycle xs ≡ xs++xs++xs++...
      cycle [x,y] ≡ [x,y,x,y,x,y,...]
iterate :: (a -> a) -> a -> [a]
      iterate f x ≡ [x,f x,f (f x),...]
```

Higher-order / Functors

```
map :: (a->b) -> [a] -> [b]
      map f [x,y,z] ≡ [f x, f y, f z]
filter :: (a -> Bool) -> [a] -> [a]
      filter (/=y) [x,y,z] ≡ [x,z]
foldl :: (a -> b -> a) -> a -> [b] -> a
      foldl f x [y,z] ≡ (x 'f' y) 'f' z
foldr :: (a -> b -> b) -> b -> [a] -> b
      foldr f z [x,y] ≡ x 'f' (y 'f' z)
```

Special folds

```
and :: [Bool] -> Bool    and [p,q,r] ≡ p && q&&r
or  :: [Bool] -> Bool    or [p,q,r] ≡ p || q||r
sum  :: Num a => [a] -> a  sum [i,j,k] ≡ i + j + k
product :: Num a => [a] -> a  product [i,j,k] ≡ i * j * k
concat :: [[a]] -> [a]    concat [xs,ys,zs] ≡ xs++ys++zs
maximum :: Ord a => [a] -> a  maximum [10,0,5] ≡ 10
minimum :: Ord a => [a] -> a  minimum [10,0,5] ≡ 0
```

Tuples

```
fst      :: (a, b) -> a           fst (x,y) ≡ x
snd      :: (a, b) -> b           snd (x,y) ≡ y
curry    :: ((a, b) -> c) -> a -> b -> c
      curry (\(x,y) -> e) ≡ \x y -> e
uncurry  :: a -> b -> c -> ((a, b) -> c)
      uncurry (\x y -> e) ≡ \ (x,y) -> e
```

Numeric

```
abs      :: Num a => a -> a           abs -10 ≡ 10
even, odd :: Num a => a -> Bool       even -10 ≡ True
gcd, lcm  :: Integral a => a -> a -> a
      gcd 4 2 ≡ 2
recip     :: Fractional a => a -> a   recip x ≡ 1/x
pi        :: Floating a => a          pi ≡ 3.1415...
sqrt, log :: Floating a => a -> a     sqrt x ≡ x**0.5
exp, sin, cos, tan, asin, acos, atan :: Floating a => a -> a
truncate, round :: (RealFrac a, Integral b) => a -> b
ceiling, floor :: (RealFrac a, Integral b) => a -> b
```

Strings

```
lines :: String -> [String]
      lines "ab\ncd\ne" ≡ ["ab","cd","e"]
unlines :: [String] -> String
      unlines ["ab","cd","e"] ≡ "ab\ncd\ne\n"
words :: String -> [String]
      words "ab cd e" ≡ ["ab","cd","e"]
unwords :: [String] -> String
      unwords ["ab","cd","ef"] ≡ "ab cd ef"
```

Read and Show classes

```
show :: Show a => a -> String  show 137 ≡ "137"
read :: Show a => String -> a  read "2" ≡ 2
```

Ord Class

```
min :: Ord a => a -> a -> a     min 'a' 'b' ≡ 'a'
max :: Ord a => a -> a -> a     max "b" "ab" ≡ "b"
compare :: Ord a => a -> a -> Ordering  compare 1 2 ≡ LT
```

Libraries / Modules

```
importing (qualified)      import Some.Module
importing (subset)         import qualified Some.Module as SM
importing (hiding)         import Some.Module (foo,foo)
importing (typeclass instances) import Some.Module ()
declaring                   module Module.Name
      ( foo, goo )
      where
      ...
./File/On/Disk.hs          import File.On.Disk
```

Tracing and monitoring (unsafe)

Debug.Trace

```
Print string, return expr  trace string $ expr
Call show before printing  traceShow expr $ expr
Trace function             fun x y | traceShow (x,y) False = undefined
call values                fun x y = ...
```

IO – Must be “inside” the IO Monad

```
Write char c to stdout      putChar c
Write string cs to stdout   putStr cs
Write string cs to stdout w/ a newline putStrLn cs
Print x, a show instance, to stdout print x
Read char from stdin       getChar
Read line from stdin as a string  getLine
Read all input from stdin as a string  getContents
Bind stdin/stdout to foo (: String -> String) interact foo
Write string cs to a file named fn  writeFile fn cs
Append string cs to a file named fn appendFile fn cs
Read contents from a file named fn  readFile fn
```

List Comprehensions

Take *pat* from *list*. If *boolPredicate*, add element *expr* to list:
[*expr* | *pat* <- *list*, *boolPredicate*, ...]

```
[x | x <- xs] ≡ xs
[f x | x <- xs, p x] ≡ map f $ filter p xs
[x | x <- xs, p x, q x] ≡ filter q $ filter p xs
[x+y | x <- [a,b], y <- [i,j]] ≡ [a+i, a+j, b+i, b+j]
[x | boolE] ≡ if boolE then [x] else []
```

GHC - Glasgow Haskell Compiler

```
compiling program.hs      $ ghc program.hs
running                    $ ./program
running directly           $ run_haskell program.hs
interactive mode (GHCi)   $ ghci
GHCi load                  > :l program.hs
GHCi reload                > :r
GHCi activate stats       > :set +s
GHCi help                  > :?
Type of an expression     > :t expr
Info (oper./func./class) > :i thing
```

Cabal package and build system

```
install package pkg      $ cabal install pkg
update package list      $ cabal update
search packages matching pat $ cabal list pat
information about package pkg $ cabal info pkg
help on commands         $ cabal help [command]
run executable/test/benchmark $ cabal run/test/bench [name]
initialize sandbox       $ cabal sandbox init
add custom source to sandbox $ cabal sandbox add-source dir
```