



---

## Functional Programming

WS 2019/20

Benjamin Dietrich, Denis Hirn

### Assignment #2

Submission Deadline: Thu, 7.11.2019

#### Exercise 1: Patterns

(3 Points)

Simplify the following definitions using Pattern Matching:

1. `f x | x == 42 = ...`
2. `g xs | not $ null xs = ...`
3. `h (_, _) = ...`
4. `i xs | (not $ null xs) && (null $ head xs) = ...`
5. `j t = snd . fst $ t`
6. `k (a,b,c,xs) | a == b && c == 42 && length xs == 2 && head xs == 'a' = ...`

## Exercise 2: List Processing

(10 Points)

This exercise is concerned with list processing in Haskell, both via explicit recursion and using functions from the prelude and `Data.List`. You can import the module `Data.List` via

```
import Data.List
```

at the top of your Haskell source file or in GHCi. It contains a large number of functions on lists. You may freely use functions from this module unless we explicitly state differently.

API documentation for the prelude, `Data.List` and other modules included in the Haskell Platform can be found online at <http://hackage.haskell.org/package/base-4.9.1.0/docs/Data-List.html>, Hoogle (<https://www.haskell.org/hoogle/>) or in your local Haskell Platform documentation.

1. Function `map :: (a -> b) -> [a] -> [b]` that applies a function to every element of a list should be well-known. Please write a similar function `mapEveryOther` that applies it's functional argument only to every second element of the input list and leaves the other elements as-is.

**Examples<sup>1</sup>:**

```
mapEveryOther ((+) 42) [1,2,3,4] ≡ [43,2,45,4]
mapEveryOther ((+) 42) [] ≡ []
mapEveryOther ((+) 42) [1] ≡ [43]
```

Before you write down the definition, write down the function's polymorphic type. Compare the types of `map` and `mapEveryOther` and explain the difference.

2. The following function performs some computation on lists.

```
questionable :: (a -> Bool) -> (a -> b) -> [a] -> [b]
questionable p f as =
  if null as
  then []
  else if p (head as)
       then questionable p f (tail as)
       else dubious f as

where
  dubious g xs =
    if null xs
    then []
    else g (head xs) : dubious g (tail xs)
```

Although this is legal Haskell code, the function's style is questionable: it mixes two aspects of list processing — the selection and transformation of list elements — that should rather be implemented independently.

- (a) Write an equivalent function `acceptable` that still uses explicit recursion but utilizes multiple equations with pattern matching and guards instead of conditional expressions and the list deconstructors `head` and `tail`.
- (b) Write an equivalent function `reasonable` that does not use explicit recursion and is defined exclusively using list-processing functions from the prelude and `Data.List`.

**Hint:** Use the following search string on Hoogle to narrow down the number of list functions that might be useful. This type describes the selection aspect of function `questionable`.

```
+Data.List (a -> Bool) -> [a] -> [a]
```

---

<sup>1</sup>Recall `((+) 42)` is a function of type `Integer -> Integer` (partial application)

### Exercise 3: Fold

(7 Points)

Formulate the following functions without using explicit recursion. Instead, make use of the prelude function

`foldr :: (a -> b -> b) -> b -> [a] -> b`<sup>2</sup>

Applying the function (`foldr f z l`), we can right-associatively fold a list (`l :: [a]`) using a binary operator (`f :: (a -> b -> b)`). This is, to reduce the list, starting from a initial value `z` of type `b` (typically the operator's identity), applying the operator element by element from right to left:

`foldr f z [x1, x2, ..., xn] ≡ x1 'f' (x2 'f' ... (xn 'f' z) ...)`

Take for example a function `sum'` which sums all elements of a list. It can be written using a fold:

```
sum' :: [Integer] -> Integer
sum' xs = foldr (+) 0 xs
```

Applied to a list `[4,2,6]` the sum it is evaluated as follows:

`sum' [4,2,6] ≡ foldr (+) 0 [4,2,6] ≡ 4 + (2 + (6 + 0)) ≡ 12`

**Note:** Obviously you must not use specialized prelude or module functions (e.g. `length`, `intercalate`, etc.) to solve the following problems.

1. `length' :: [a] -> Integer` – to count the size of a list.

**Hint:** You can use `let` or `where` to locally define the operator to fold with.

2. `commaSep :: [String] -> String` – to concatenate a list of strings, separated by commas (',').

**Example:** `commaSep ["Hello","World"] ≡ "Hello,World"`

3. Rewrite the following function, using `foldr` instead of explicit recursion. The function removes duplicate elements from a sorted list:

```
removeDups :: [Integer] -> [Integer]
removeDups [] = []
removeDups [x] = [x]
removeDups (x:y:ys) | x == y = removeDups (y:ys)
                    | otherwise = x:removeDups (y:ys)
```

---

<sup>2</sup>Actually the prelude function `foldr` has a more general type. However, applied to lists its type can be described in this concrete version.