Functional Programming Concept with

Tutorial for

Programming Language Laboratory (CS 431)

July – November 2019

Functional Programming(FP)

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  - Idea originated from Lambda Calculus formalism

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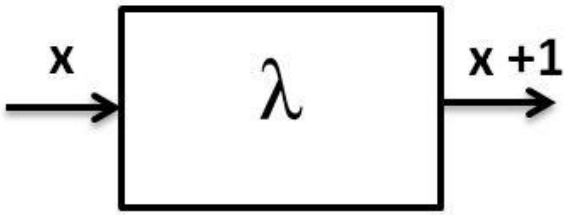

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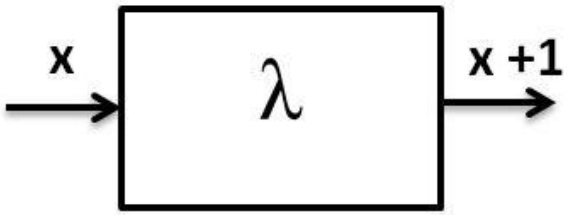

$\lambda x.\ x+1$

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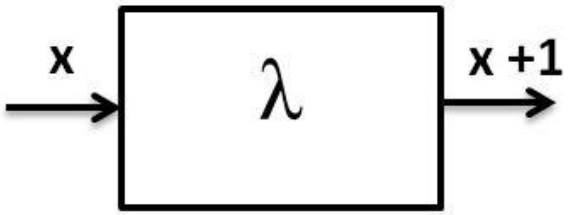

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True:

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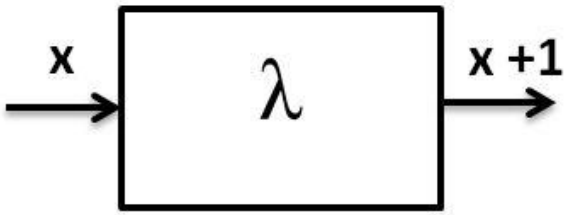

$\lambda x.\ x+1$

True: $\lambda x.\lambda y.x$

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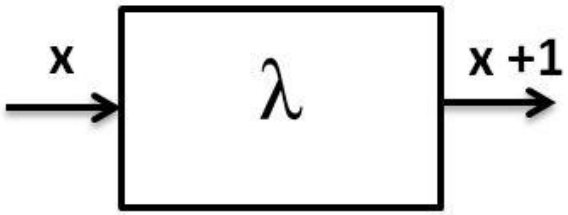

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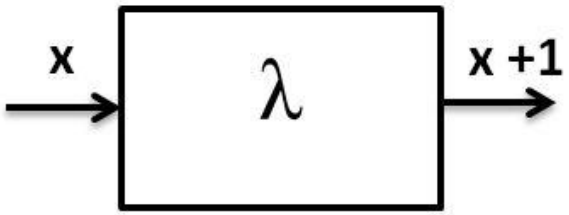

$\lambda x.\ x+1$

True: $\lambda x.\lambda y.x$

False: $\lambda x.\lambda y.y$

Functional Programming(FP)

- Key Idea - computation as ‘evaluation of mathematical functions’
  - Idea originated from Lambda Calculus formalism
- Languages that follow functional programming paradigm
  - Haskell
  - LISP
  - Python
  - Erlang
  - Racket
  - F#
  - Clojure
  - Scala

Functional Programming

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we are going with Haskell this time

Haskell

- Standardized purely functional programming language
- Named after logician and mathematician Haskell Brooks Curry
- History
  - First version (“Haskell 1.0”) was introduced in 1990
  - The latest standard of Haskell is “Haskell 2010”

Haskell - Features

- Purely functional
- Statically typed
- Type inference
- Lazy
- Concurrent
- Packages

Purely functional

- Every function in Haskell is a function in the mathematical sense (i.e., "pure")
  - The pure function returns the same output every time for the same input
  - In a pure functional language, you can't do anything that has a side effect

Purely functional

```
function impure(str: string){
        str = str + “Post”;
        print(str);
        return(str);
}
```

State of function gets changed

Ex. Impure function

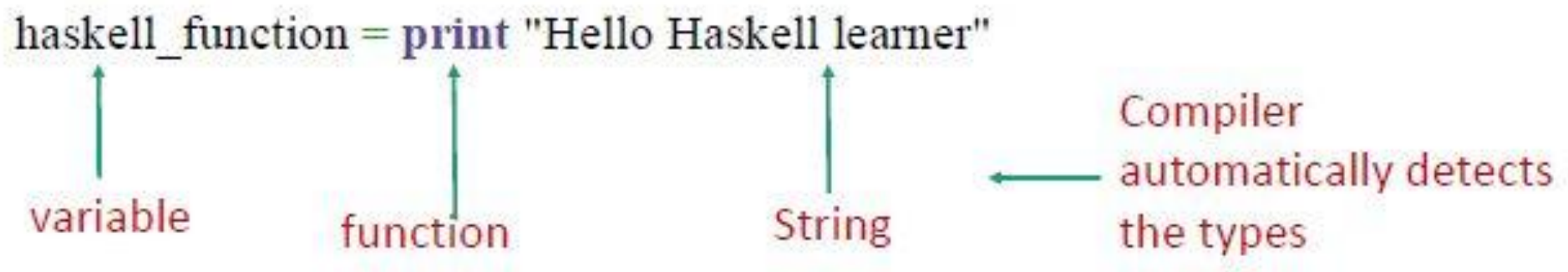
```
function impure(str: string){
        return(str + “Post”);
}
```

No change in state **Immutable**

Ex. Pure function

Statically Typed

- Every expression in Haskell has a type which compile time is determined at compile time
  - The compiler knows which piece of code is a number, which is a string and so on



Statically Typed

- All the types composed together by function application have to match up. If they don't, the program will be rejected by the compiler

- Ex. addMe :: Int -> Int -> Int ⟵ type signature or function declaration
- addMe x y = x+y ⟵ function definition

```
*Main> addMe 4 5
9
```

```
*Main> addMe 4 5.5

<interactive>:23:9: error:
    • No instance for (Fractional Int) arising from the literal '5.5'
    • In the second argument of 'addMe', namely '5.5'
      In the expression: addMe 4 5.5
      In an equation for 'it': it = addMe 4 5.5
```

Type Inference

- You don't have to explicitly label every piece of code because the type system can intelligently figure it out

  Eg. If we write a=5+4

  Haskell will automatically infer that a is a number

Lazy

- Nothing is evaluated unless it has to be

  Eg. Function call : f 5 (29^35792)

Both the x and y values are evaluated and passed to function f

Non lazy languages like C or Java

Haskell pass the arguments value as it is without doing any actual computation of 29^35792

Haskell

Saves on CPU usage and user's time!

Concurrency

- Functional programming, by its nature (lack of side effect), is suitable for parallelism
- Concurrency in Haskell is mostly done with Haskell threads
- The Glasgow Haskell Compiler (GHC), comes with concurrency library containing a number of useful concurrency primitives and abstractions technique called Software Transactional Memory (STM)
- STM is an alternative to the lock based synchronization, whose basic objective is to evaluate a set of expression in isolated manner

Haskell - Packages

- Open source contribution to Haskell is very active with a wide range of packages available on the public package servers
- There are 6,954 packages freely available; for instances

bytestring	Binary data	base	Prelude, IO, threads
network	Networking	text	Unicode text
parsec	Parser library	directory	File/directory
hspec	RSpec-like tests	attoparsec	Fast parser
monad-logger	Logging	persistent	Database ORM
template-haskell	Meta-programming	tar	Tar archives

Haskell - Application

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- facebook anti-spam programs

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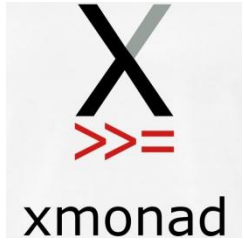
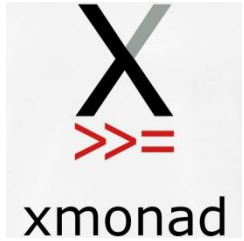


Haskell - Application

- facebook anti-spam programs
- 

a window manager for the X Window System

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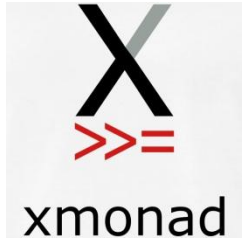
- 

a window manager for the X Window System

darcs

Haskell - Application

- facebook anti-spam programs
- xmonad a window manager for the X Window System
- darcs a revision control system

Some other FP Applications

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- 

Scala

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Erlang

Some other FP Applications

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Erlang
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Lisp

Haskell

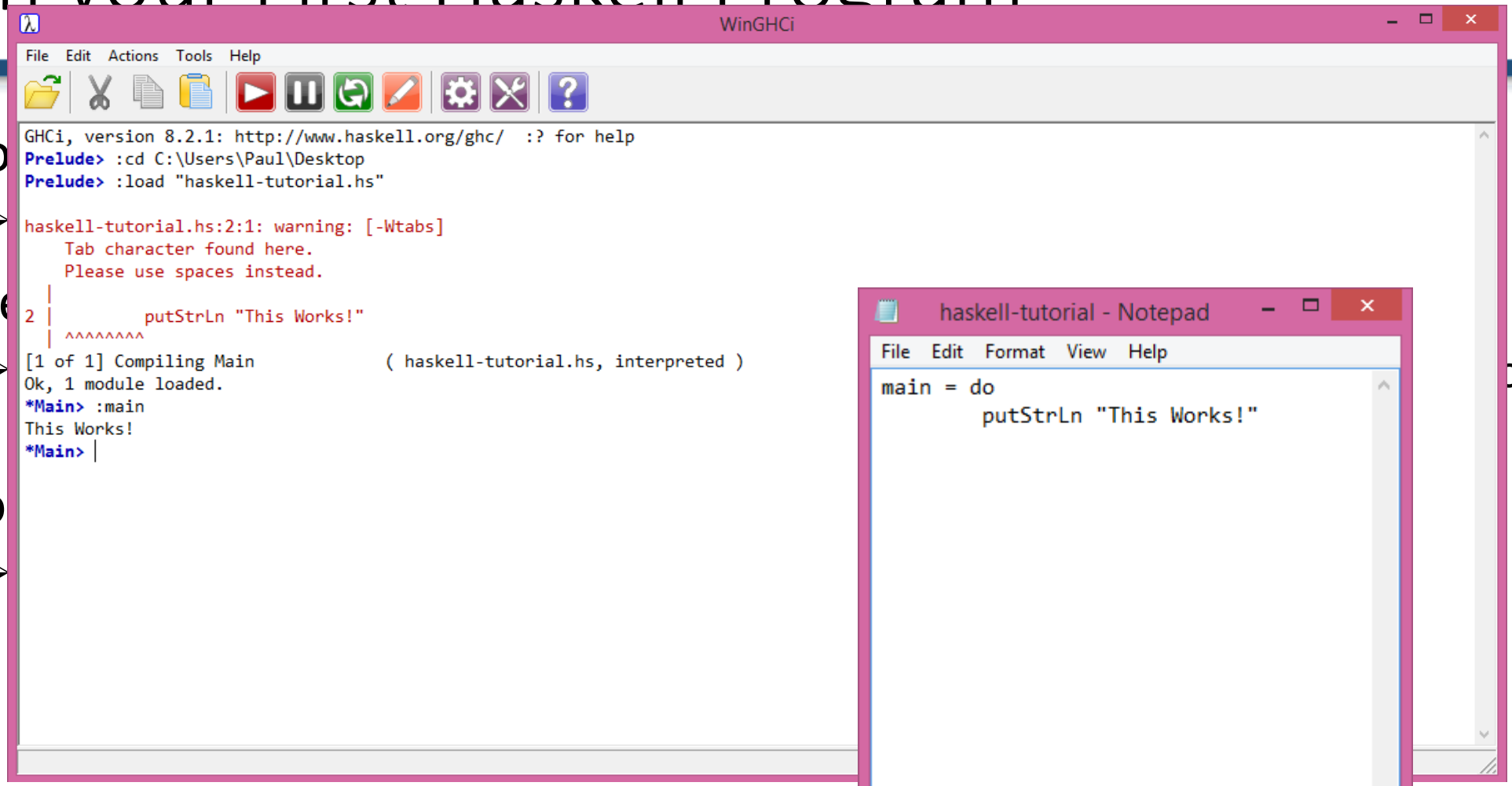
Lets try to understand basic features of Haskell with examples

Run your First Haskell Program

- Download and Install Haskell
  - Download link https://www.haskell.org/downloads
- File extension .hs
  - Open text editor, write your program, save your program with .hs extension (e.g., haskell-tutorail.hs)
- Compilation and Run
  - For Windows OS
    - Open WinGHCi from start menu
    - Load your program (File -> Load..)
    - Run the function you want

Run your First Haskell Program

- Do
  -
- File
  -
- Co
  -



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- File extension .hs
  - Open text editor, write your program, save your program with .hs extension (e.g., haskell-tutorail.hs)
- Compilation and Run
  - Otherwise
    - Open GHCi
    - Enter into directory where you saved your program (:cd C:\Users\Paul\Desktop)
    - Load your program (:load "haskell-tutorial.hs")
    - Run the function you want

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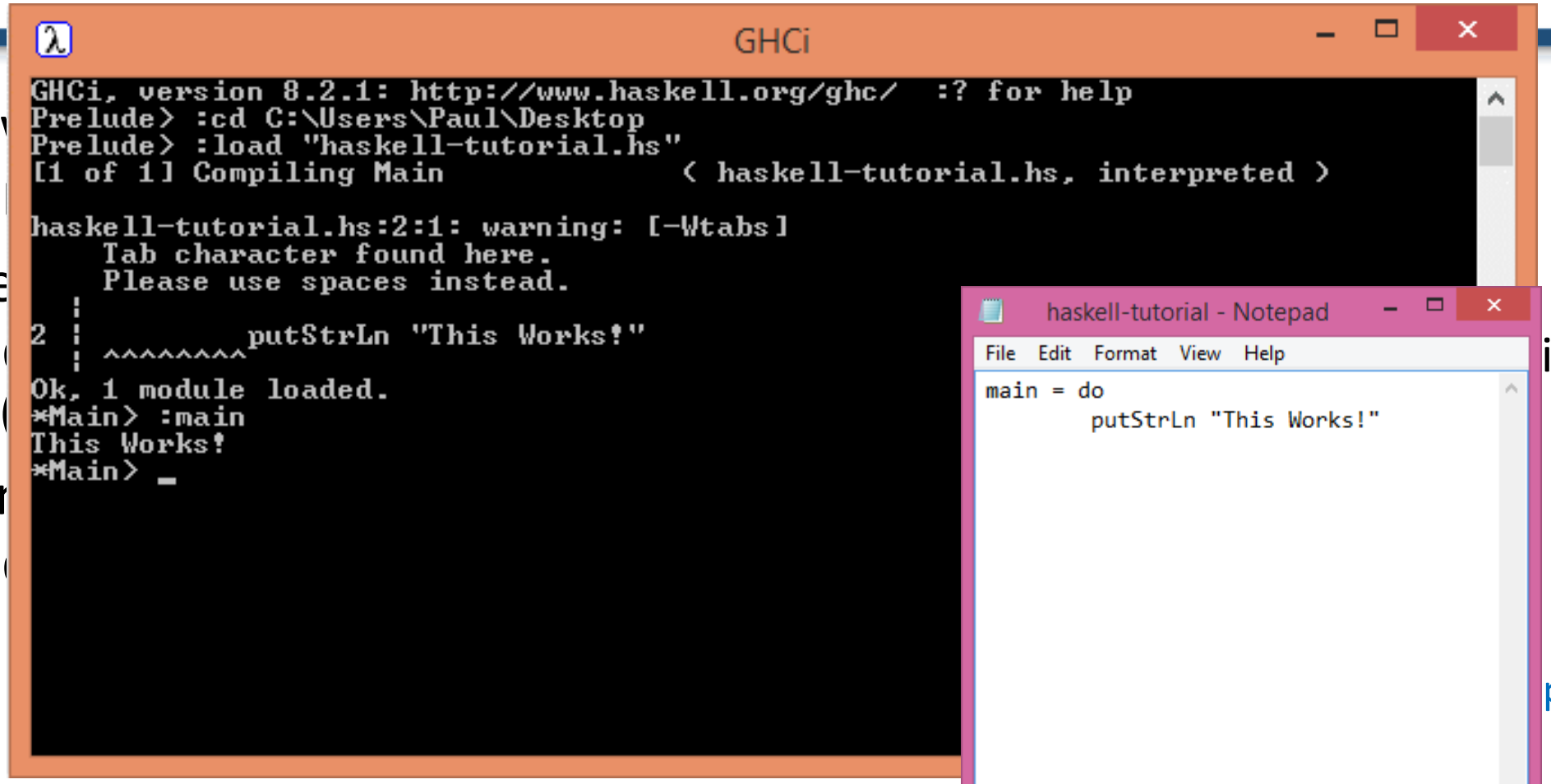


ion

p)

- Run the function you want

Few things you may keep in mind

- Once you modify your program
  - Save it
  - Before running its function, recompile it - reload (*main> :r)
- Comment Line
  - --Comment
  - {-
    Multiple Comments
    -}
- Clear Screen
  - Ctrl+S

Date Types

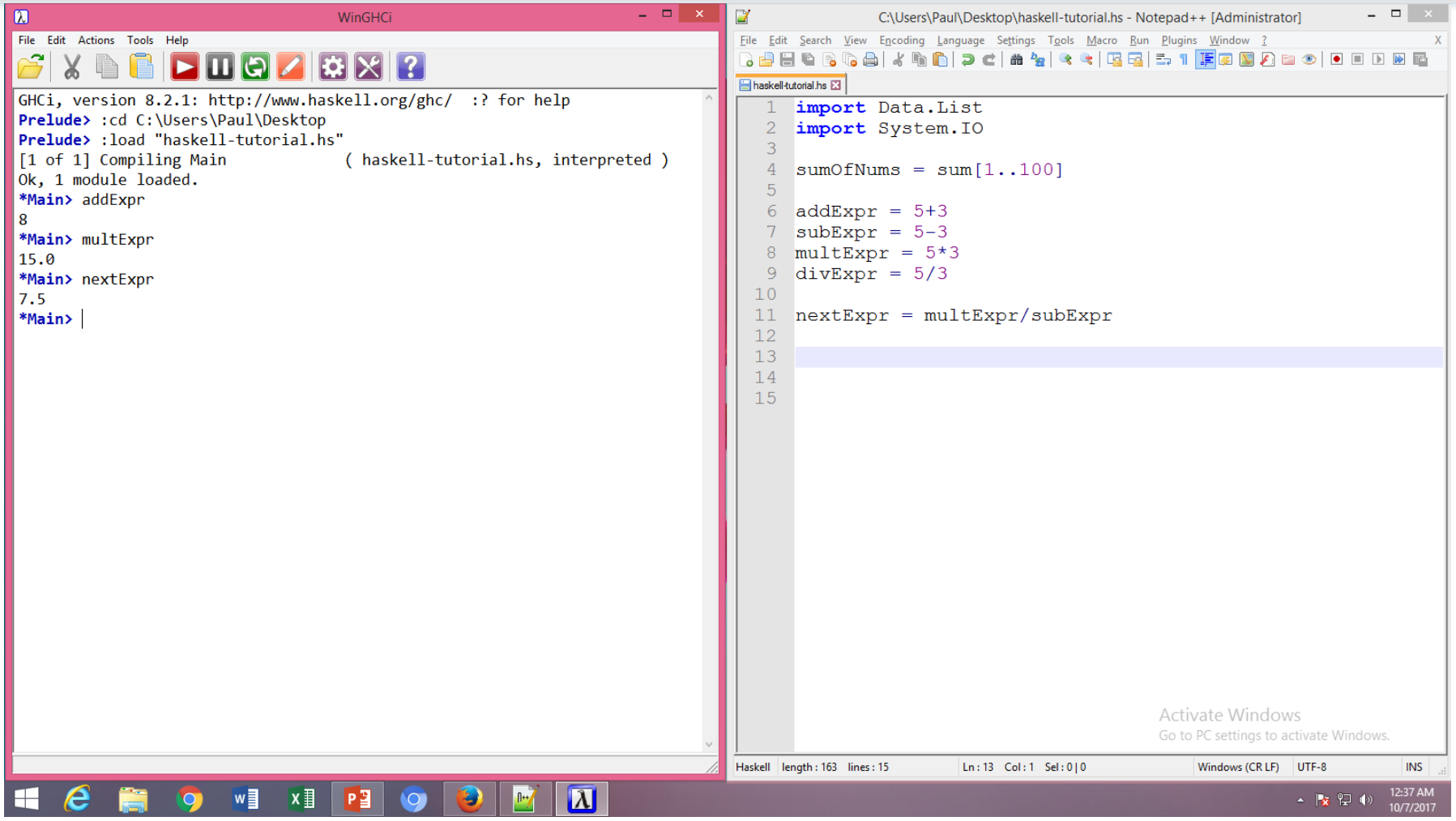
- Haskell uses type inference
  - Range of ‘Int’: -2^63 to 2^63
  - Range of ‘Integer’: Unbound -- as per the capability of memory of the system
  - Other data types: Float,Double, Bool, Char, Tuple -- will be discussing with example
  - permanent3 :: Int

    permanent3 = 3

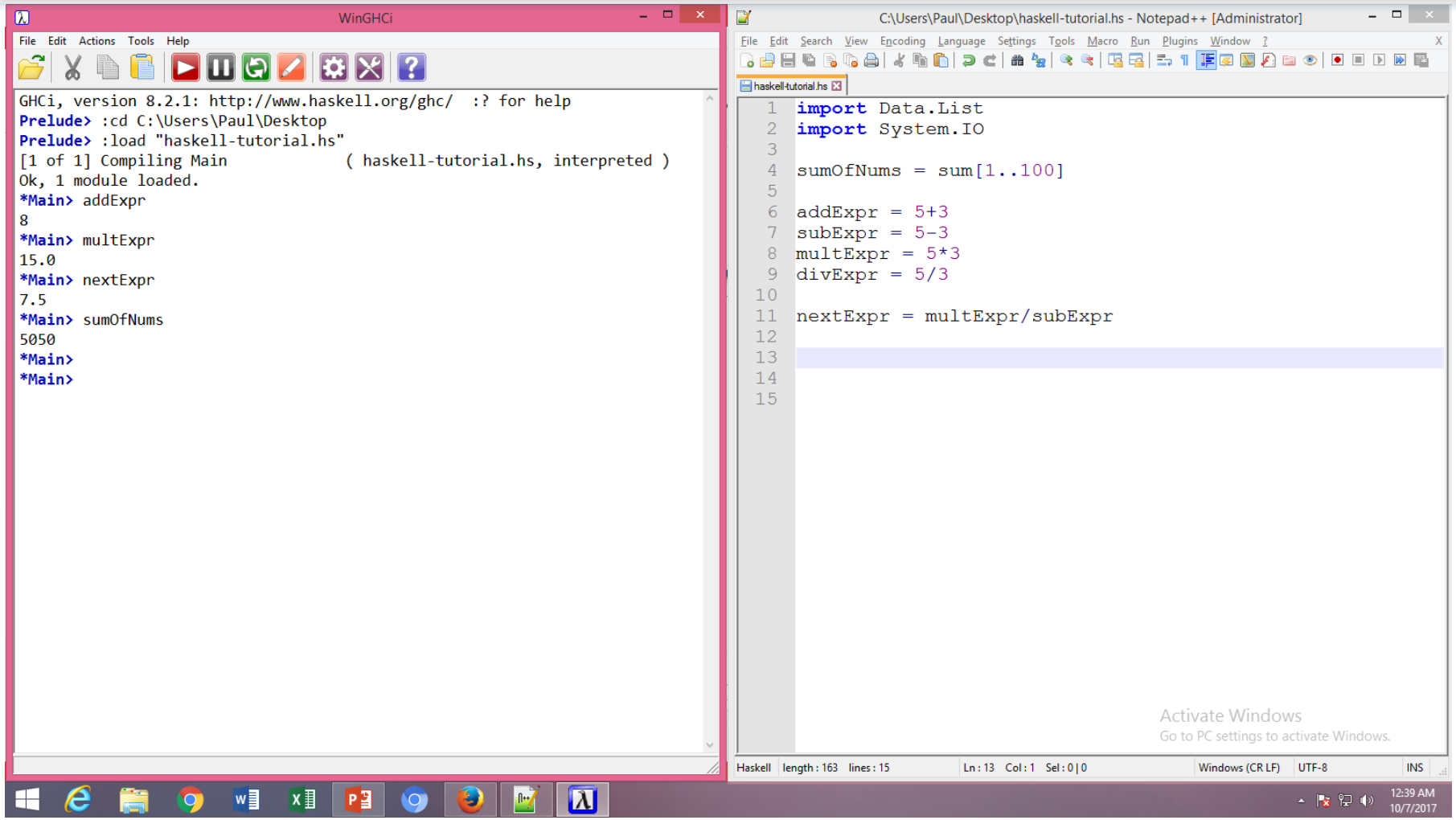
    permanent value for a variable

    --Never Change

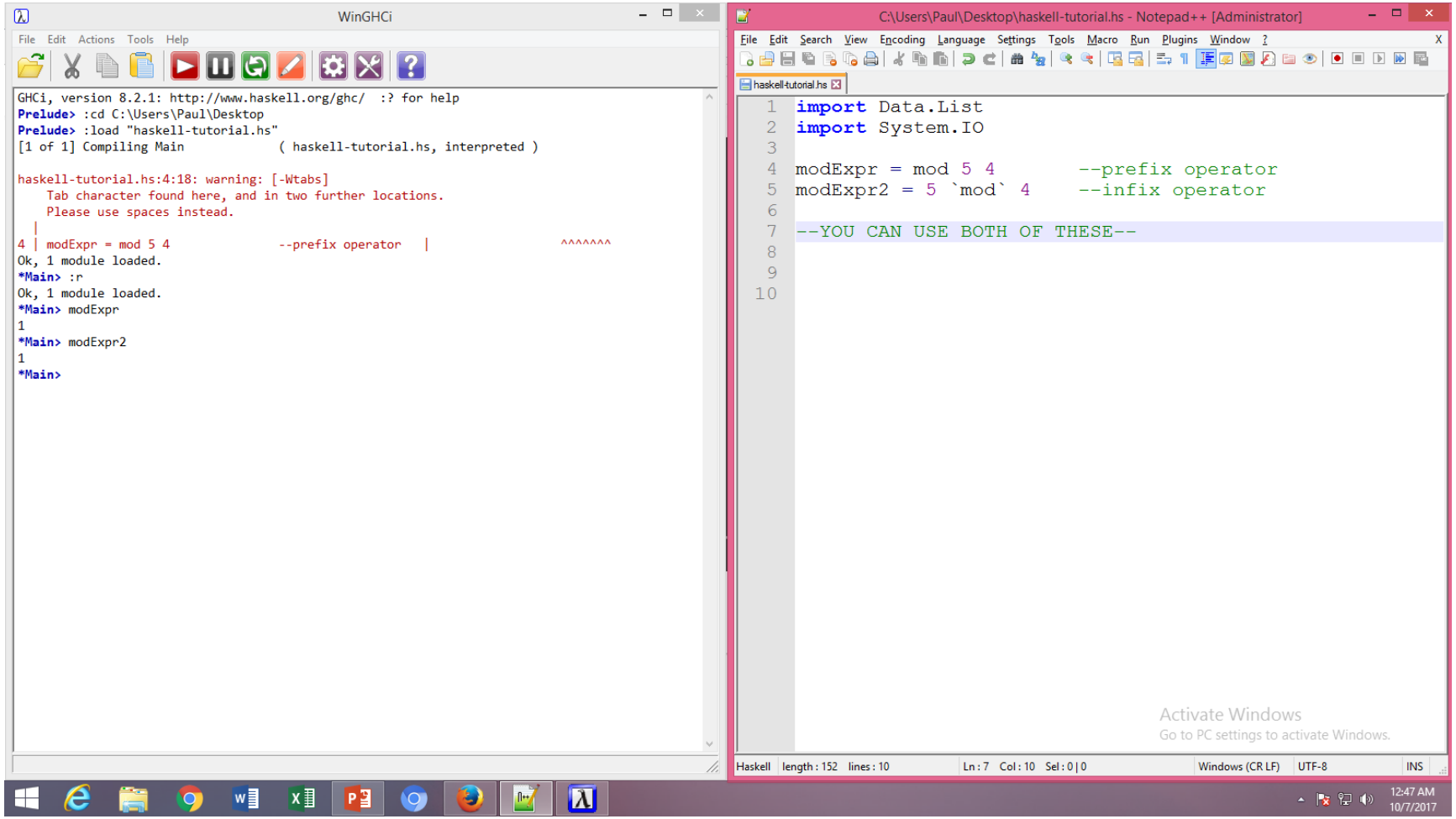
Expressions



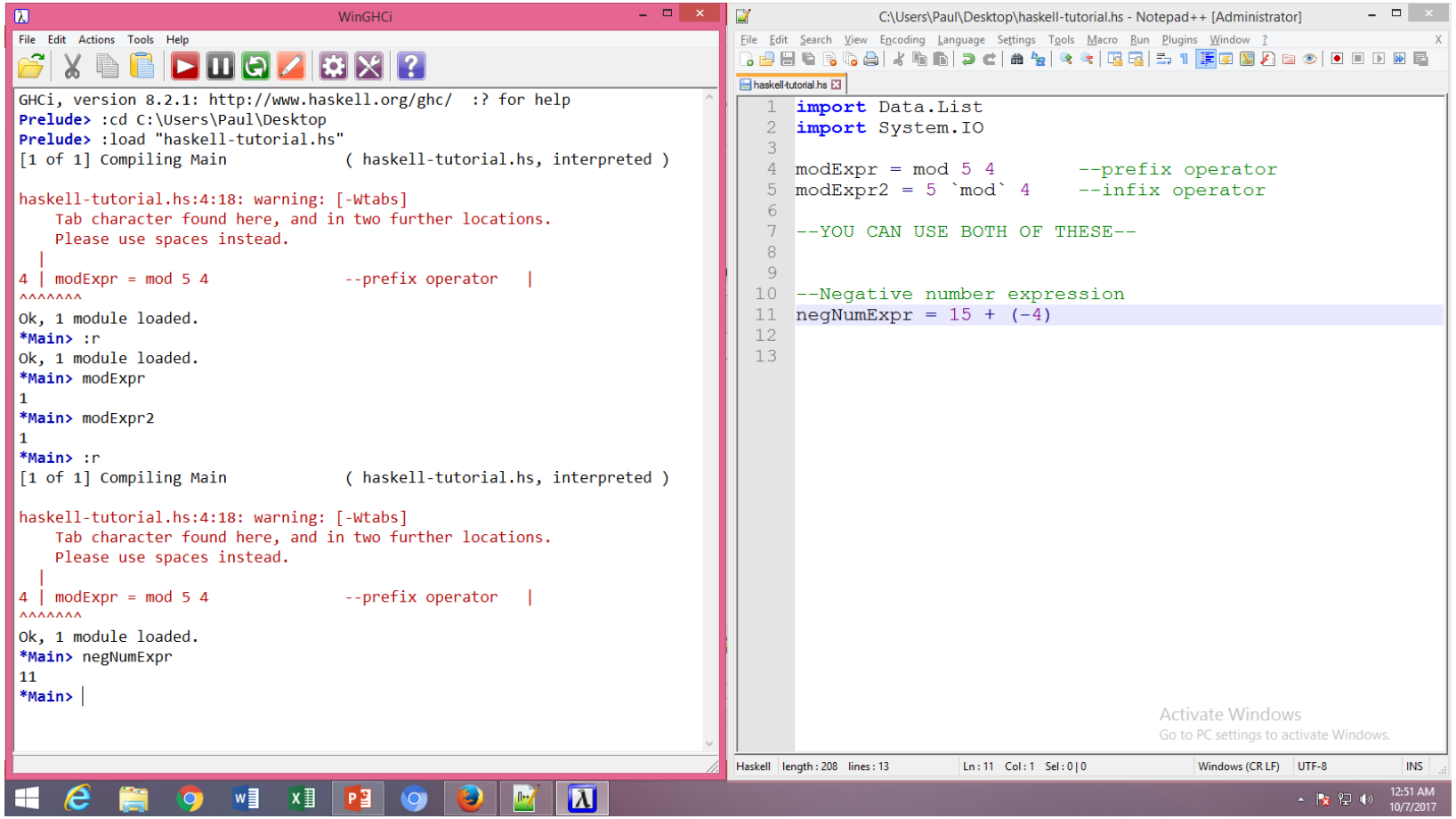
Expressions



Infix and Prefix Operator



Negative Number Expression



Other built-in Math Function

- piVal = pi
- ePow9 = exp 9
- logOf9 = log 9
- Squared9 = 9 ** 2
- truncateVal = truncate 9.999
- roundVal = round 9.999
- ceilingVal = ceiling 9.999
- floorVal = floor 9.999
- Also
  - sin, cos, tan, asign, acos, atan, signh, cosh, tanh, asignh, acosh, atanh

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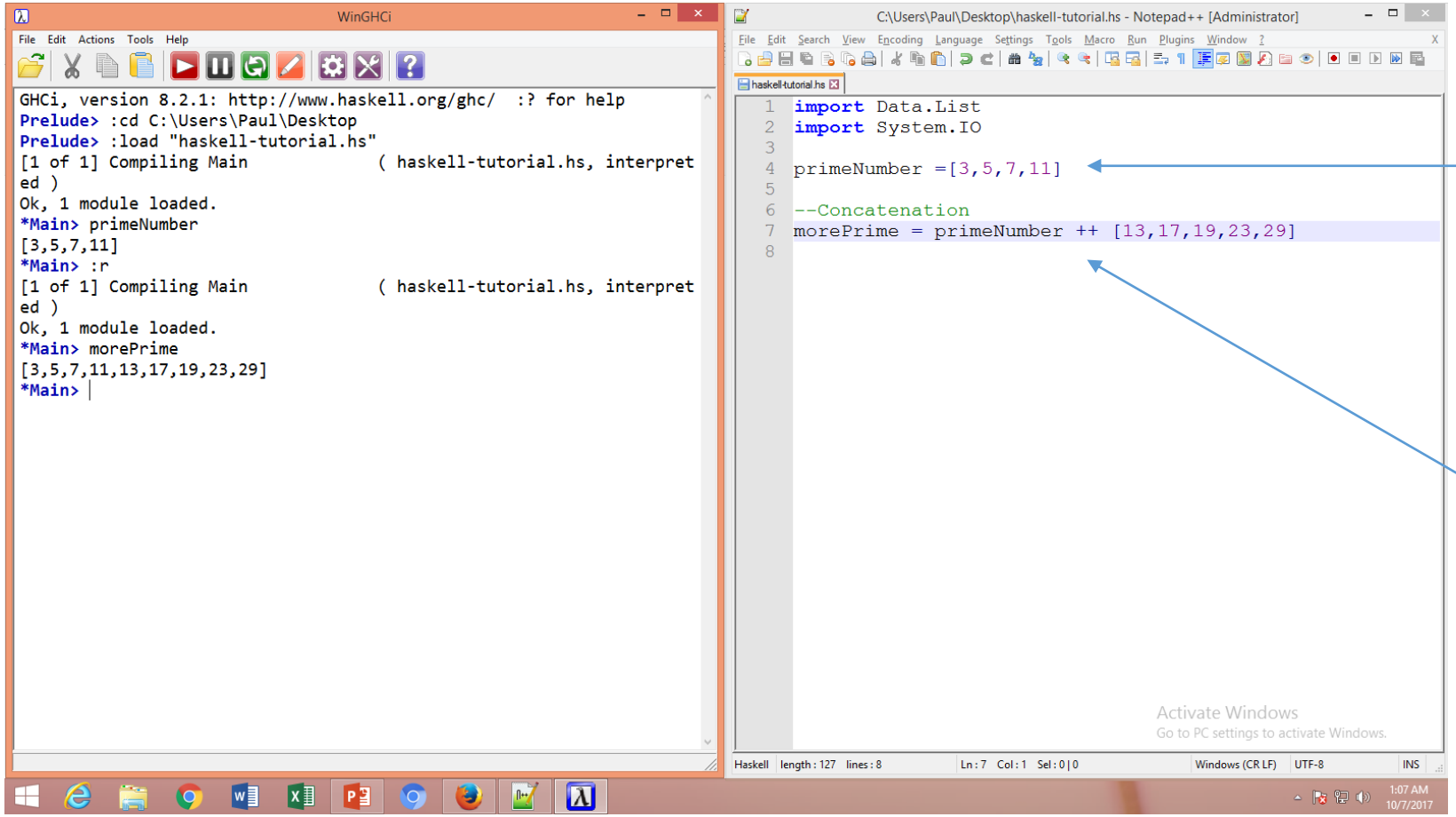
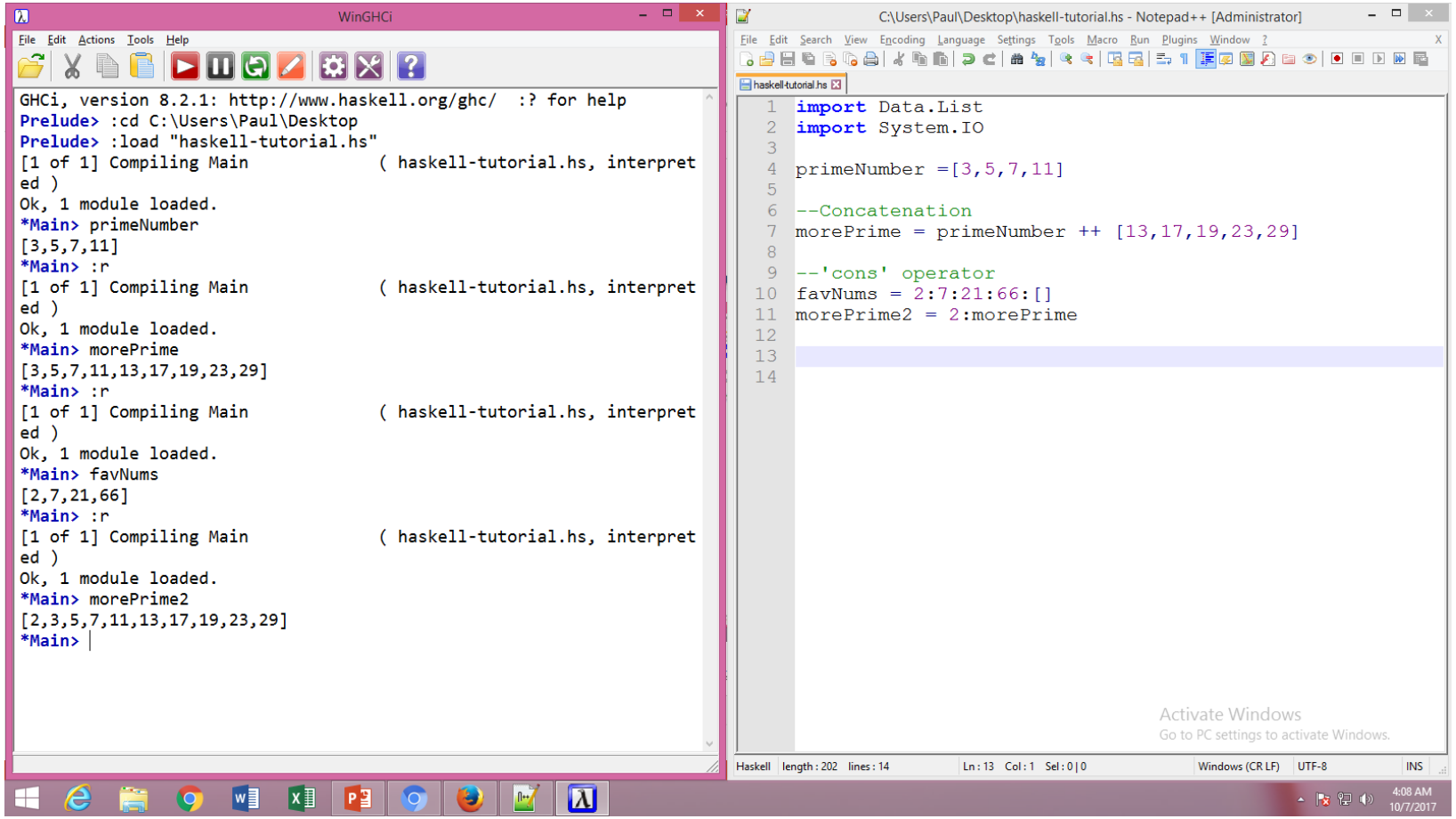
EXPLORE THESE

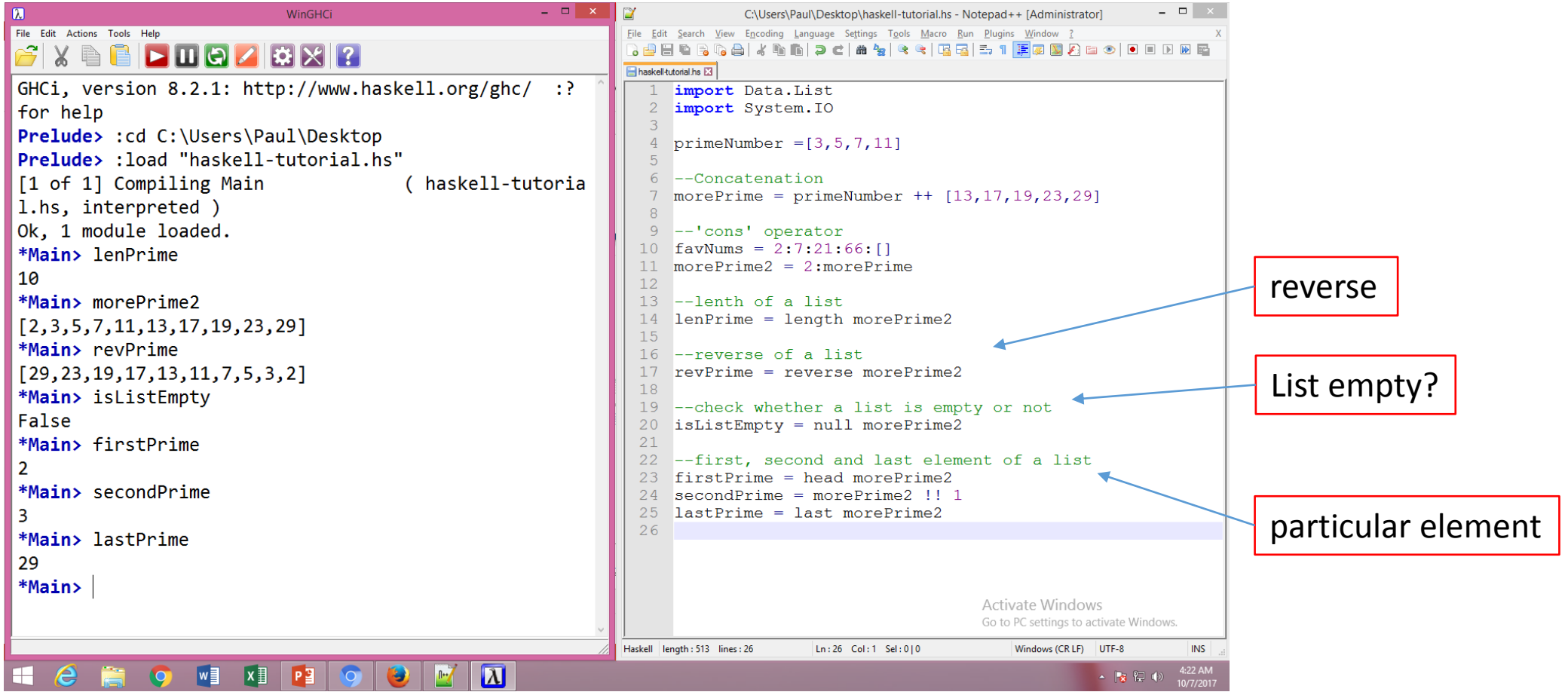
List - Concatenation



List – ‘cons’ operator



More Operations on List



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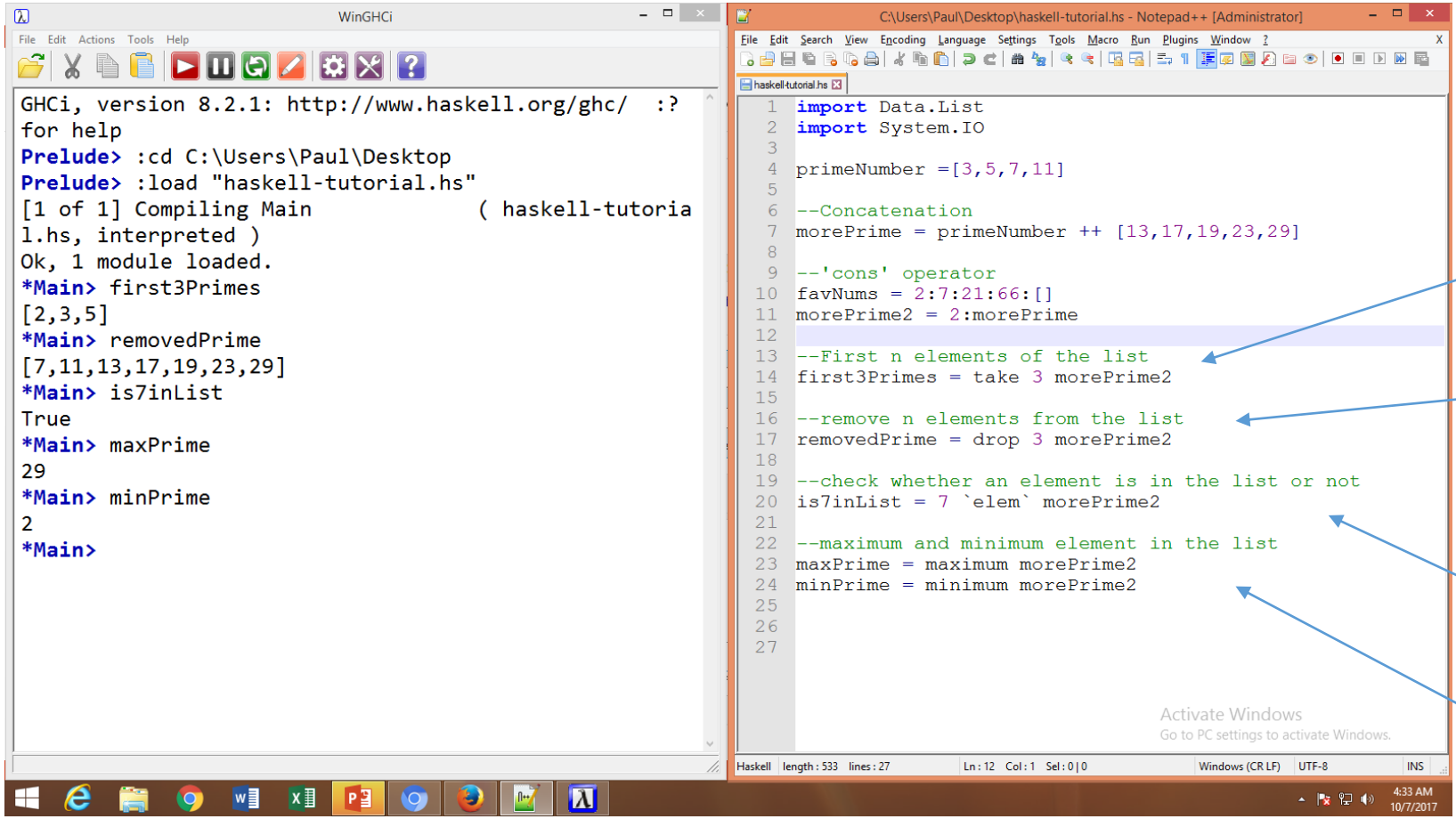

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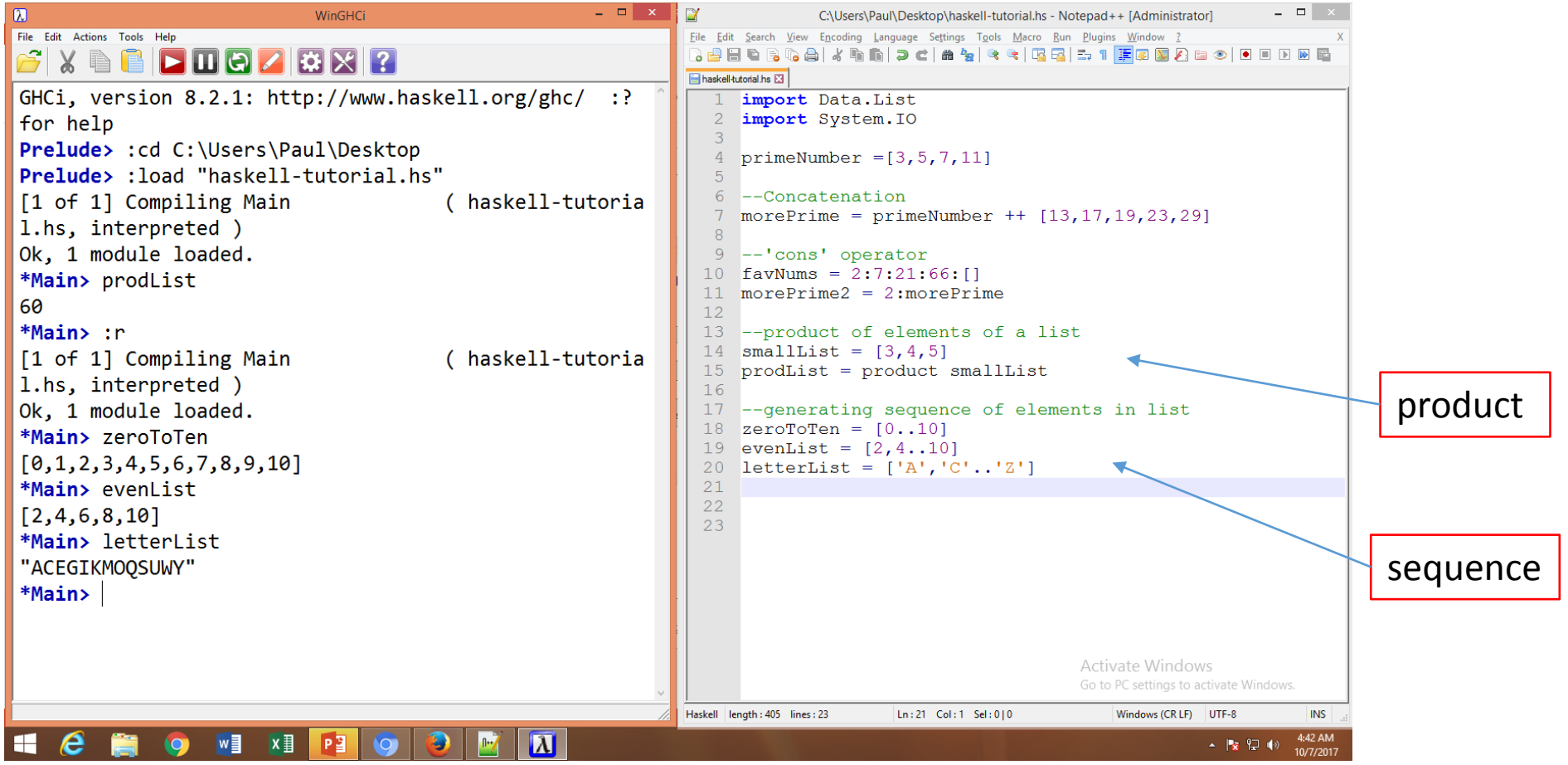

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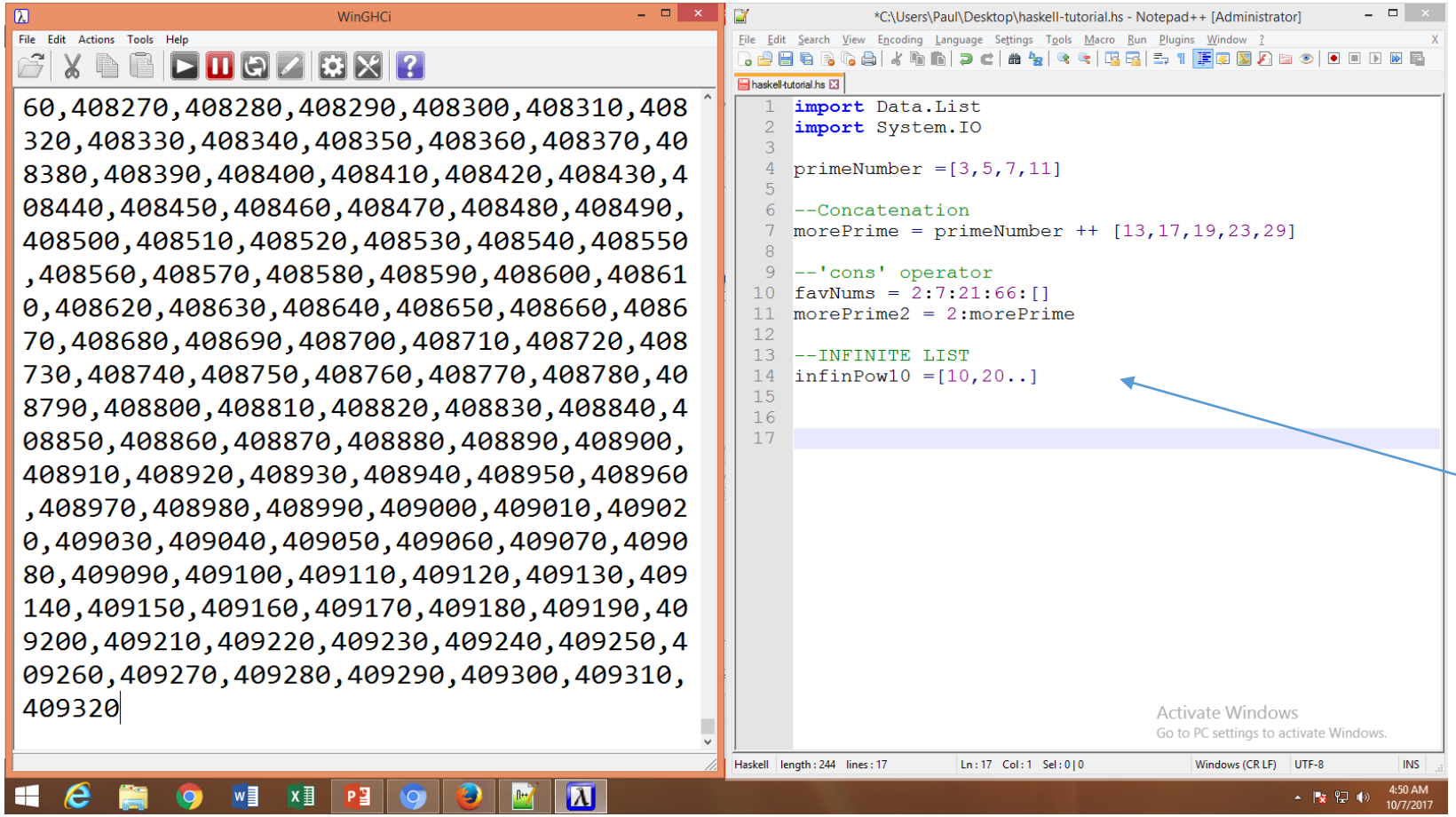

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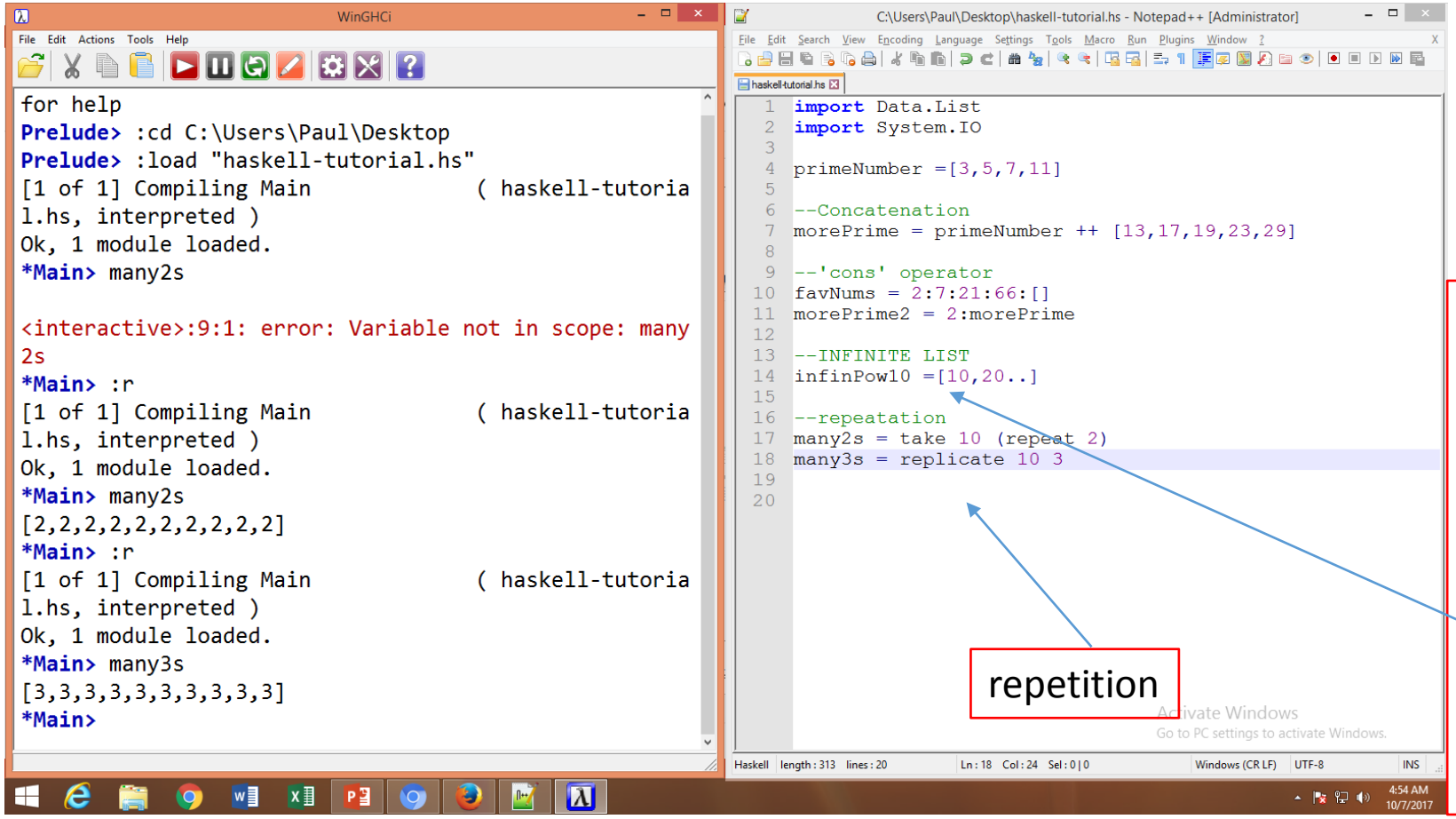
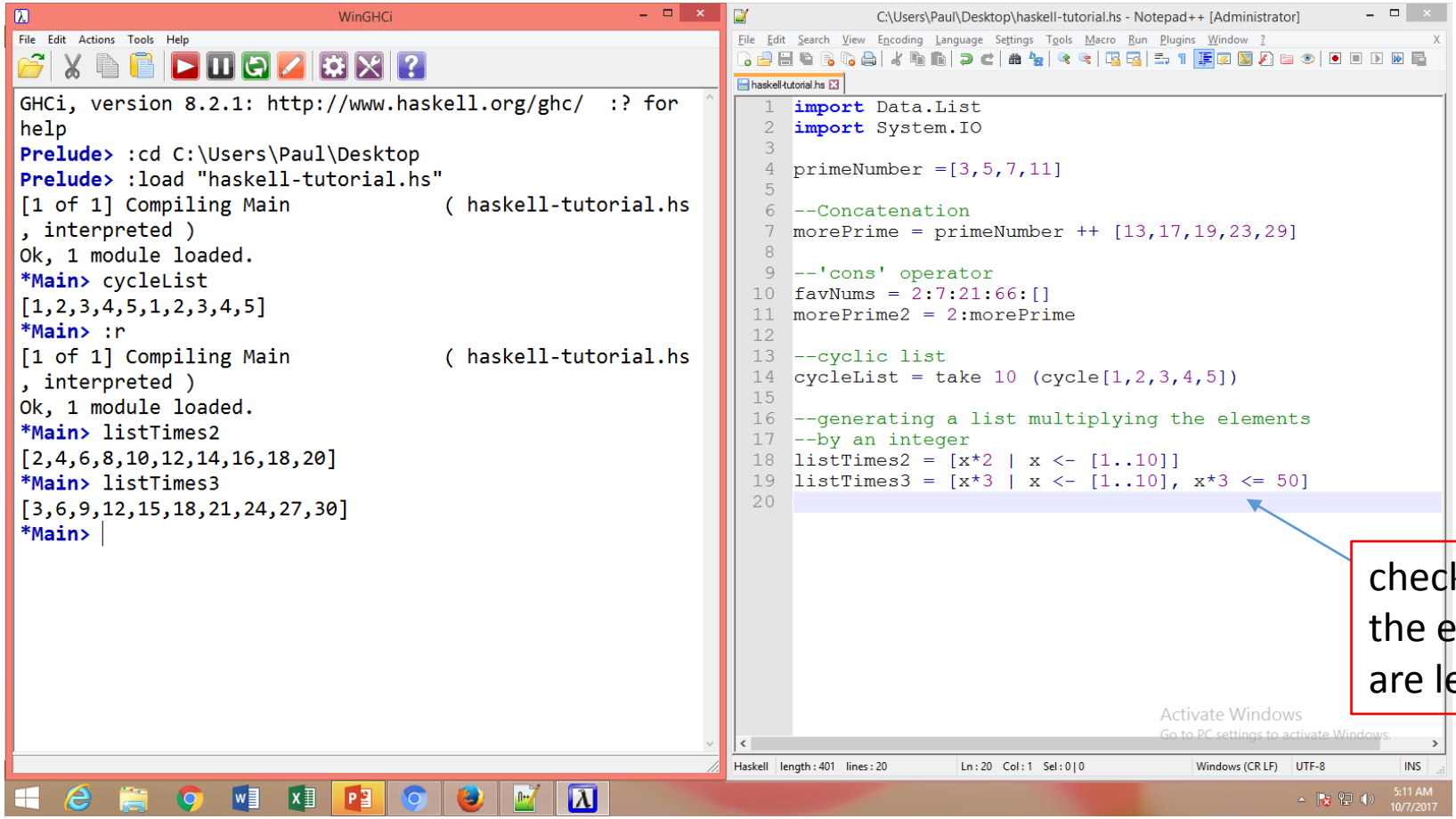


One of the examples of advantages of laziness property and functional approach: here, the presence of ***infinite list*** does not affect other expressions/ functions in the program

More Operations on List



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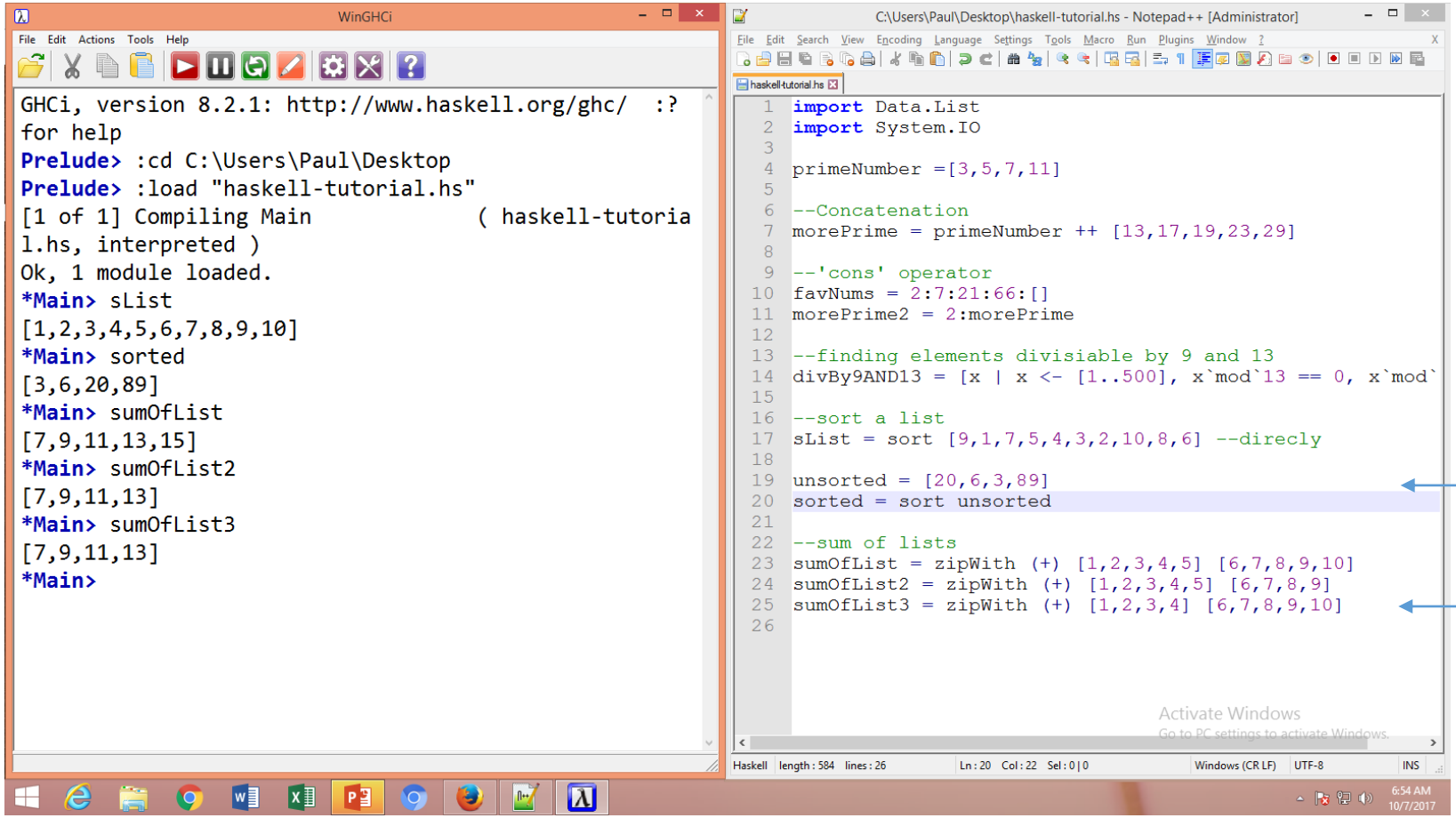

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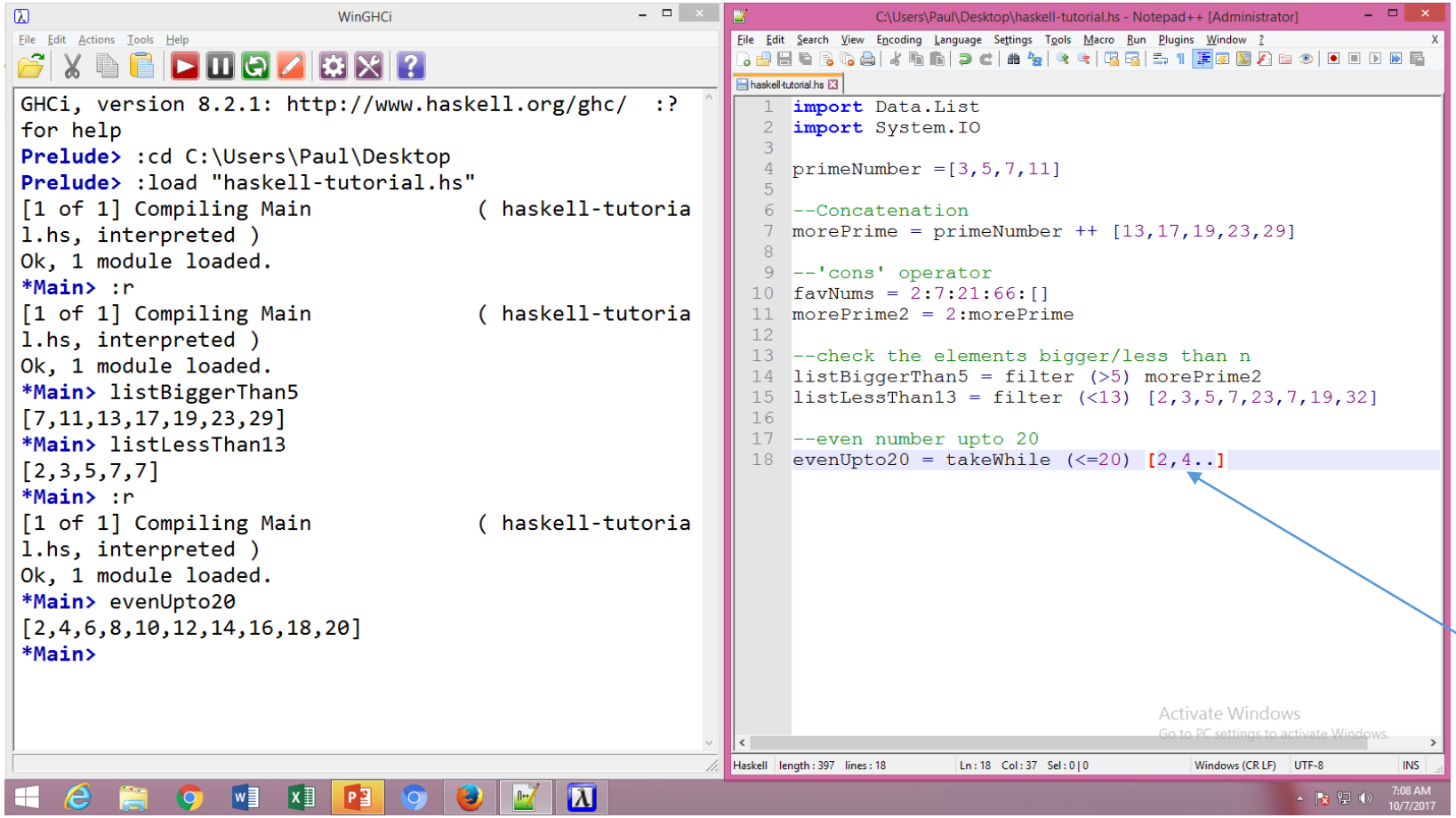
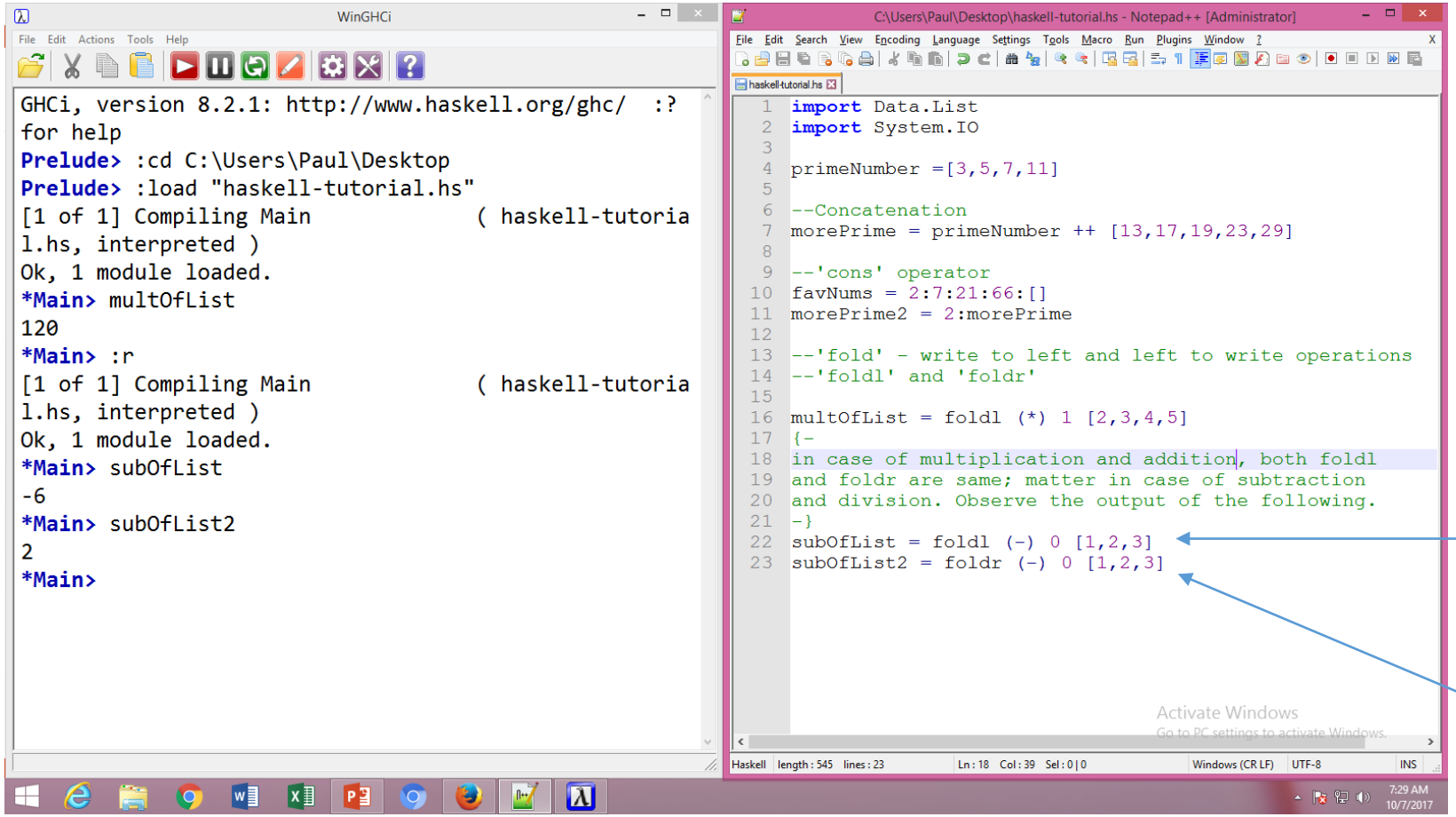


another example of laziness; although infinite list, check up to 20

More Operations on List

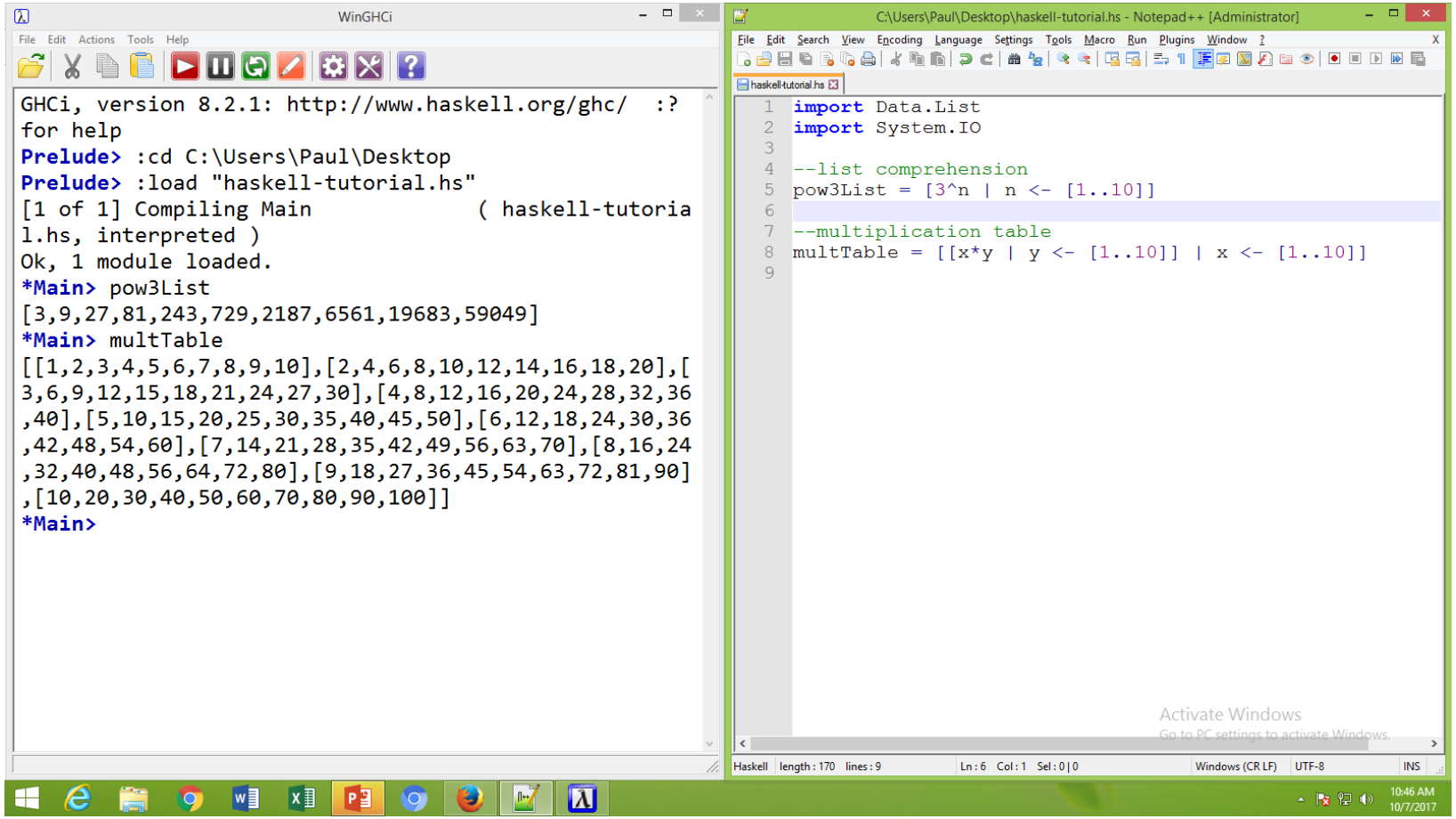


foldl & foldr

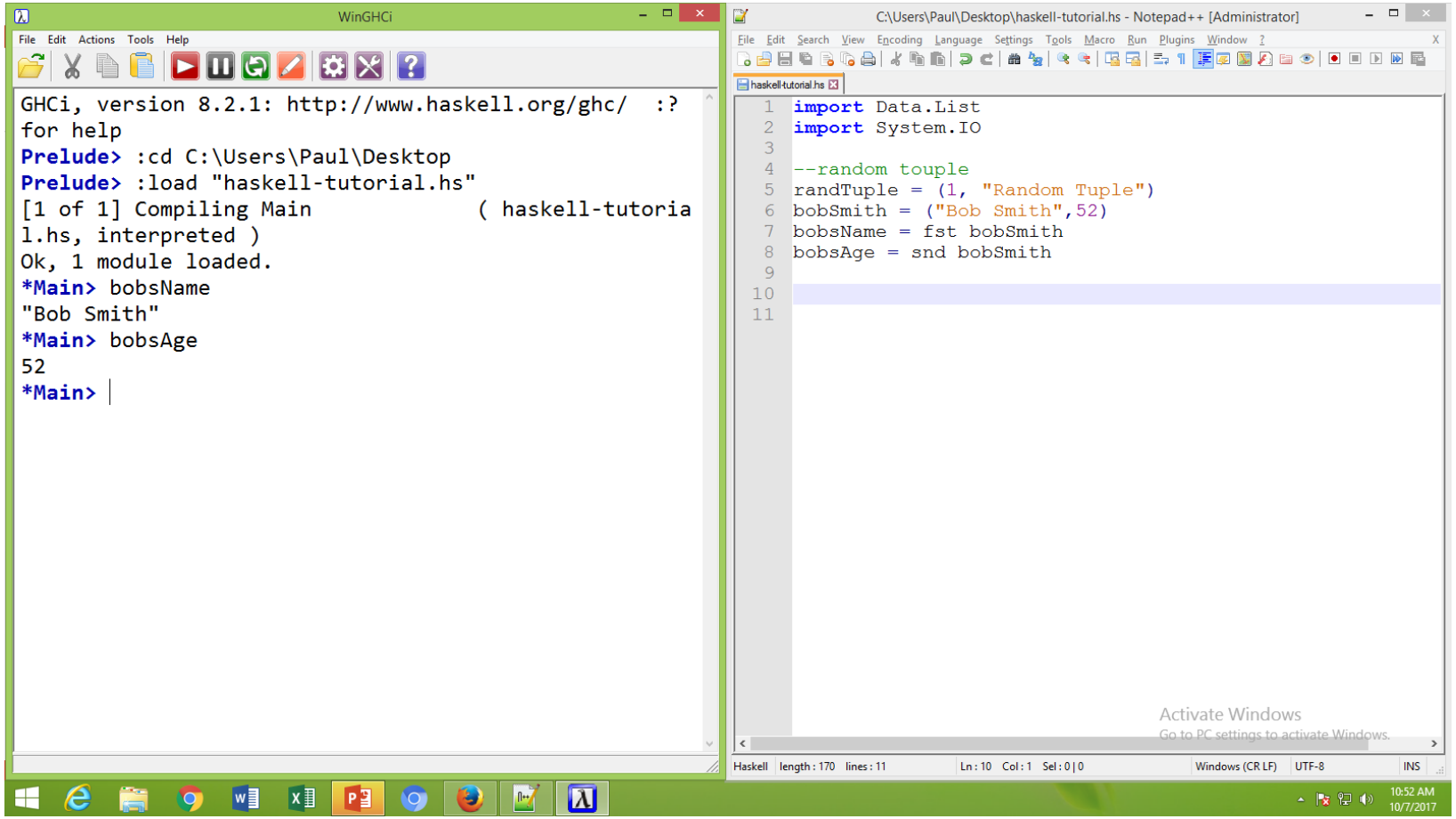
(((0-1)-2)-3)

1-(2-(3-0))

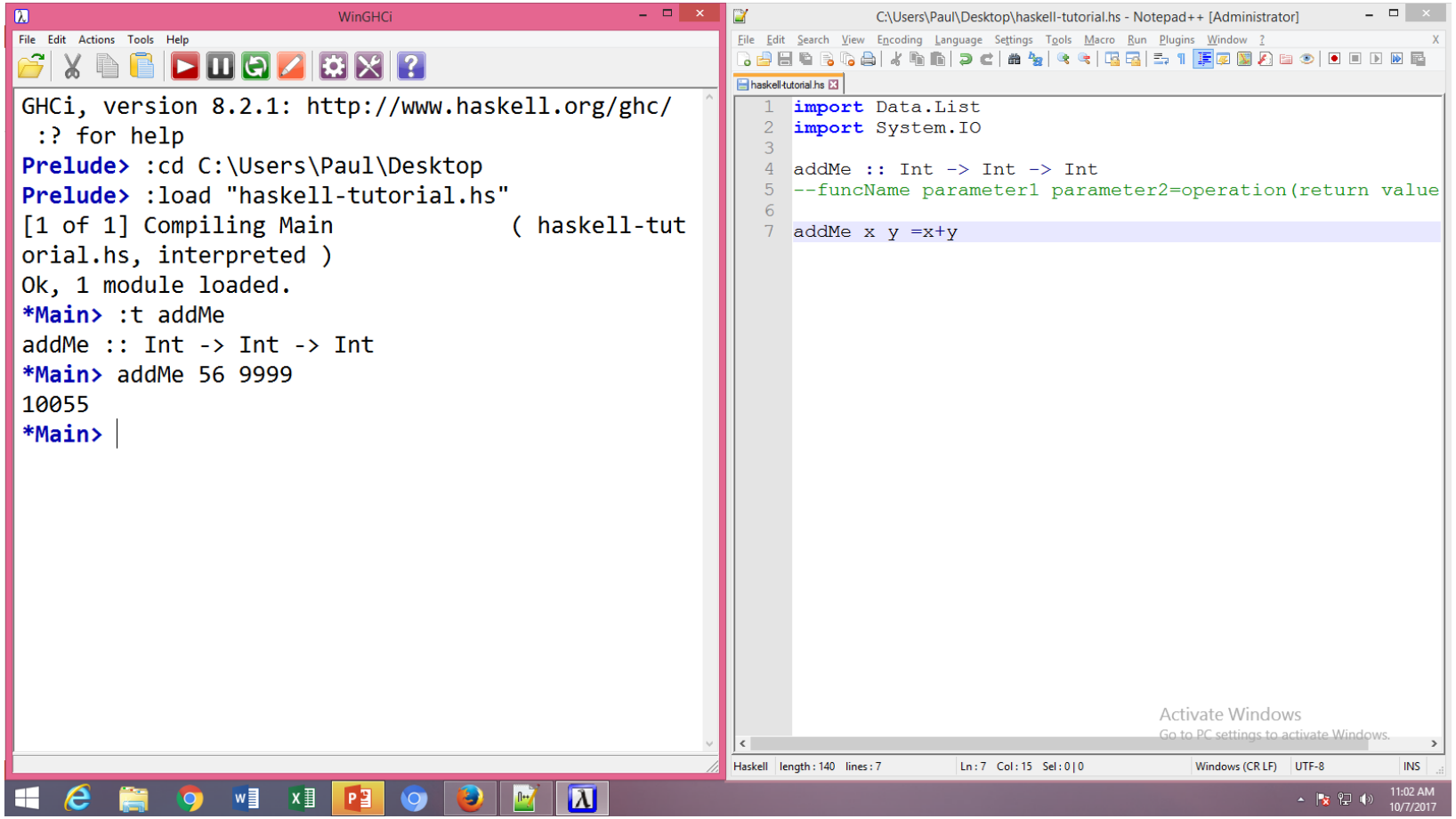
More Operations on List



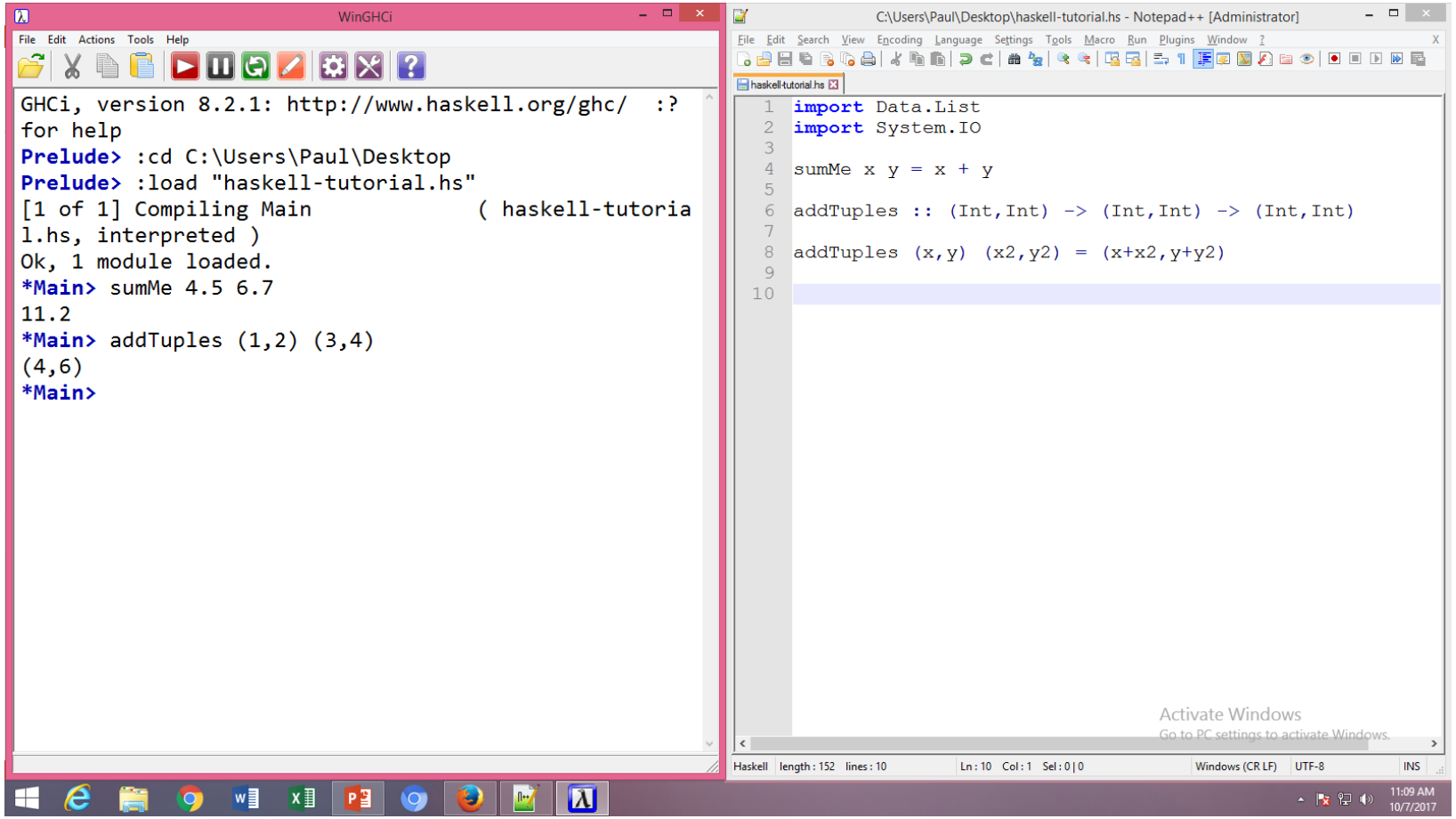
Multiple Data Type



Function Declaration



User Type Declaration



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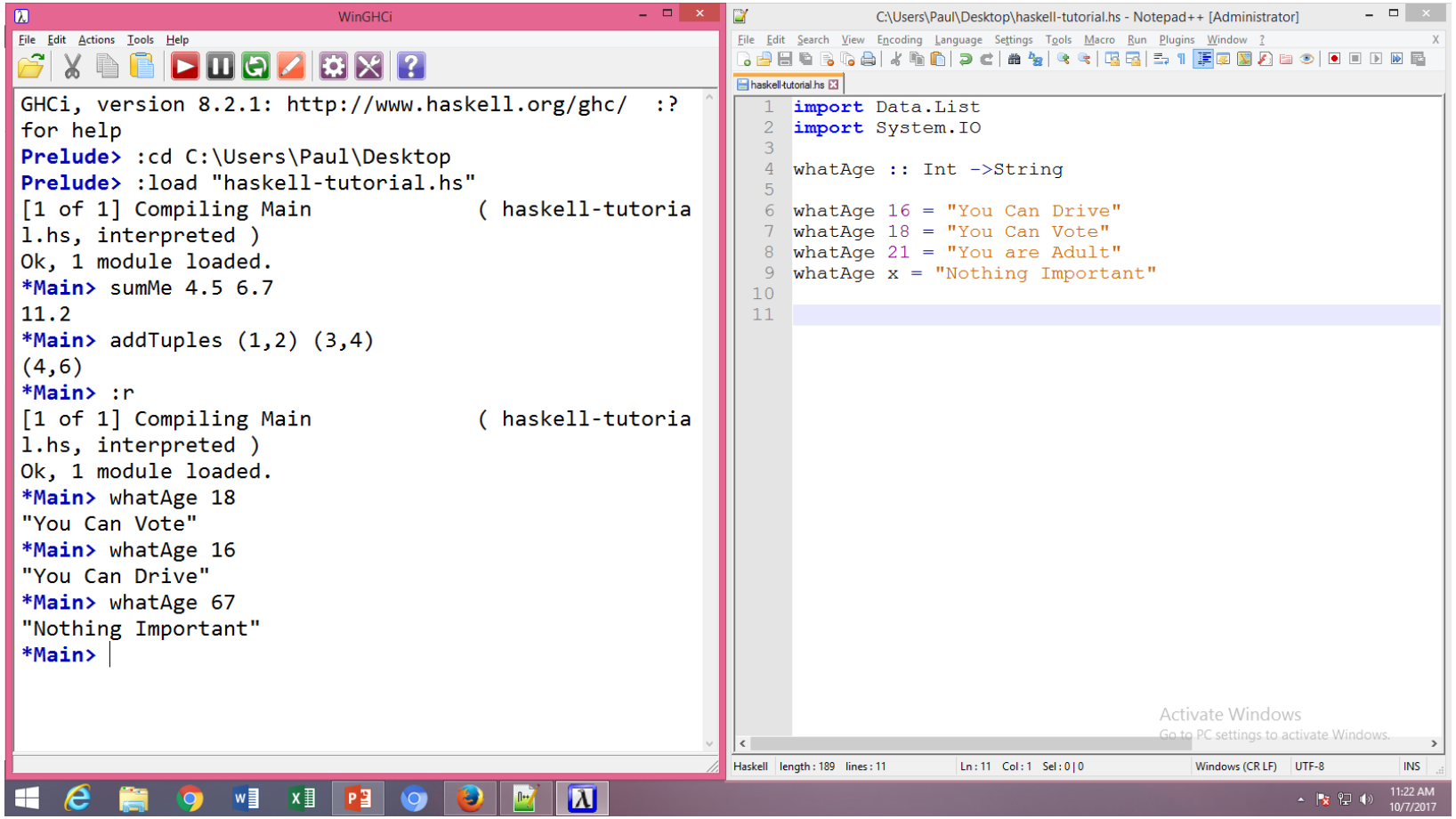
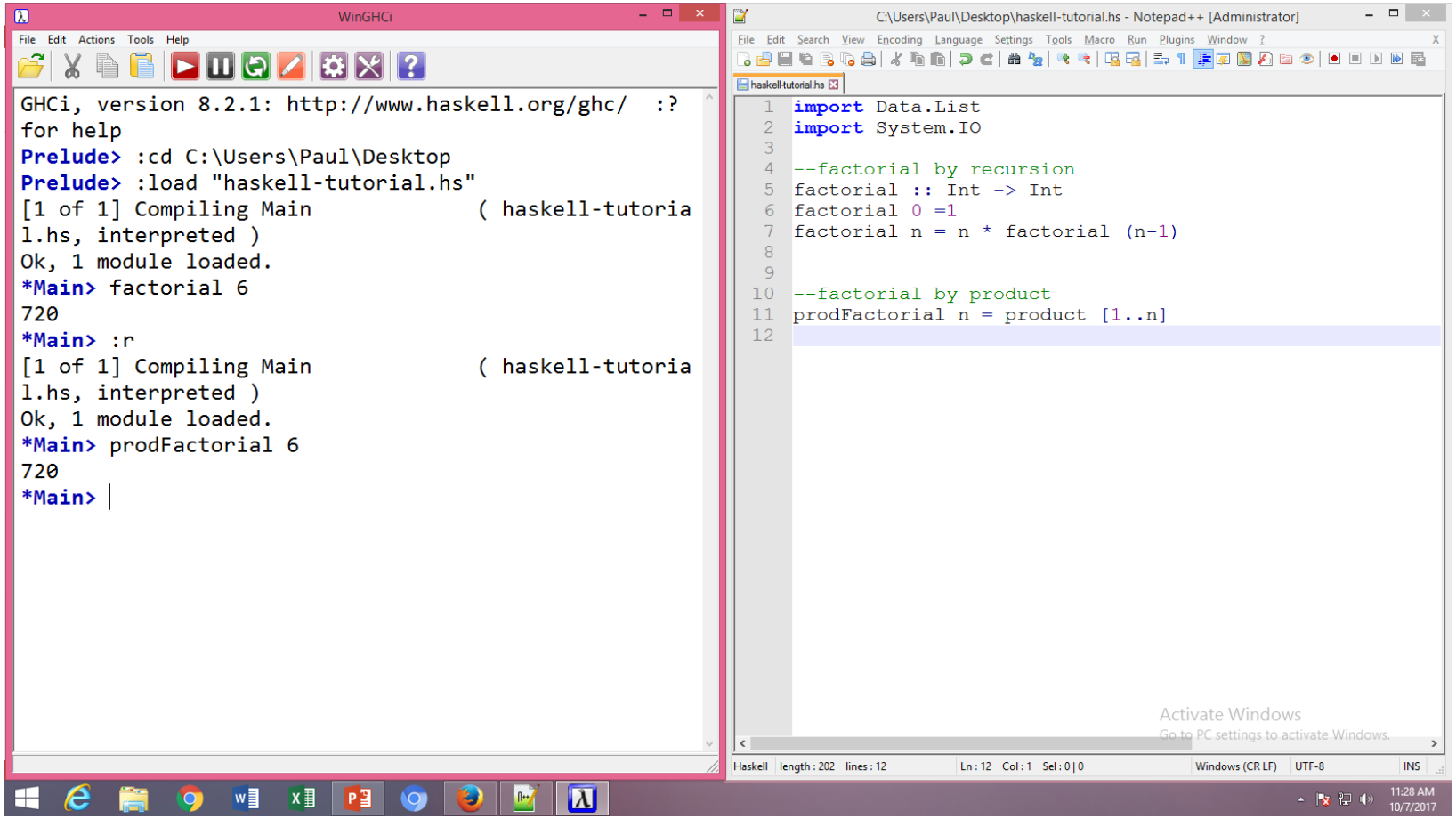
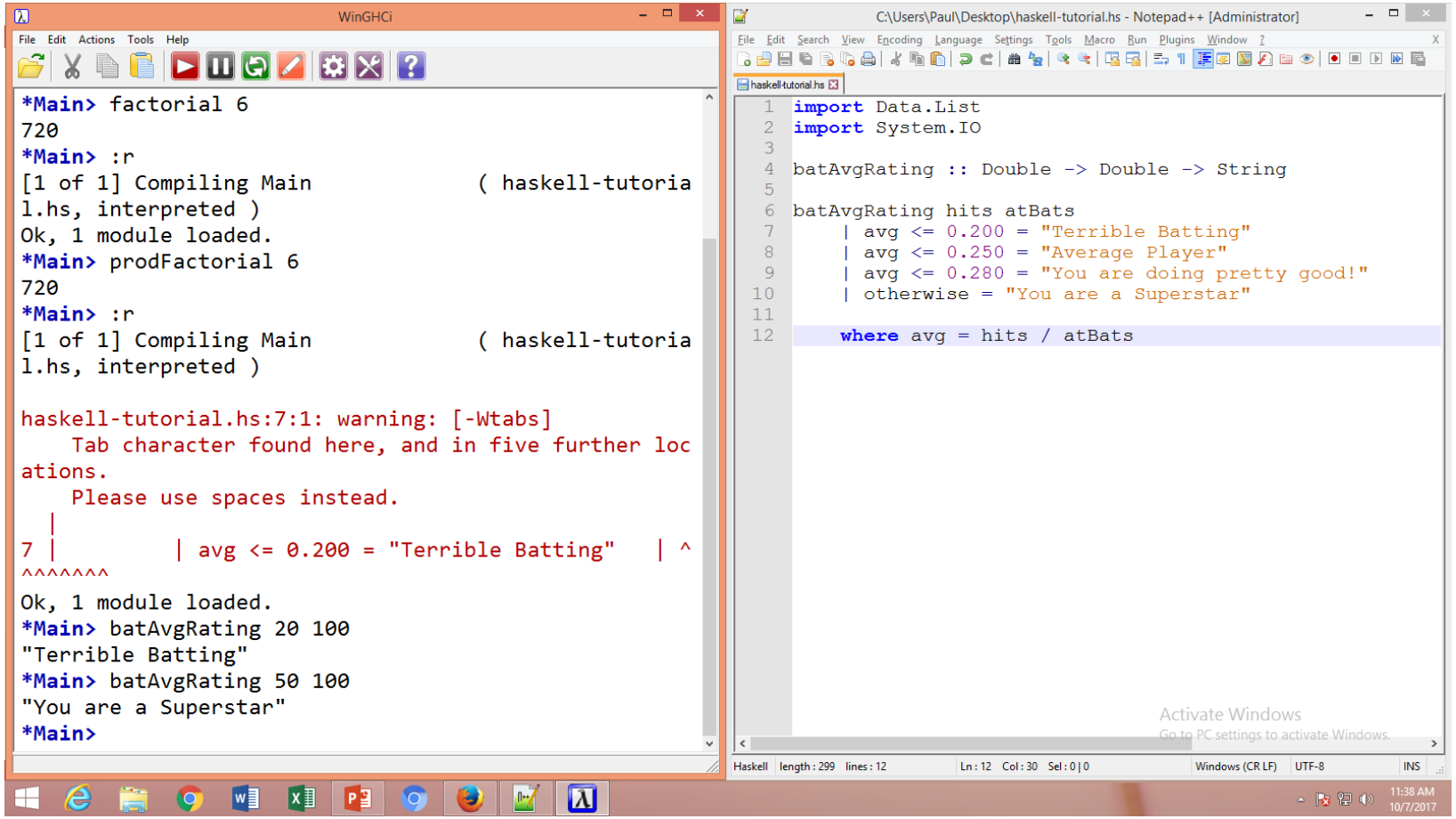


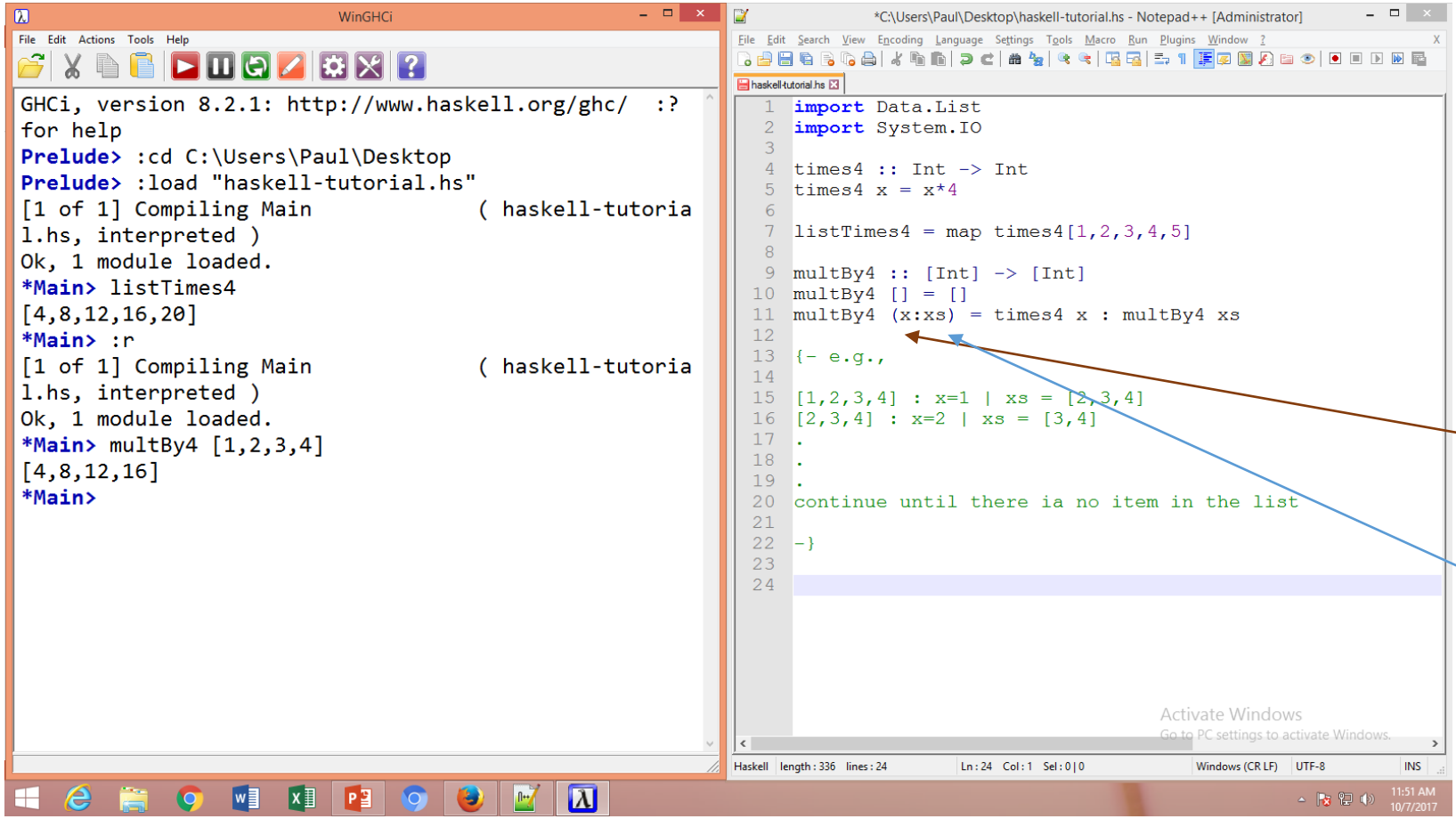
Factorial (by recursion and by product)



Guard (where clause)

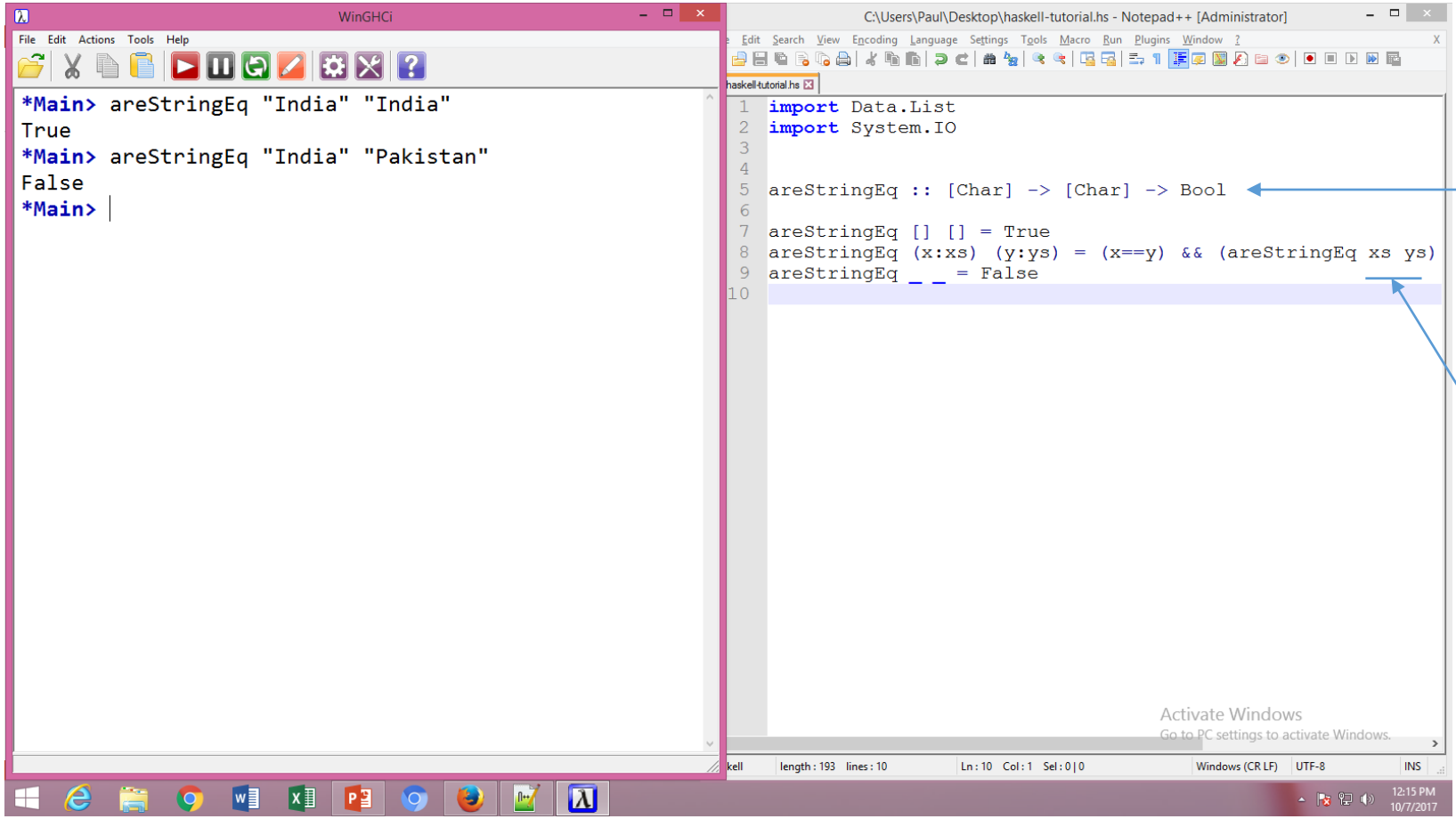


Higher Order Functions



you don't know how many items in the list Beforehand; x represents first element in the list, and xs represents remaining elements of the list

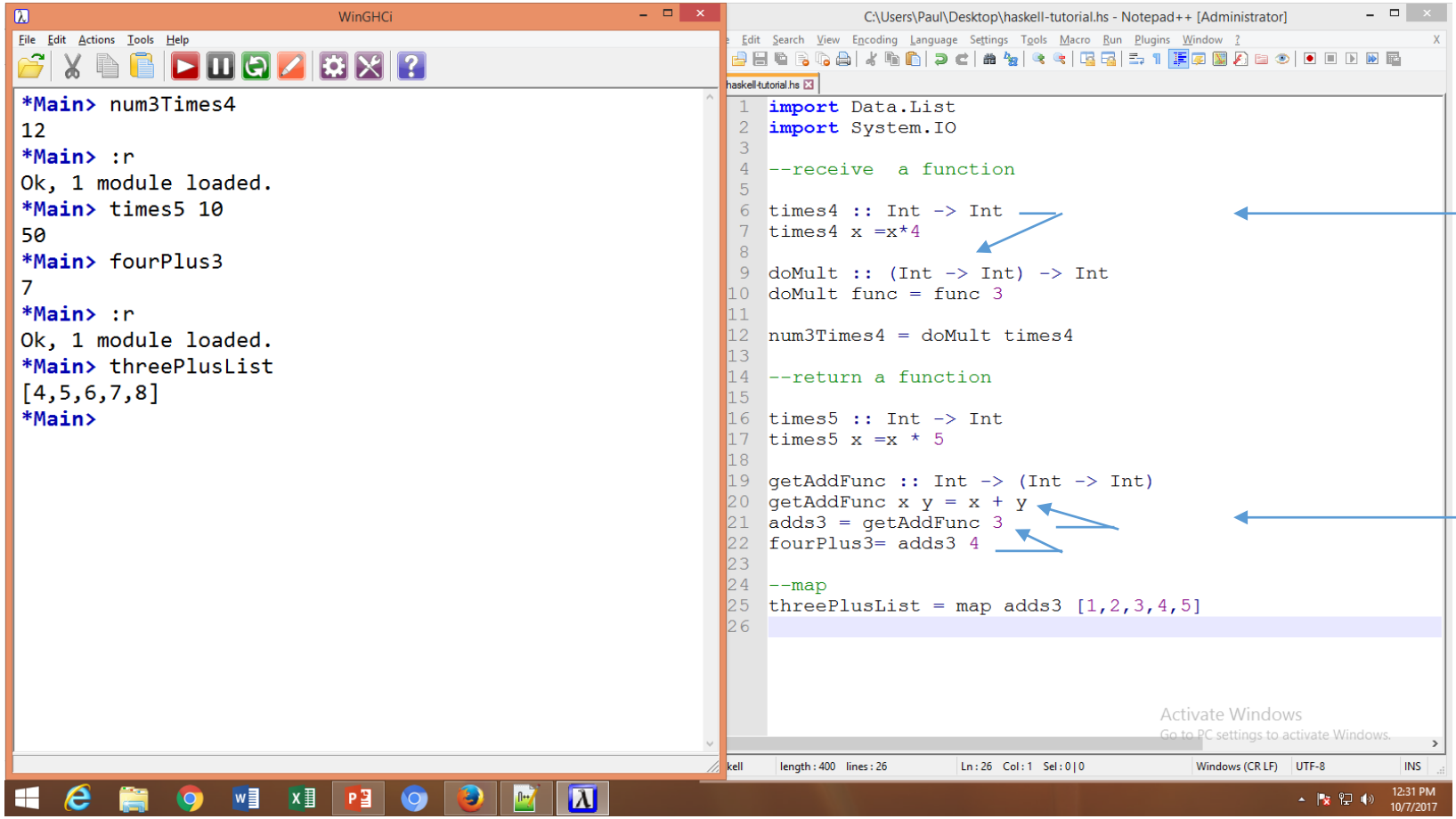
Higher Order Functions



return type

remaining

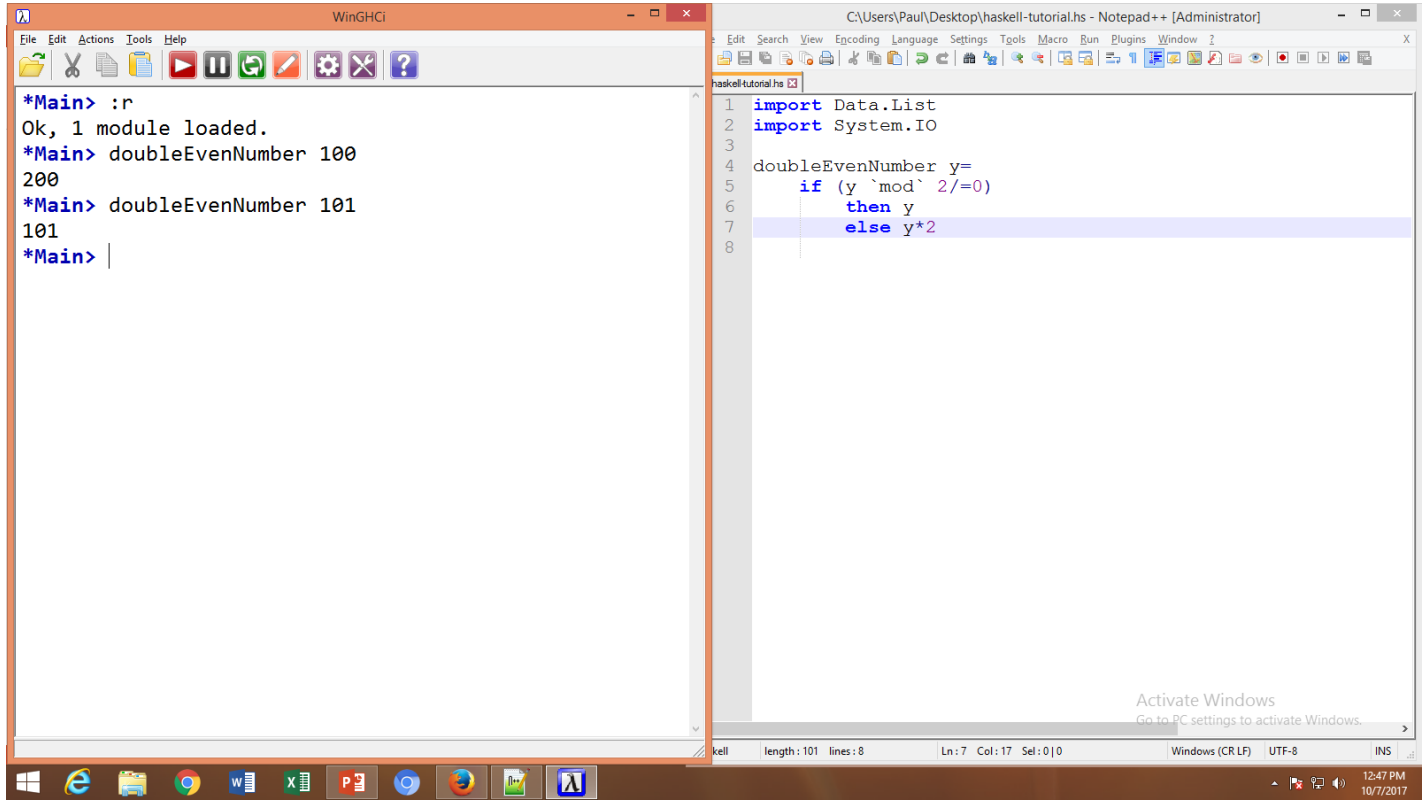
Receive and Return a Function



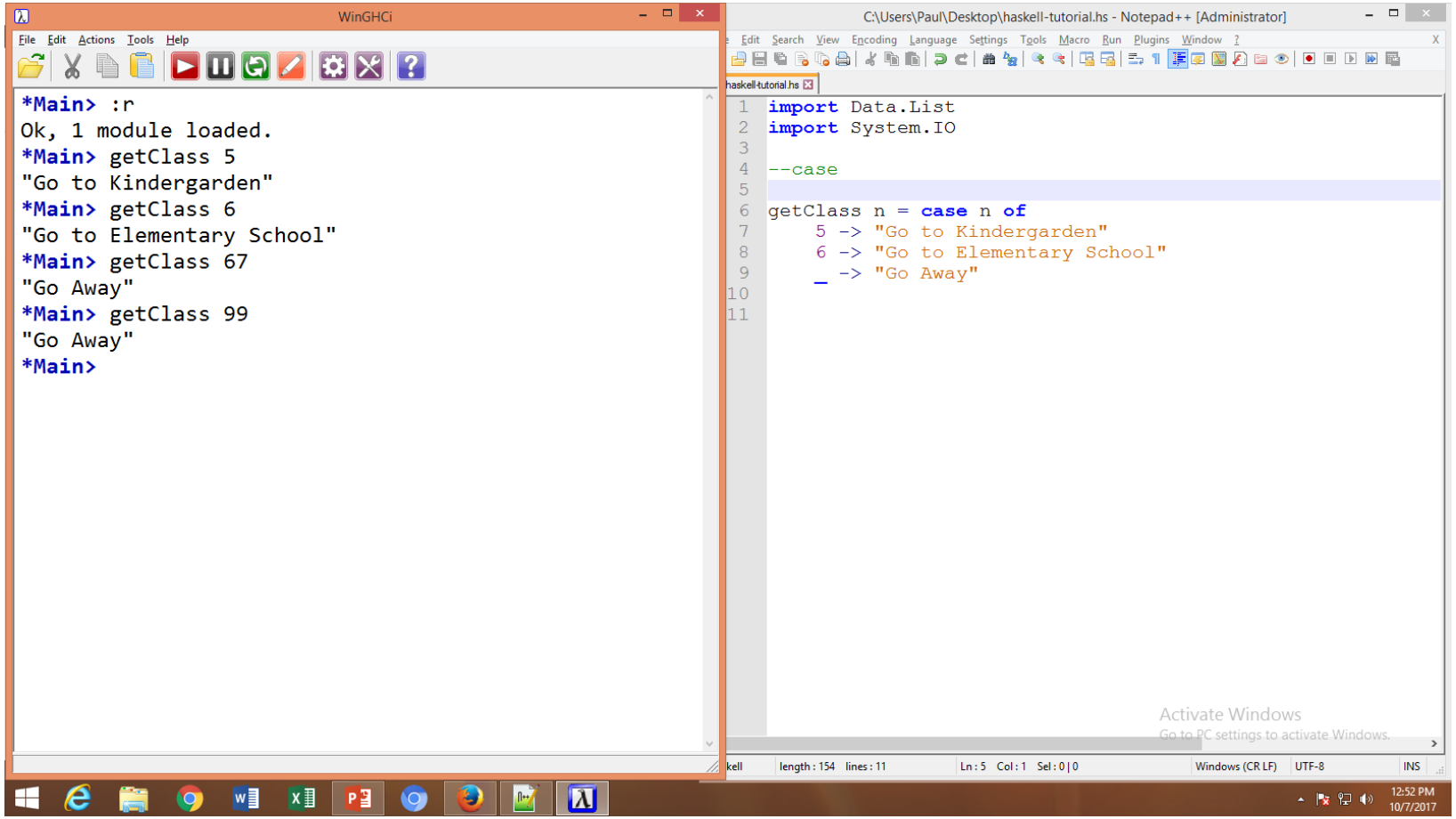
Other Operators

- Comparison
  - `<` --less than
  - `>` --greater than
  - `<=` --less than equal to
  - `>=` --greater than equal to
  - `==` --equal to
- Logical
  - `&&` --AND
  - `||` --OR
  - `not` --NOT

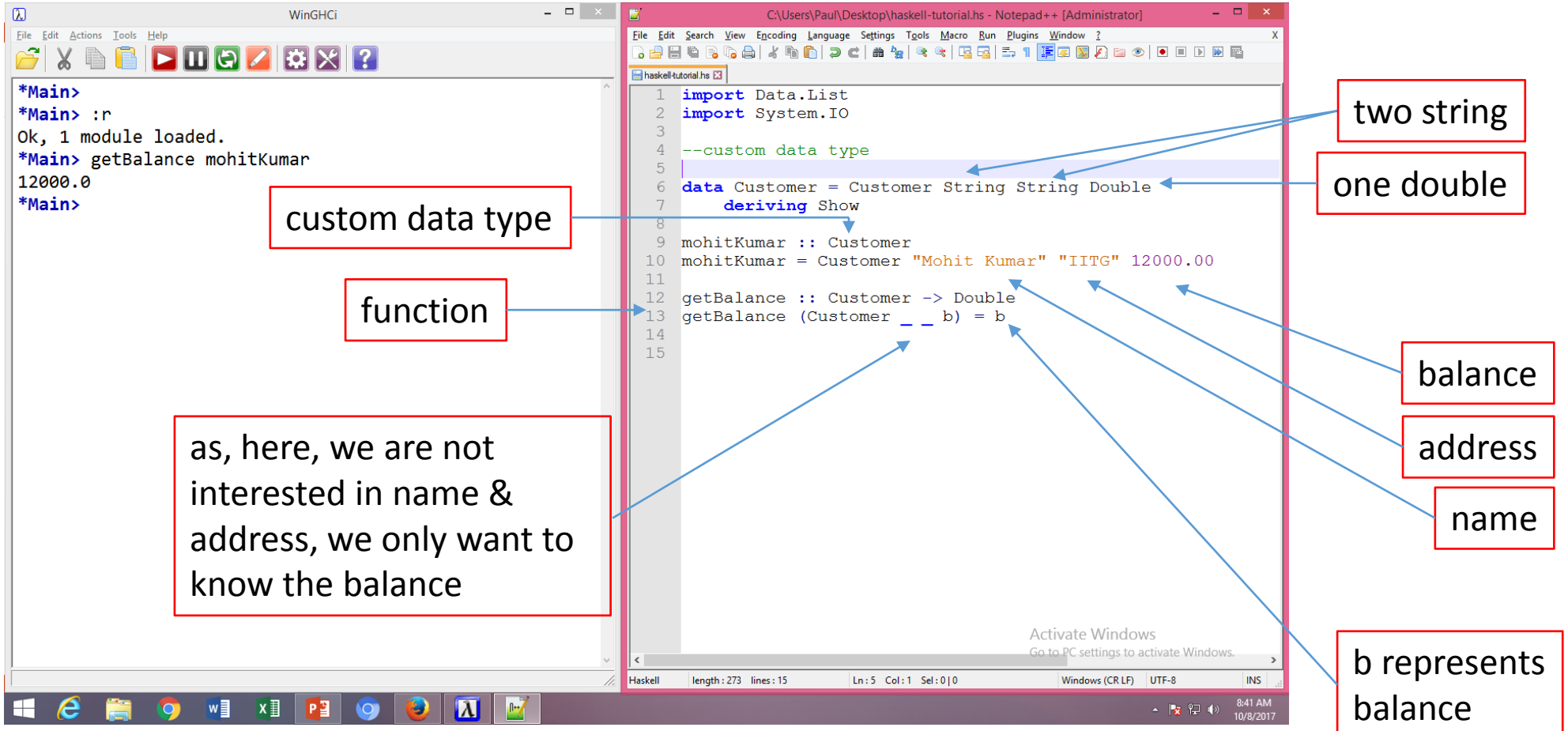
Example



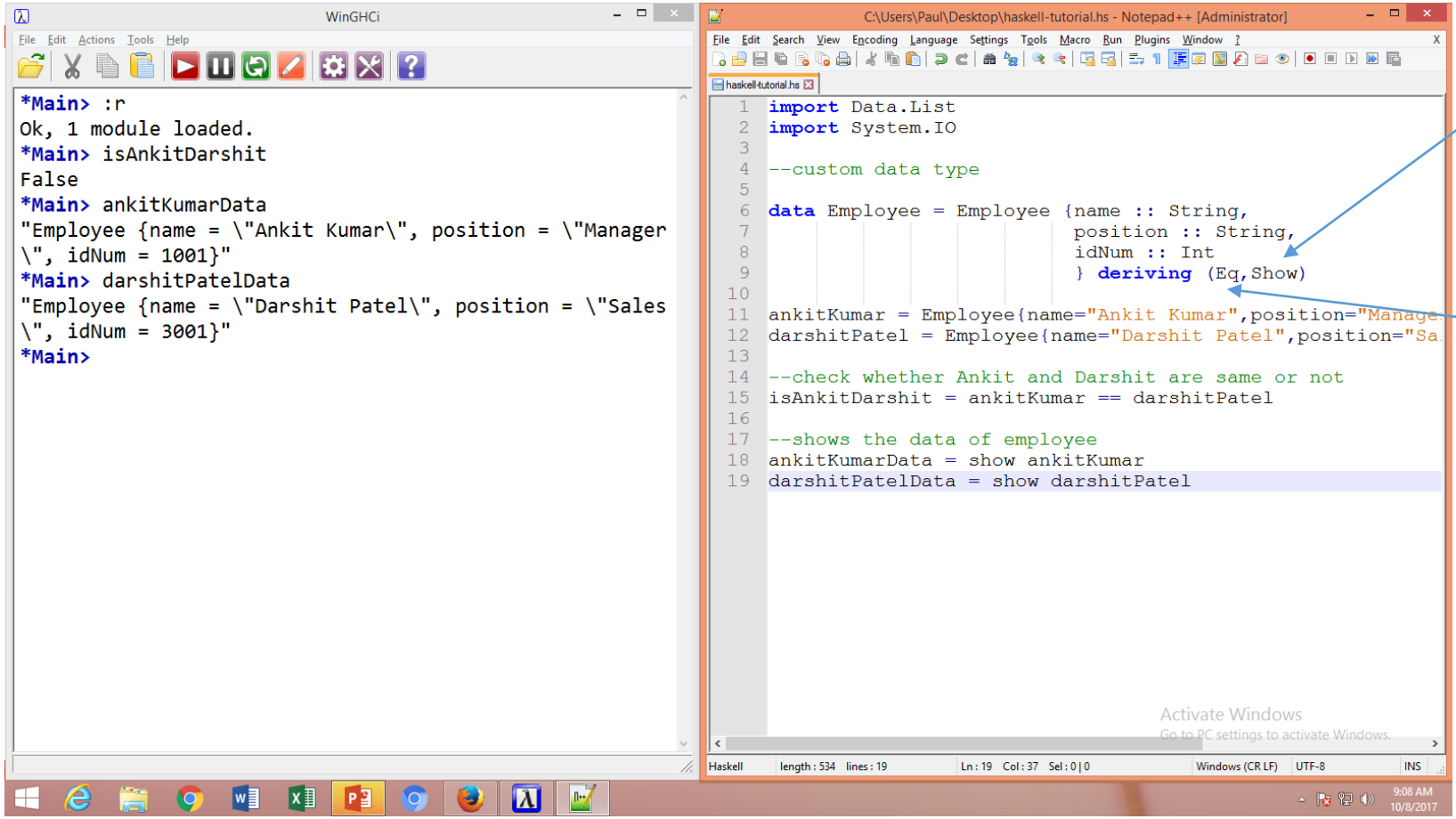
Case


WinGHCi
File Edit Actions Tools Help
*Main> :r
Ok, 1 module loaded.
*Main> getClass 5
"Go to Kindergarden"
*Main> getClass 6
"Go to Elementary School"
*Main> getClass 67
"Go Away"
*Main> getClass 99
"Go Away"
*Main>
C:\Users\Paul\Desktop\haskell-tutorial.hs - Notepad++ [Administrator]
haskell-tutorial.hs
1 import Data.List
2 import System.IO
3
4 --case
5
6 getClass n = case n of
7 5 -> "Go to Kindergarden"
8 6 -> "Go to Elementary School"
9 _ -> "Go Away"
10
11
Activate Windows
Go to PC settings to activate Windows.
length : 154 lines : 11
Ln : 5 Col : 1 Sel : 0 | 0
Windows (CR LF)
UTF-8
INS
12:52 PM
10/7/2017

Custom Data Type



Type Classes



able to show the employee details

able to check for the equality

END OF TUTORIAL

YOU MAY EXPLORE

http://www.learnyouahaskell.com

FOR MORE DETAIL