PROGRAMMING IN HASKELL

Function Application and Composition

$ as function application

$ is the function application operator

```
($) :: (a -> b) -> a -> b

f $ x = f x
```

$ as function application

It's function application but:

- normal function application has high precedence,
- $ has low precedence
- normal function application is left associate, e.g.,
  f a b c === ((f a) b) c
- $ is right associative

```
*Main> (^2) 4 + 3
19
*Main> (^2) $ 4 + 3
49
```

$ as function application

```
*Main> (^2) 4 + 3
19
*Main> (^2) $ 4 + 3
49
```

Improved syntax with $

Most often it's a convenience that lets us write fewer parentheses.

Example:

```
sum (map sqrt [1..130])
sum $ map sqrt [1..130]
```

when $ is encountered, expression on right is used as parameter to function on left

More examples

```
sqrt (3+4+9)
sqrt $ 3+4+9

*Main> sum (filter (> 10) (map (*2) [2..10]))
80

*Main> sum $ filter (>10) (map (*2) [2..10])
80

*Main> sum $ filter (>10) $ map (*2) [2..10]
80
```

Another example

```
*Main>(10*) $ 3
30
*Main> ($ 3) (10*)
30

*Main> map ($ 3) [(4+), (10*), (^2), sqrt]
[7.0,30.0,9.0,1.7320508075688772]
```

How does this work?

expression on right is used as parameter to function on left

Function Composition

We have seen function composition
(f . g) (x) = f (g (x))

Call g with some value, call f with the result

(.) :: (b -> c) -> (a -> b) -> a -> c
f . g = \x -> f (g x)
parameter of f must be the same as the return type of g
Example:
    (negate . (*3)) 4
What's the answer?

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Function Composition – why

Often convenient to create functions on the fly
Could use lambda, but composition may be more concise

```
*Main> map (\x -> negate (abs x)) [5,-3, -2, 7]
[-5,-3,-2,-7]

*Main> map (negate . abs) [5, -3, -2, 7]
[-5,-3,-2,-7]
```

Function Composition – why

```
*Main> map (\xs -> negate (sum (tail xs)))
[[1..5],[3..6],[1..7]]

    [-14,-15,-27]

*Main> map (negate . sum . tail)
[[1..5],[3..6],[1..7]]
[-14,-15,-27]
```

Function Composition with multiple parameters

If a function takes multiple parameters, must partially apply

```
*Main> sum (replicate 5 (max 6 9))
45
*Main> (sum . replicate 5) (max 6 9)
45
*Main> sum . replicate 5 $ max 6 9
45
```

The process

To rewrite a function with lots of parentheses using function composition

- first write out the innermost function and its parameters
- then put a $ before it
- compose all prior functions by omitting their last parameter (but not other parameters) and putting . between them

The process

```
*Main> replicate2 (product (map(*3) (zipWith max
[1,2] [4,5])))
[180,180]
```

```
*Main> replicate 2 . product . map (*3) $ zipWith
max [1,2] [4,5]
[180,180]
```

Aside on zipWith

zipWith takes a function and two lists as parameters and then joins the two lists by applying the function between corresponding elements. Here's how we'll implement it:

```
zipWith' :: (a -> b -> c) -> [a] -> [b] -> [c]
zipWith' _ [] _ = []
zipWith' _ _ [] = []
zipWith' f (x:xs) (y:ys) = f x y : zipWith' f xs ys
```

Aside on zipWith

```
ghci> zipWith' (+) [4,2,5,6] [2,6,2,3]
[6,8,7,9]
ghci> zipWith' max [6,3,2,1] [7,3,1,5]
[7,3,2,5]
ghci> zipWith' (++) ["foo ", "bar ", "baz "] ["fighters",
 "hoppers", "aldrin"]
["foo fighters","bar hoppers","baz aldrin"]
ghci> zipWith' (*) (replicate 5 2) [1..]
[2,4,6,8,10]
ghci> zipWith' (zipWith' (*)) [[1,2,3],[3,5,6],[2,3,4]] [
[3,2,2],[3,4,5],[5,4,3]]
[[3,4,6],[9,20,30],[10,12,12]]
```

Aside on zipWith

Note that you can use function application as the function

```
zipWith ($) funcList valueList

zipWith ($) [(+ 5),(* 3)] [1,5]  gives you
[6,15]
```

Examples

Using $

1. Write bigCubes that takes a list and returns a list of cubes that are > 500

2. Write lottaBiggest that takes a list and replicates the largest element 4 times. lottaBiggest [2,5,3,1] => [5,5,5,5]

Examples

Using $

3. Write powers that takes a number and creates a list of that number squared, cubed, and quadrupled. powers 2 => [4,8,16]

4. Assume people are dining. We have a list of tip percents (assume people tip at different rates):

```
*Main> let pcts = [0.15, 0.2, 0.21]
```

Examples

Using $
5. We have a list of bills (what people owe, minus tip)

    *Main> let amts = [20.5, 30, 25]

Write calcBill that takes amts and pcts and calculates what each person will pay, based on their amt and pct. Then apply a 4% tax rate.

*Main>calcBillamtspcts
[24.518,37.44,31.46]