Elm Introduction
Functional Programming

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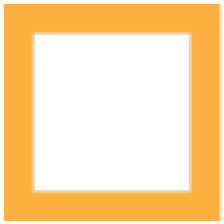

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Spring 2018

Outline

Imperative programming

Instructing program state

Imperative programming

Instructing program state

- State

Imperative programming

Instructing program state

- State
- Statements (action of stating)

Procedural programming

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Imperative programming (can) lack structure

Procedural programming

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Imperative programming (can) lack structure

- Procedures group statements

Procedural programming

Imperative programming (can) lack structure

- Procedures group statements
  == blocks

Procedural programming

Imperative programming (can) lack structure

- Procedures group statements
  == blocks == modules

Procedural programming

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Imperative programming (can) lack structure

- Procedures group statements
  == blocks == modules == functions (not mathematical)
- Scope

Structures procedures using objects

Object oriented programming

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Structures procedures using objects

- Objects

Object oriented programming

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Structures procedures using objects

- Objects
- Classes

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- Objects
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- Types

Object oriented programming

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Structures procedures using objects

- Objects
- Classes
- Types (broken)

Object oriented programming

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Structures procedures using objects

- Objects
- Classes
- Types (broken)
- Inheritance and delegation

Object oriented programming

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Structures procedures using objects

- Objects
- Classes
- Types (broken)
- Inheritance and delegation
- Polymorphism

Object oriented programming

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Structures procedures using objects

- Objects
- Classes
- Types (broken)
- Inheritance and delegation
- Polymorphism
- Exceptions as control structures

Exercise 1 - Broken Java

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Clone the `java-exercises` from `cphbus-functional-programming`

`https://github.com/cphbus-functional-programming/java-exercises`

Work on the `FixMe` files in the `breakingjava` folder

Goal: Fix the broken code *without compiling it*!

Untouched by the above misery

Untouched by the above misery

- Types

Functional programming

Untouched by the above misery

- Types
- Pure functions (no side-effects)

Functional programming

Untouched by the above misery

- Types
- Pure functions (no side-effects)
- Recursion

Functional programming

Untouched by the above misery

- Types
- Pure functions (no side-effects)
- Recursion
- Higher-order functions

In Java

```
Person p = null;
```

Types

In Java

```
Person p = null;
```

In Elm

```
Person p = Person "Hermann Minkowski"
```

In Java

```
Person doSomething() {
  fireNuclearMissiles();
  return new Person("Robby the Robot")
}
```

Side-effects

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In Java

```
Person doSomething() {
  fireNuclearMissiles();
  return new Person("Robby the Robot")
}
```

In Elm

```
doSomething : Person
doSomething = Person "Isaac Asimov"
```

Exceptions

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In Java

```
Person doSomething() {
  throw new RuntimeException("I'm␣unchecked!");
}
```

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In Java

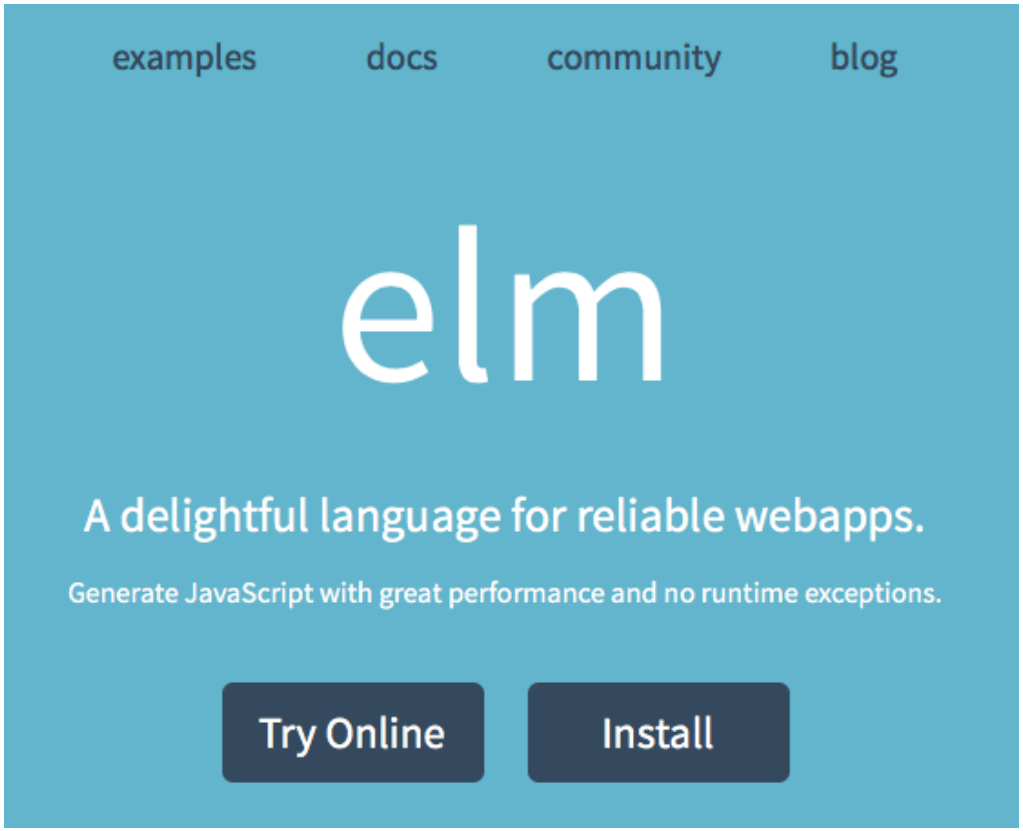
```
Person doSomething() {
  throw new RuntimeException("I'm unchecked!");
}
```

In Elm

```
doSomething : Either String Person
doSomething = Left "'Elp!"
```

Elm website

Go to `http://elm-lang.org`
Select install



Elm command line tools

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- `elm-repl` — play with Elm expressions
- `elm-reactor` - get a project going quickly
- `elm-make` - compile Elm code directly
- `elm-package` - download packages

Atom packages

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language-elm 1.5.0 — 35,190

Syntax highlighting and autocompletion for the language Elm


edubkendo

Uninstall | Disable

linter-elm-make 0.22.5 — 27,383

Lint Elm code with elm-make


mybuddymichael

Uninstall | Disable

save-commands 0.6.11 — 2,929

Package for Atom. Assign parametrized shell commands to file globs to be automatically run whenever the file is saved


JsonHunt

Uninstall | Enable

Elm css packages

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See: https://github.com/rtfeldman/elm-css

```
$ npm install -g elm-css
$ git clone https://github.com/rtfeldman/elm-css.git
$ cd elm-css/examples
$ elm-css src/Stylesheets.elm
$ less homepage.css

elm package install rtfeldman/elm-css-helpers
```

Project structure

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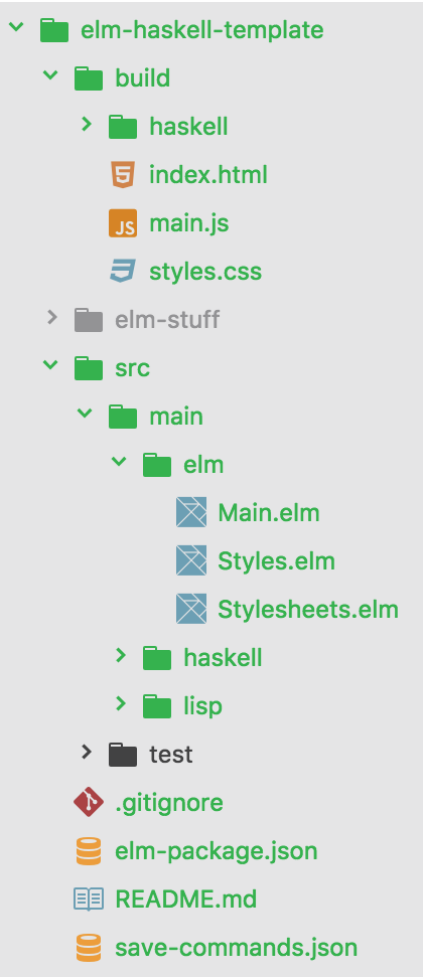
Structure of the elm-haskell-template



index.html

```
<!DOCTYPE html>
<html lang="en">
  <head>
      <meta charset="UTF-8">
      <title>Title</title>
      <link rel="stylesheet"
        href="styles.css"
        type="text/css">
      <script src="main.js"></script>
  </head>
  <body>
    <script type="text/javascript">
      Elm.Main.fullscreen()
    </script>
  </body>
</html>
```

save-commands Script

- src/main/elm/**/*.elm

```
elm make src/main/elm/Main.elm
-output=build/main.js
```

- src/main/elm/Styles.elm

```
elm-css src/main/elm/Stylesheets.elm -output
build
```

- src/main/haskell/**/*.hs

```
ghc -make src/main/haskell/Main.hs -o
build/haskell/main
```

Values

- Strings
  - `"Hello"`
  - `"Hello"++" "++"World!"` is `"Hello World!"`
- Numbers
  - `7`
  - `22.67`
  - `2 + 3 * 4` is `14`
  - `9/2` is `4.5`
  - `9//2` is `4`

Functions

```
> isNegative n = n < 0
<function>

> isNegative 4
False

> isNegative -7
True

> isNegative (-3 * -4)
False
```

Selections


```
> if True then "hello" else "world"
"hello"

> if False then "hello" else "world"
"world"
```

Lists

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```
> names = [ "Alice", "Bob", "Chuck" ]
["Alice","Bob","Chuck"]

> List.isEmpty names
False

> List.length names
3

> List.reverse names
["Chuck","Bob","Alice"]
```

Lists

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```
> numbers = [1,4,3,2]
[1,4,3,2]

> List.sort numbers
[1,2,3,4]

> double n = n * 2
<function>

> List.map double numbers
[2,8,6,4]
```

Tuples

```
> import String

> goodName name = \
|    if String.length name <= 20 then \
|      (True, "name␣accepted!") \
|    else \
|      (False, "name␣was␣too␣long")

> goodName "Tom"
(True, "name␣accepted!")
```

Records


```
> point = { x = 3, y = 4 }
{ x = 3, y = 4 }

> point.x
3

> bill = { name = "Gates", age = 57 }
{ age = 57, name = "Gates" }

> bill.name
"Gates"
```

Records

```
> .name bill
"Gates"

> List.map .name [bill,bill,bill]
["Gates","Gates","Gates"]

> { bill | name = "Nye" }
{ age = 57, name = "Nye" }

> { bill | age = 22 }
{ age = 22, name = "Gates" }
```

Records

```
> under70 {age} = age < 70
<function>

> under70 bill
True

> under70 { species = "Triceratops", age = 68000000 }
False
```

Primitives and Lists

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```
> "hello"
"hello" : String

> not True
False : Bool

> round 3.1415
3 : Int
```

```
> [ "Alice", "Bob" ]
[ "Alice", "Bob" ] : List String

> [ 1.0, 8.6, 42.1 ]
[ 1.0, 8.6, 42.1 ] : List Float

> []
[] : List a
```

Functions

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```
> import String
> String.length
<function> : String -> Int

> String.length "Supercalifragilisticexpialidocious"
34 : Int

> String.length [1,2,3]
-- error!

> String.length True
-- error!
```

Lambdas - anonymous functions

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```
> \n -> n / 2
<function> : Float -> Float

> (\n -> n / 2) 128
64 : Float

> oneHundredAndTwentyEight = 128.0
128 : Float

> half = \n -> n / 2
<function> : Float -> Float

> half oneHundredAndTwentyEight
64 : Float

> half n = n / 2
<function> : Float -> Float
```

Functions with more arguments

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```
> divide x y = x / y
<function> : Float -> Float -> Float

> divide 3 2
1.5 : Float

> divide x = \y -> x / y
<function> : Float -> Float -> Float

> divide = \x -> (\y -> x / y)
<function> : Float -> Float -> Float
```

Functions - again

```
divide 3 2
```

Functions - again

```
divide 3 2
```

```
(divide 3) 2                    -- 1: Implicit parentheses
```

Functions - again

```
divide 3 2
```

```
(divide 3) 2                          -- 1: Implicit parentheses
```

```
((\x -> (\y -> x / y)) 3) 2 -- 2: Expand 'divide'
```

Functions - again

```
divide 3 2
```

```
(divide 3) 2                          -- 1: Implicit parentheses
```

```
((\x -> (\y -> x / y)) 3) 2 -- 2: Expand 'divide'
```

```
(\y -> 3 / y) 2                       -- 3: Replace x with 3
```

Functions - again

```
divide 3 2
```

```
(divide 3) 2                          -- 1: Implicit parentheses
```

```
((\x -> (\y -> x / y)) 3) 2 -- 2: Expand 'divide'
```

```
(\y -> 3 / y) 2                       -- 3: Replace x with 3
```

```
3 / 2                                 -- 4: Replace y with 2
```

Functions - again

```
divide 3 2
```

```
(divide 3) 2                          -- 1: Implicit parentheses
```

```
((\x -> (\y -> x / y)) 3) 2 -- 2: Expand 'divide'
```

```
(\y -> 3 / y) 2                       -- 3: Replace x with 3
```

```
3 / 2                                 -- 4: Replace y with 2
```

```
1.5                                   -- 5: Do the math
```

Type annotations

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```
half : Float -> Float
half n =
  n / 2

divide : Float -> Float -> Float
divide x y =
  x / y

askVegeta : Int -> String
askVegeta powerLevel =
  if powerLevel > 9000 then
    "It's over 9000!!!"
  else
    "It is " ++ toString powerLevel ++ "."
```

Exercise 2 - Fibonacci numbers

$$fib(n) = \begin{cases} 0 & n = 0 \\ 1 & n = 1 \\ fib(n-1) + fib(n-2) & n > 1 \end{cases}$$

- Define a function recursively that calculates the fibonacci number of n

Exercise 2 - Fibonacci numbers

$$fib(n) = \begin{cases} 0 & n = 0 \\ 1 & n = 1 \\ fib(n-1) + fib(n-2) & n > 1 \end{cases}$$

- Define a function recursively that calculates the fibonacci number of n
- Define an **effective** recursive function for the problem

If statements

```
> if True then "hello" else "world"
```

```
if 10 == 10 then "hi"
```

If statements

```
> if True then "hello" else "world"
```

```
if 10 == 10 then "hi"
```

Won't compile!

If statements

```
> if True then "hello" else "world"
```

`if 10 == 10 then "hi"` **Won't compile!** `if 10 == 10 then "hi" else "ho"`

If statements

```
> if True then "hello" else "world"
```

`if 10 == 10 then "hi"` **Won't compile!** `if 10 == 10 then "hi" else "ho"`

Remember that **everything must have a return type**!

case matches

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```
case n of
  0 -> "Zero"
  1 -> "One"
  _ -> "Moar"
```

case matches


```
case n of
  0 -> "Zero"
  1 -> "One"
  _ -> "Moar"
```

```
case n of
  0 -> "Zero"
  1 -> "One"
  2 -> "Two"
```

case matches

```
case n of
  0 -> "Zero"
  1 -> "One"
  _ -> "Moar"
```

```
case n of
  0 -> "Zero"
  1 -> "One"
  2 -> "Two"
```

Error!: this ‘case‘ does not have branches for all possibilities.

case matches

```
case n of
  0 -> "Zero"
  1 -> "One"
  _ -> "Moar"
```

```
case n of
  0 -> "Zero"
  1 -> "One"
  2 -> "Two"
```

Error!: `this ‘case‘ does not have branches for all possibilities.` Because everything has a fixed type, we *know* whether we will match everything!
This is seriously **cool**!

Debugging

How do you normally debug in Java?

Debugging

How do you normally debug in Java?
What is the problem with that in Elm?

Debugging

How do you normally debug in Java?
What is the problem with that in Elm?
Everything needs a return type. Also debugging/println/logging.

Debugging

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How do you normally debug in Java?
What is the problem with that in Elm?
Everything needs a return type. Also debugging/println/logging.
Solution is to encapsulate the side-effect:

```
import Debug

if (Debug.log "A is" a) == 10 then "hi" else "ho" -- "A
```

Exercise 4 - Elm basics

Solve each of the problems below by writing **one** function that:

- Takes a number n as its input and returns $n * 50$ as its output
- Takes a string as its input and returns the length of the string
- Takes two numbers a, b as its input and returns $a/b * 50$
- Takes two strings as its input and returns the strings concatenated