Data Types in Haskell

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Outline

Type Definitions in Haskell

Partial Functions



So far we've seen a few types in Haskell:

- Int, Integer, Bool
- Char
- Lists: [Char], [a] for some a
- Tuples, e.g. ([Char], Int) or (a, b, c)
- Function types: a -> b, Int -> Int -> Int

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As well as some type *classes* like Ord or Eq or Num.

Haskell lets you define your own types too:

```
data Suit = Hearts | Spades | Clubs | Diamonds
data Rank = A | K | Q | J | Ten | Nine | ...
data Card = Card Suit Rank
```

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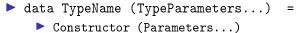
More Examples

```
data Nat = 0 | S Nat
data MyList a = MyNil | MyCons a (MyList a)
```

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```
data SortedList a = Sorted [a]
sort :: (Ord a) => [a] -> Sorted [a]
```

Syntax



Constructor (Parameters...)

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- 1. Define a datatype for days of the week.
- 2. Define a datatype for class meeting times (e.g. CSCI 054 meets on Mondays and Wednesdays from hour 13, minute 15 until hour 14, minute 30).
- 3. Define a datatype for a class, including its name and meeting times.

Matching

Remember from earlier in the course: construction is dual to matching!

is_face_card (Card _ K) = True is_face_card (Card _ Q) = True is_face_card (Card _ J) = True is_face_card _ = False

Matching

```
insert x (Sorted []) = Sorted [x]
insert x (Sorted (y:1))
| x <= y = Sorted (x:y:1)
| otherwise = let Sorted s = insert x (Sorted 1) in Sorted
```

This tells the caller—if you assume insert is correct, and you have evidence 1 is sorted, the output will also give you evidence 1 is sorted.



Write a function using your class datatype from the earlier exercise to calculate how many minutes of time you meet for a class during the week.

You can write a helper function if you want.

contact_minutes :: Class -> Int

Remember this function?

list_min [] = error "oh no" list_min [x] = x list_min (x:xs) = min x (list_min xs)

It's very unsatisfying that it crashes on an empty list.

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Maybe

I prefer this one:

```
list_min :: (Ord a) => [a] -> Maybe a
list_min [] = Nothing
list_min (x:xs) =
  case list_min xs of
   Nothing -> Just x
   Just rest -> min x rest
```

Haskell's Maybe a type has two variants: Nothing and Just a. (Some programming language libraries call this type Option, with variants None and Some.)

Maybe

Our new list_min can never throw an error, no matter what list we give it. But the tradeoff is that now we need to write a case around the call to list_min:

```
case list_min l of
Nothing -> "Empty list"
Just x -> "Smallest element found"
```

Still, it's much better to have to write error handling code than to maybe crash sometimes.

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If we were very sure the list weren't empty, we could define:

```
unwrap :: Maybe a -> a
unwrap (Just x) = x
unwrap Nothing = error "empty Maybe!"
```

(unwrap (list_min [1,2,3])) * 2

But we can also do work on the Maybe, to avoid excessive unwrapping:

```
fmap (x \rightarrow x * 2) (list_min 1)
```

This will return double the minimum element of 1 if it exists (as Just 14 or whatever), or else Nothing if there was no minimum element.

It's a lot like map for lists, but for arbitrary mappable types.

<code>Implement find_by :: (a -> Bool) -> [a] -> Maybe a, which returns the first a in the list satisfying the test. It's ok to use either filter or recursion.</code>

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Either

In case a computation might fail in more than one way, Haskell also provides Either:

data Either a b = Left a | Right b
For example, reading a file from disk might give Left String or
Right FileNotFound or Right FileAccessForbidden error or
Right FileTooBig, from a type like:
data FileReadError = FileNotFound |
FileAccessForbidden | FileTooBig | ...
Some languages call this type Result with variants Ok, Err.

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$\mathsf{find}_{\mathsf{uniqueby}}$

Given the error type data FindError a = EmptyList | NotUnique([a]), define find_unique_by :: (a -> Bool) -> [a] -> Either a (FindError a), which returns one of:

- 1. The first found element in the list, if it's the only one passing the test;
- 2. Right EmptyList, if the list is empty; or
- 3. Right NotUnique(dupes) if there is more than one element that passes the test.

Either

We can also define tools like fmap for Either, that do things like "map the Right variant to a different type", or "map the Left a variant to an Either c d, producing either Left c or Right d depending on the result", or "If this is a Left x, produce Just x, otherwise produce Nothing".

These *combinators* can be really useful for avoiding code with lots of cases and ifs! You can code on the error-free path for the most part using combinators, and handle errors at the end of the chain.

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