

<http://xkcd.com/1312/>



Tony Hoare's

“Hints on Programming
Language Design”

CS 252:

Advanced Programming Language Principles



Introduction to Haskell

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Key traits of Haskell

1. Purely functional
2. Lazy
3. Statically typed
4. Type inference
5. Fully curried functions

Interactive Haskell

```
$ ghci
```

```
GHCi, version 7.6.3
```

```
...
```

```
Prelude> 3 + 4
```

```
7
```

```
Prelude> let f x = x + 1
```

```
Prelude> f 3
```

```
4
```

```
Prelude>
```

Needed in ghci,
but not in a
script

Running Haskell from Unix command line

```
$ cat helloWorld.hs
```

```
main :: IO ()
```

```
main = do
```

```
    putStrLn "Hello World"
```

```
$ runhaskell helloWorld.hs
```

```
Hello World
```

```
$
```

Haskell Base Types

- Int – bounded integers
- Integer – unbounded
- Float
- Double
- Bool
- Char

Lists

- Comma separated, as in Java.
- Some useful operators:
 - `++` concatenation
 - `:` prepend an item
 - `!!` get an element at the given index
 - `head` first item
 - `tail` rest of the list
 - `last` last item
 - `init` the beginning part of the list

List examples

```
Prelude> "I hate the homeless" ++  
  "ness problem that plagues our city"  
"I hate the homelessness problem that  
plagues our city"
```

```
Prelude> let s = "bra" in  
  s !! 2 : s ++ 'c' : last s : "da" ++ s  
"abracadabra"
```

```
Prelude>
```

Ranges

```
Prelude> [1..15]
```

```
[1,2,3,4,5,6,7,8,9,10,11,12,13,14,15]
```

```
Prelude> ['a'..'z']
```

```
"abcdefghijklmnopqrstuvwxyz"
```

```
Prelude> [1,3..27]
```

```
[1,3,5,7,9,11,13,15,17,19,21,23,25,27]
```

```
Prelude> let evens = [2, 4..]
```

```
Prelude> take 5 evens
```

```
[2,4,6,8,10]
```

List Comprehensions

- Based on set notation:

$$S = \{ 2 \cdot x \mid x \in \mathbb{N}, x \leq 10 \}$$

- The equivalent in Haskell is:

```
[2*x | x <- [1..10]]
```

- What does this give us?

```
[(a, b, c) | a <- [1..10],  
             b <- [1..10],  
             c <- [1..10],  
             a^2 + b^2 == c^2 ]
```

A "tuple"

A Simple Function

```
> let inc x = x + 1
```

```
> inc 5
```

```
6
```

```
> inc 'c'
```

```
<interactive>:9:1:
```

```
  No instance for (Num Char)
  arising from a use of `inc'
```

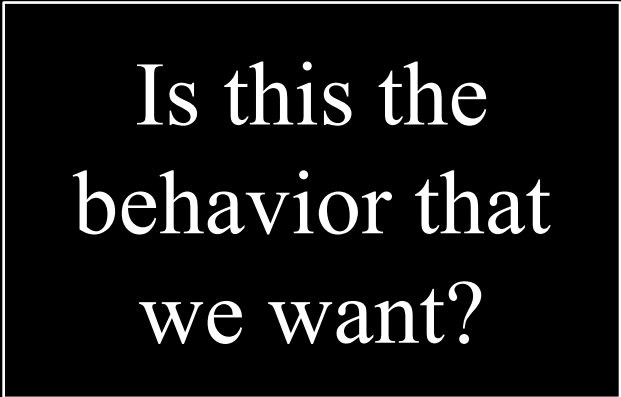
```
  Possible fix: add an instance
  declaration for (Num Char)
```

```
  In the expression: inc 'c'
```

```
  In an equation for `it': it =
  inc 'c'
```

```
> inc 2.5
```

```
3.5
```



Is this the
behavior that
we want?

Adding a *type signature*.

Now we will get a
compilation error
on `inc 2.5`

`inc :: Int -> Int`

`inc x = x + 1`

```
> inc (-5)
```

```
-4
```

Note the parens:
inc -5
would be a syntax
error

Is *this* the behavior
that we want?

Using *pattern matching*.

```
inc :: Int -> Int
```

```
inc x | x < 0 =
```

This is a *guard condition*

```
    error "no negative nums"
```

```
inc x = x + 1
```

Can't reassign variables in Haskell

"If you say that a is 5, you can't say it's something else later because you just said it was 5.

What are you, some kind of liar?"

Recursion

- Base case
 - tells us when to stop
- Recursive step
 - calls the function with a *smaller version* of the same problem

Recursive Example

`addNums :: [Integer] -> Integer`

`addNums [] = 0`

`addNums (x:xs) = x + addNums xs`

Lab: parts 1 & 2 (groups of 2-3)

Lab assignment is in CodeCheck. Links are available in Canvas and the course website.

Implement:

1. `maxNum`

2. "fizzbuzz" game

```
> fizzbuzz 15
```

```
"1 2 fizz 4 buzz fizz 7 8
```

```
fizz buzz 11 fizz 13 14
```

```
fizzbuzz"
```

Types

Haskell Types

- `:type` tells you the types for different values.
- `:t` is a shortcut.

```
Prelude>:t 'A'
```

```
'A' :: Char
```

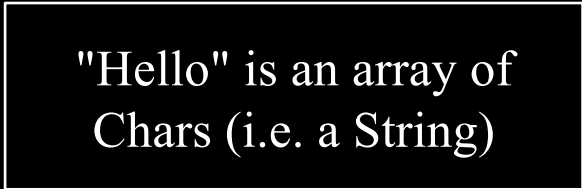


'A' is a Char

What is the Type?

```
Prelude>:t "Hello"
```

```
"Hello" :: [Char]
```



"Hello" is an array of
Chars (i.e. a String)

What is the Type?

```
Prelude>:t head
```

```
head :: [a] -> a
```

What is a?
Is a a type?

a is a *type variable*;
it stands in place of
other types.

What is the Type?

```
Prelude>:t (==)
```

```
(==) :: Eq a => a -> a -> Bool
```

This symbol indicates
that Eq is a typeclass

Eq a indicates that a
may be any type,
provided that it satisfies
the expected behavior.
(Think of Java interfaces)

Some Typeclasses

- **Eq** – Support equality testing
- **Ord** – Can be ordered
- **Show** – Representable as strings
- **Read** – Buildable from a string representation
- **Enum** – Sequentially ordered
- **Bounded** – Upper and lower bound

JSON example
(in class)

Lab 1, part 3: JSON pretty printer

Download `JSON.hs` and
`jsonDriver.hs`

In `JSON.hs`, implement the `JObject`
case in `toString`

HW1: implement a BigNum module

HW1 explores how you might support big numbers in Haskell if it did *not* support them.

- Use a list of 'blocks' of digits, least significant block first. So 9,073,201 is stored as:
[201,73,9]
- Starter code is available on the course website.

NOTE: YOU MAY NOT CHANGE THE TYPE SIGNATURES.

Overview of Homework

- Grade school addition
- Big number addition

- Grade school multiplication
- Big number multiplication

Read "Learn you a Haskell"
chapters 4 & 5