Haskell

Haskell is a Functional Programming Language that has been specially designed to handle symbolic computation and list processing applications. Functional programming is based on mathematical functions. Besides Haskell, some of the other popular languages that follow Functional Programming paradigm include: Lisp, Python, Erlang, Racket, F#, Clojure, etc.

In **conventional programing**, instructions are taken as a set of declarations in a specific syntax or format, but in the case of **functional programing**, all the computation is considered as a combination of separate mathematical functions.

Going Functional with Haskell

Haskell is a widely used purely functional language. Here, we have listed down a few points that make this language so special over other conventional programing languages such as Java, C, C++, PHP, etc.

- **Functional Language** – In conventional programing language, we instruct the compiler a series of tasks which is nothing but telling your computer "what to do" and "how to do?" But in Haskell we will tell our computer "what it is?"
- **Laziness** – Haskell is a lazy language. By **lazy**, we mean that Haskell won't evaluate any expression without any reason. When the evaluation engine finds that an expression needs to be evaluated, then it creates a **thunk data structure** to collect all the required information for that specific evaluation and a pointer to that **thunk data structure**. The evaluation engine will start working only when it is required to evaluate that specific expression.
- **Modularity** – A Haskell application is nothing but a series of functions. We can say that a Haskell application is a collection of numerous small Haskell applications.
- **Statically Typed** – In conventional programing language, we need to define a series of variables along with their type. In contrast, Haskell is a type interference language. By the term, type interference language, we mean the Haskell compiler is intelligent enough to figure out the type of the variable declared, hence we need not explicitly mention the type of the variable used.
- **Maintainability** – Haskell applications are modular and hence, it is very easy and cost-effective to maintain them.

Functional programs are more concurrent and they follow parallelism in execution to provide more accurate and better performance. Haskell is no exception; it has been developed in a way to handle **multithreading** effectively.

Hello World

It is a simple example to demonstrate the dynamism of Haskell. Take a look at the following code. All that we need is just one line to print "Hello Word" on the console.

```
main = putStrLn "Hello World"
```

Once the Haskell compiler encounters the above piece of code, it promptly yields the following output –

```
Hello World
```

Haskell - Environment Set Up

There are three different types of **installers** available in the market –

- **Minimal Installer** – It provides GHC (The Glasgow Haskell Compiler), CABAL (Common Architecture for Building Applications and Libraries), and Stack tools.
- **Stack Installer** – In this installer, the GHC can be downloaded in a cross platform of managed toll chain. It will install your application globally such that it can update its API tools whenever required. It automatically resolves all the Haskell-oriented dependencies.
- **Haskell Platform** – This is the best way to install Haskell because it will install the entire platform in your machine and that to from one specific location. This installer is not distributive like the above two installers.

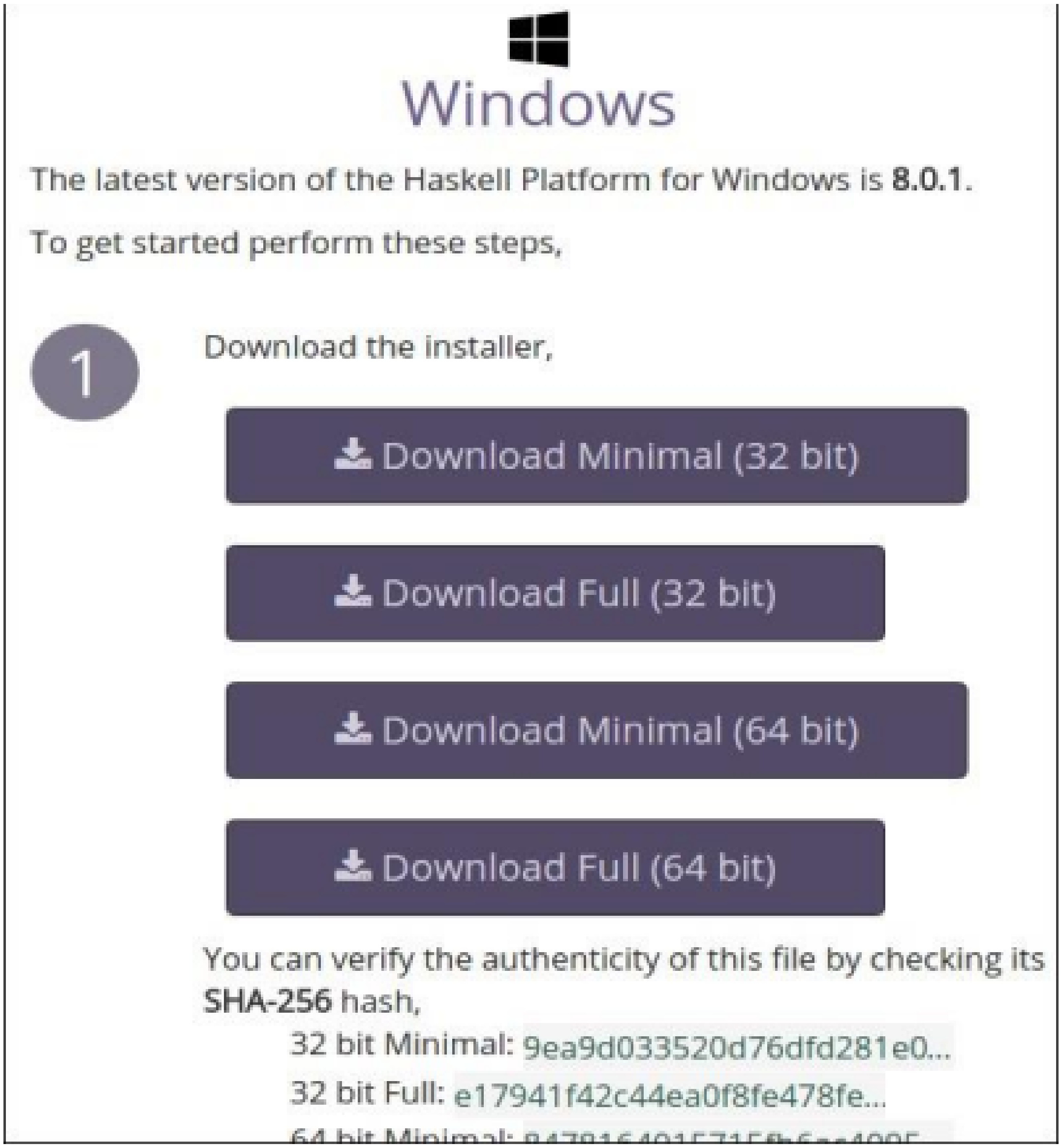
you need to download the available Haskell setup from its official webpage – https://www.haskell.org/downloads

Go to the terminal section of the page and type **"ghci"**. This command automatically loads Haskell compiler and starts Haskell online. You will receive the following output after using the **ghci** command.

```
sh-4.3$ ghci
GHCi,version7.8.4:http://www.haskell.org/ghc/:?forhelp
Loading package ghc-prim...linking...done.
Loading packageinteger gmp...linking... done.
Loading package base...linking...done.
Prelude>
```

Environment Set Up in Windows

To set up Haskell environment on your Windows computer, go to their official website https://www.haskell.org/platform/windows.html and download the Installer according to your customizable architecture.



Check out your system's architecture and download the corresponding setup file and run it. It will install like any other Windows application

Haskell - Basic Data Models

Haskell is a purely functional programing language, hence it is much more interactive and intelligent than other programming languages. In this chapter, we will learn about basic data models of Haskell which are actually predefined or somehow intelligently decoded into the computer memory.

Numbers

Haskell is intelligent enough to decode some number as a number. Therefore, you need not mention its type externally as we usually do in case of other programing languages. As per example go to your prelude command prompt and just run "2+2" and hit enter.

```
sh-4.3$ ghci
GHCi, version 7.6.3: http://www.haskell.org/ghc/ :? for help
```

```
Loading package ghc-prim ... linking ... done.
Loading package integer-gmp ... linking ... done.
Loading package base ... linking ... done.
Prelude> 2+2
```

You will receive the following output as a result.

```
4
```

In the above code, we just passed two numbers as arguments to the GHCI compiler without predefining their type, but compiler could easily decode these two entries as numbers.

Now, let us try a little more complex mathematical calculation and see whether our intelligent compiler give us the correct output or not. Try with "15+(5*5)-40"

```
Prelude> 15+(5*5)-40
```

The above expression yields "0" as per the expected output.

```
0
```

Characters

Like numbers, Haskell can intelligently identify a character given in as an input to it. Go to your Haskell command prompt and type any character with double or single quotation.

Let us provide following line as input and check its output.

```
Prelude> :t "a"
```

It will produce the following output –

```
"a" :: [Char]
```

Take a look at the following example where we are passing some invalid input as a char which in turn leads to an error.

```
Prelude> :t a
<interactive>:1:1: Not in scope: 'a'

Prelude> a
<interactive>:4:1: Not in scope: 'a'
```

By the error message "<interactive>:4:1: Not in scope: `a'" the Haskell compiler is warning us that it is not able to recognize your input. Haskell is a type of language where everything is represented using a number.

Haskell follows conventional ASCII encoding style. Let us take a look at the following example to understand more –

```
Prelude> '\97'
'a'
Prelude> '\67'
'C'
```

String

A **string** is nothing but a collection of characters. There is no specific syntax for using string, but Haskell follows the conventional style of representing a string with double quotation.

Take a look at the following example where we are passing the string "Tutorialspoint.com".

```
Prelude> :t "Hello SE IT B Students"
```

It will produce the following output on screen –

" Hello SE IT B Students " :: [Char]

See how the entire string has been decoded as an array of Char only. Let us move to the other data type and its syntax. Once we start our actual practice, we will be habituated with all the data type and its use.

Boolean

Boolean data type is also pretty much straightforward like other data type. Look at the following example where we will use different Boolean operations using some Boolean inputs such as "True" or "False".

```
Prelude> True && True
True
Prelude> True && False
False
Prelude> True || True
True
Prelude> True || False
True
```

List and List Comprehension

Like other data types, **List** is also a very useful data type used in Haskell. As per example, [a,b,c] is a list of characters, hence, by definition, List is a collection of same data type separated by comma.

Take a look at the following example which shows how Haskell treats a List.

```
Prelude> [1,2,3,4,5]
```

It will produce the following output –

[1,2,3,4,5]

Lists in Haskell are homogeneous in nature, which means they won't allow you to declare a list of different kind of data type. Any list like [1,2,3,4,5,a,b,c,d,e,f] will produce an error.

```
Prelude> [1,2,3,4,5,a,b,c,d,e,f]
```

This code will produce the following error –

```
<interactive>:17:12: Not in scope: 'a'
<interactive>:17:14: Not in scope: 'b'
<interactive>:17:16: Not in scope: 'c'
<interactive>:17:18: Not in scope: 'd'
<interactive>:17:20: Not in scope: 'e'
<interactive>:17:22: Not in scope: 'f'
```

List Comprehension

List comprehension is the process of generating a list using mathematical expression. Look at the following example where we are generating a list using mathematical expression in the format of [output | range ,condition].

```
Prelude> [x*2| x<-[1..10]]
[2,4,6,8,10,12,14,16,18,20]
Prelude> [x*2| x<-[1..5]]
[2,4,6,8,10]
Prelude> [x| x<-[1..5]]
[1,2,3,4,5]
```

This method of creating one List using mathematical expression is called as **List Comprehension**.

Tuple

Haskell provides another way to declare multiple values in a single data type. It is known as **Tuple**. A Tuple can be considered as a List, however there are some technical differences in between a Tuple and a List.

A Tuple is an immutable data type, as we cannot modify the number of elements at runtime, whereas a List is a mutable data type.

On the other hand, List is a homogeneous data type, but Tuple is heterogeneous in nature, because a Tuple may contain different type of data inside it.

Tuples are represented by single parenthesis.

Look at the following example to see how Haskell treats a Tuple.

```
Prelude> (1,1,'a')
```

It will produce the following output –

(1,1,'a')

In the above example, we have used one Tuple with two **number** type variables, and a **char** type variable.

Haskell - Basic Operators

Addition Operator

As the name suggests, the addition (+) operator is used for addition function. The following sample code shows how you can add two integer numbers in Haskell –

```
main = do
 let var1 = 2
 let var2 = 3
 putStrLn "The addition of the two numbers is:"
 print(var1 + var2)
```

In the above file, we have created two separate variables **var1** and **var2**. At the end, we are printing the result using the **addition** operator.

This code will produce the following output on screen –

```
The addition of the two numbers is:
5
```

Subtraction Operator

As the name suggests, this operator is used for subtraction operation. The following sample code shows how you can subtract two integer numbers in Haskell –

```
main = do
 let var1 = 10
 let var2 = 6
 putStrLn "The Subtraction of the two numbers is:"
 print(var1 - var2)
```

In this example, we have created two variables **var1** and **var2**. Thereafter, we use the subtraction (–) operator to subtract the two values.

This code will produce the following output on screen –

```
The Subtraction of the two numbers is:
4
```

Multiplication Operator

This operator is used for multiplication operations. The following code shows how to multiply two numbers in Haskell using the Multiplication Operator –

```
main = do
 let var1 = 2
 let var2 = 3
 putStrLn "The Multiplication of the Two Numbers is:"
 print(var1 * var2)
```

This code will produce the following output, when you run it in our online platform –

```
The Multiplication of the Two Numbers is:
6
```

Division Operator

Take a look at the following code. It shows how you can divide two numbers in Haskell –

Take a look at the following code. It shows how you can divide two numbers in Haskell –

```
main = do
 let var1 = 12
 let var2 = 3
 putStrLn "The Division of the Two Numbers is:"
 print(var1/var2)
```

It will produce the following output –

```
The Division of the Two Numbers is:
4.0
```

Sequence / Range Operator

Sequence or Range is a special operator in Haskell. It is denoted by "(..)". You can use this operator while declaring a list with a sequence of values.

If you want to print all the values from 1 to 10, then you can use something like "[1..10]". Similarly, if you want to generate all the alphabets from "a" to "z", then you

can just type **"[a..z]"**.
The following code shows how you can use the Sequence operator to print all the values from 1 to 10 –

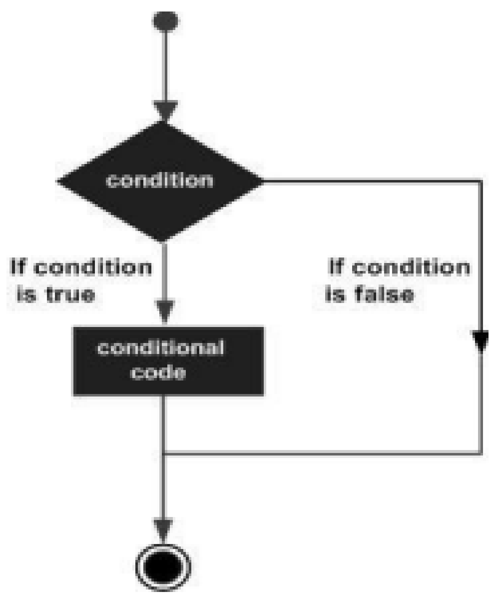
```
main :: IO()
main = do
 print [1..10]
```

It will generate the following output –

```
[1,2,3,4,5,6,7,8,9,10]
```

Haskell - Decision Making

Decision Making is a feature that allows the programmers to apply a condition in the code flow. The programmer can execute a set of instructions depending on a predefined condition. The following flowchart shows the decision-making structure of Haskell –



Haskell provides the following types of decision-making statements –

Sr.No.	Statement & Description
1	if–else statement One **if** statement with an **else** statement. The instruction in the **else** block will execute only when the given Boolean condition fails to satisfy.
2	Nested if-else statement Multiple **if** blocks followed by **else** blocks

Haskell - Types and Type Class

Haskell is a functional language and it is strictly typed, which means the data type used in the entire application will be known to the compiler at compile time.

Inbuilt Type Class

In Haskell, every statement is considered as a mathematical expression and the category of this expression is called as a **Type**. You can say that "Type" is the data type of the expression used at compile time.

To learn more about the **Type**, we will use the ":t" command. In a generic way, **Type** can be considered as a value, whereas **Type Class** can be the considered as a set of similar kind of Types.

Int

Int is a type class representing the Integer types data. Every whole number within the range of 2147483647 to -2147483647 comes under the **Int** type class. In the following example, the function **fType()** will behave according to its type defined.

```
fType :: Int -> Int -> Int
fType x y = x*x + y*y
main = print (fType 2 4)
```

Here, we have set the type of the function **fType()** as **int**. The function takes two **int** values and returns one **int** value. If you compile and execute this piece of code, then it will produce the following output –

```
sh-4.3$ ghc -O2 --make *.hs -o main -threaded -rtsopts
sh-4.3$ main
20
```

Integer

Integer can be considered as a superset of **Int**. This value is not bounded by any number, hence an Integer can be of any length without any limitation. To see the basic difference between **Int** and **Integer** types, let us modify the above code as follows –

```
Type :: Int -> Int -> Int
fType x y = x*x + y*y
main = print (fType 212124454 44545454454554545445454544545)
```

If you compile the above piece of code, the following error message will be thrown –

```
main.hs:3:31: Warning:
```

Literal 4454545444545554545445454544545 is out of the Int range -
9223372036854775808..9223372036854775807
Linking main ...

This error occurred because our function fType() expecting one Int type value, and we are passing some real big Int type value. To avoid this error, Let us modify the type "Int" with "Integer" and observe the difference.

```
fType :: Integer -> Integer -> Integer
fType x y = x*x + y*y
main = print (fType 212124454 44545454454554545445454544545)
```

Now, it will produce the following output –

sh-4.3$ main
1984297512562793395882644631364297686099210302577374055141

1 Float

```
fType :: Float -> Float -> Float
fType x y = x*x + y*y
main = print (fType 2.5 3.8)
```

The function takes two float values as the input and yields another float value as the output. When you compile and execute this code, it will produce the following output –

sh-4.3$ main
20.689999

Double

```
fType :: Double -> Double -> Double
fType x y = x*x + y*y
main = print (fType 2.56 3.81)
```

When you execute the above piece of code, it will generate the following output –

sh-4.3$ main
21.0697

Bool

Bool is a Boolean Type. It can be either True or False. Execute the following code to understand how the Bool type works in Haskell –

```
main = do
 let x = True

 if x == False
 then putStrLn "X matches with Bool Type"
 else putStrLn "X is not a Bool Type"
```

Here, we are defining a variable "x" as a Bool and comparing it with another Boolean value to check its originality. It will produce the following output –

sh-4.3$ main
X is not a Bool Type

Char

```
fType :: Char-> Char
fType x = 'K'
main = do
 let x = 'v'
 print (fType x)
```

The above piece of code will call **fType()** function with a **char** value of 'v' but it returns another char value, that is, 'K'. Here is its output –

sh-4.3$ main
'K'

Note that we are not going to use these types explicitly because Haskell is intelligent enough to catch the type before it is declared. In the subsequent lecture of this chapter, we will see how different types and Type classes make Haskell a strongly typed language.

EQ Type Class

EQ type class is an interface which provides the functionality to test the equality of an expression. Any Type class that wants to check the equality of an expression should be a part of this EQ Type Class.

All standard Type classes mentioned above is a part of this **EQ** class. Whenever we are checking any equality using any of the types mentioned above, we are actually making a call to **EQ** type class.

In the following example, we are using the **EQ** Type internally using the "==" or "/=" operation.

```
main = do
 if 8 /= 8
 then putStrLn "The values are Equal"
 else putStrLn "The values are not Equal"
```

It will yield the following output –

```
sh-4.3$ main
The values are not Equal
```

Ord Type Class

Ord is another interface class which gives us the functionality of ordering. All the **types** that we have used so far are a part of this **Ord** interface. Like EQ interface, Ord interface can be called using ">", "<", "<=", ">=", "compare".

```
main = print (4 <= 2)
```

Here, the Haskell compiler will check if 4 is less than or equal to 2. Since it is not, the code will produce the following output –

```
sh-4.3$ main
False
```

Show

Show has a functionality to print its argument as a String. Whatever may be its argument, it always prints the result as a String. In the following example, we will print the entire list using this interface. "show" can be used to call this interface.

```
main = print (show [1..10])
```

It will produce the following output on the console. Here, the double quotes indicate that it is a String type value.

```
sh-4.3$ main
"[1,2,3,4,5,6,7,8,9,10]"
```

Read

Read interface does the same thing as Show, but it won't print the result in String format. In the following code, we have used the **read** interface to read a string value and convert the same into an Int value.

```
main = print (readInt "12")
readInt :: String -> Int
readInt = read
```

Here, we are passing a String variable ("12") to the **readInt** method which in turn returns 12 (an Int value) after conversion. Here is its output –

```
sh-4.3$ main
12
```

Enum

Enum is another type of Type class which enables the sequential or ordered functionality in Haskell. This Type class can be accessed by commands such as **Succ, Pred, Bool, Char**, etc.

The following code shows how to find the successor value of 12.

```
main = print (succ 12)
```

It will produce the following output –

```
sh-4.3$ main
13
```

Bounded

All the types having upper and lower bounds come under this Type Class. For example, **Int** type data has maximum bound of "9223372036854775807" and minimum bound of "-9223372036854775808".

The following code shows how Haskell determines the maximum and minimum bound of Int type.

```
main = do
 print (maxBound :: Int)
 print (minBound :: Int)
```

It will produce the following output –

```
sh-4.3$ main
9223372036854775807
```

Now, try to find the maximum and minimum bound of Char, Float, and Bool types.

Num

This type class is used for numeric operations. Types such as Int, Integer, Float, and Double come under this Type class. Take a look at the following code –

```
main = do
 print(2 :: Int)
```

```
print(2 :: Float)
```

It will produce the following output –

```
sh-4.3$ main
2
2.0
```

Integral

Integral can be considered as a sub-class of the Num Type Class. Num Type class holds all types of numbers, whereas Integral type class is used only for integral numbers. Int and Integer are the types under this Type class.

Floating

Like Integral, Floating is also a part of the Num Type class, but it only holds floating point numbers. Hence, **Float** and **Double** come under this type class.

Custom Type Class

Like any other programming language, Haskell allows developers to define user-defined types. In the following example, we will create a user-defined type and use it.

```
data Area = Circle Float Float Float
surface :: Area -> Float
surface (Circle _ _ r) = pi * r ^ 2
main = print (surface $ Circle 10 20 10 )
```

Here, we have created a new type called **Area**. Next, we are using this type to calculate the area of a circle. In the above example, "surface" is a function that takes **Area** as an input and produces **Float** as the output.

Keep in mind that "data" is a keyword here and all user-defined types in Haskell always start with a capital letter.

It will produce the following output –

```
sh-4.3$ main
314.15927
```

Haskell - Functions

Functions play a major role in Haskell, as it is a functional programming language. Like other languages, Haskell does have its own functional definition and declaration.

- Function declaration consists of the function name and its argument list along with its output.
- Function definition is where you actually define a function.

Let us take small example of **add** function to understand this concept in detail.

```
add :: Integer -> Integer -> Integer --function declaration
add x y = x + y --function definition

main = do
 putStrLn "The addition of the two numbers is:"
 print(add 2 5) --calling a function
```

Here, we have declared our function in the first line and in the second line, we have written our actual function that will take two arguments and produce one integer type output.

Like most other languages, Haskell starts compiling the code from the **main** method. Our code will generate the following output –

```
The addition of the two numbers is:
7
```

```
fact :: Int -> Int
fact 0 = 1
fact n = n * fact ( n - 1 )

main = do
 putStrLn "The factorial of 5 is:"
 print (fact 5)
```

We all know how to calculate the factorial of a number. The compiler will start searching for a function called "fact" with an argument. If the argument is not equal to 0, then the number will keep on calling the same function with 1 less than that of the actual argument.

When the pattern of the argument exactly matches with 0, it will call our pattern which is "fact 0 = 1". Our code will produce the following output –

```
The factorial of 5 is:
120
```

This a example of pattern matching.

Guards

Guards is a concept that is very similar to pattern matching. In pattern matching, we usually match one or more expressions, but we use **guards** to test some property of an expression.

Although it is advisable to use pattern matching over **guards**, but from a developer's perspective, **guards** is more readable and simple. For first-time users, **guards** can look very similar to If-Else statements, but they are functionally different.

In the following code, we have modified our **factorial** program by using the concept of **guards**.

```
fact :: Integer -> Integer
fact n | n == 0 = 1
 | n /= 0 = n * fact (n-1)
main = do
 putStrLn "The factorial of 5 is:"
 print (fact 5)
```

Here, we have declared two **guards**, separated by "|" and calling the **fact** function from **main**. Internally, the compiler will work in the same manner as in the case of pattern matching to yield the following output –

```
The factorial of 5 is:
120
```

Where is a keyword or inbuilt function that can be used at runtime to generate a desired output. It can be very helpful when function calculation becomes complex.

Consider a scenario where your input is a complex expression with multiple parameters. In such cases, you can break the entire expression into small parts using the "where" clause.

In the following example, we are taking a complex mathematical expression. We will show how you can find the roots of a polynomial equation [x^2 - 8x + 6] using Haskell.

```
roots :: (Float, Float, Float) -> (Float, Float)
roots (a,b,c) = (x1, x2) where
 x1 = e + sqrt d / (2 * a)
 x2 = e - sqrt d / (2 * a)
 d = b * b - 4 * a * c
 e = - b / (2 * a)
main = do
 putStrLn "The roots of our Polynomial equation are:"
 print (roots(1,-8,6))
```

Notice the complexity of our expression to calculate the roots of the given polynomial function. It is quite complex. Hence, we are breaking the expression using the **where** clause. The above piece of code will generate the following output –

```
The roots of our Polynomial equation are:
(7.1622777,0.8377223)
```

Recursion Function

Recursion is a situation where a function calls itself repeatedly. Haskell does not provide any facility of looping any expression for more than once. Instead, Haskell wants you to break your entire functionality into a collection of different functions and use recursion technique to implement your functionality.

Let us consider our pattern matching example again, where we have calculated the factorial of a number. Finding the factorial of a number is a classic case of using Recursion. Here, you might, "How is pattern matching any different from recursion?" The difference between these two lie in the way they are used. Pattern matching works on setting up the terminal constrain, whereas recursion is a function call.

In the following example, we have used both pattern matching and recursion to calculate the factorial of 5.

```
fact :: Int -> Int
fact 0 = 1
fact n = n * fact ( n - 1 )

main = do
 putStrLn "The factorial of 5 is:"
 print (fact 5)
```

It will produce the following output –

```
The factorial of 5 is:
120
```

Higher Order Function

Till now, what we have seen is that Haskell functions take one **type** as input and produce another **type** as output, which is pretty much similar in other imperative languages. Higher Order Functions are a unique feature of Haskell where you can use a function as an input or output argument.

Although it is a virtual concept, but in real-world programs, every function that we define in Haskell use higher-order mechanism to provide output. If you get a chance to look into the library function of Haskell, then you will find that most of the library functions have been written in higher order manner.

Let us take an example where we will import an inbuilt higher order function map and use the same to implement another higher order function according to our choice.

```
import Data.Char
import Prelude hiding (map)

map :: (a -> b) -> [a] -> [b]
map _ [] = []
map func (x : abc) = func x : map func abc
main = print $ map toUpper "hello all"
```

In the above example, we have used the **toUpper** function of the Type Class **Char** to convert our input into uppercase. Here, the method "map" is taking a function as an argument and returning the required output. Here is its output –

```
sh-4.3$ ghc -O2 --make *.hs -o main -threaded -rtsopts
sh-4.3$ main
"HELLO ALL"
```

For more examples Please refer lecture notes.

Lambda Expression

We sometimes have to write a function that is going to be used only once, throughout the entire lifespan of an application. To deal with this kind of situations, Haskell developers use another anonymous block known as **lambda expression** or **lambda function**.

A function without having a definition is called a lambda function. A lambda function is denoted by "\" character. Let us take the following example where we will increase the input value by 1 without creating any function.

```
main = do
 putStrLn "The successor of 4 is:"
  print ((\x -> x + 1) 4)
```

Here, we have created an anonymous function which does not have a name. It takes the integer 4 as an argument and prints the output value. We are basically operating one function without even declaring it properly. That's the beauty of lambda expressions.

Our lambda expression will produce the following output –

```
sh-4.3$ main
The successor of 4 is:
5
```

Head Function

Head function works on a List. It returns the first of the input argument which is basically a list. In the following example, we are passing a list with 10 values and we are generating the first element of that list using the head function.

```
main = do
 let x = [1..10]
 putStrLn "Our list is:"
 print (x)
 putStrLn "The first element of the list is:"
 print (head x)
```

It will produce the following output –

```
Our list is:
[1,2,3,4,5,6,7,8,9,10]
The first element of the list is:
1
```

Tail Function

Tail is the function that complements the **head** function. It takes a **list** as the input and yields the entire list without the head part. That means, the **tail** function returns the entire list without the first element. Take a look at the following example –

```
main = do
 let x = [1..10]
 putStrLn "Our list is:"
 print (x)
 putStrLn "The tail of our list is:"
 print (tail x)
```

It will produce the following output –

```
Our list is:
[1,2,3,4,5,6,7,8,9,10]
The tail of our list is:
[2,3,4,5,6,7,8,9,10]
```

Last Function

As the name suggests, it yields the last element of the list that is provided as the input. Check the following example.

```
main = do
 let x = [1..10]
 putStrLn "Our list is:"
 print (x)
 putStrLn "The last element of our list is:"
 print (last x)
```

It will produce the following output –

Our list is:
[1,2,3,4,5,6,7,8,9,10]
The last element of our list is:
10

Init Function

Init works exactly as the opposite of **tail** function. It takes a list as an argument and returns the entire list without the last entry.

```
main = do
 let x = [1..10]
 putStrLn "Our list is:"
 print (x)
 putStrLn "Our list without the last entry:"
 print (init x)
```

Now, observe its output –

Our list is:
[1,2,3,4,5,6,7,8,9,10]
Our list without the last entry:
[1,2,3,4,5,6,7,8,9]

Null Function

Null is a Boolean check function which works on a String and returns **True** only when the given list is empty, otherwise it returns **False**. The following code checks whether the supplied list is empty or not.

```
main = do
 let x = [1..10]
 putStrLn "Our list is:"
 print (x)
 putStrLn "Is our list empty?"
 print (null x)
```

It will produce the following output –

Our list is:
[1,2,3,4,5,6,7,8,9,10]

Reverse Function

It works on a String input and converts the entire input into reverse order and give one output as a result. Below is the code base for this function.

```
main = do
let x = [1..10]
putStrLn "Our list is:"
print (x)
putStrLn "The list in Reverse Order is:"
print (reverse x)
```

It will produce the following output –

Our list is:
[1,2,3,4,5,6,7,8,9,10]
The list in Reverse Order is:
[10,9,8,7,6,5,4,3,2,1]

Length Function

This function is used to calculate the length of the **list** given as an argument. Take a look at the following example –

```
main = do
let x = [1..10]
putStrLn "Our list is:"
print (x)
putStrLn "The length of this list is:"
print (length x)
```

We have 10 elements in our list, hence our code will yield 10 as the output.

Our list is:
[1,2,3,4,5,6,7,8,9,10]
The length of this list is:
10

Take Function

Take function is used to create a sub-string from another String. The following code shows how you can use the take function in Haskell –

```
main = print(take 5 ([1 .. 10]))
```

The code generates a sub-string containing 5 elements from the supplied list

– [1,2,3,4,5]

Drop Function

This function is also used to generate a sub-string. It functions as the opposite of the **take** function. Look at the following piece of code –

```
main = print(drop 5 ([1 .. 10]))
```

The code drops the first 5 elements from the supplied list and prints the remaining 5 elements. It will produce the following output –

[6,7,8,9,10]

Maximum Function

This function is used to find the element with the maximum value from the supplied list.

```
main = do
 let x = [1,45,565,1245,02,2]
 putStrLn "The maximum value element of the list is:"
 print (maximum x)
```

The above piece of code will generate following output –

The maximum value element of the list is:
1245

Sum Function

As the name suggests, this function returns the summation of all the elements present in the supplied list. The following code takes a list of 5 elements and returns their summation as the output.

```
main = do
 let x = [1..5]
 putStrLn "Our list is:"
 print (x)
 putStrLn "The summation of the list elements is:"
 print (sum x)
```

It will produce the following output –

Our list is:
[1,2,3,4,5]
The summation of the list elements is:
15

Product Function

You can use this function to multiply all the elements in a list and print its value.

```
main = do
 let x = [1..5]
 putStrLn "Our list is:"
 print (x)
 putStrLn "The multiplication of the list elements is:"
 print (product x)
```

Our code will produce the following output –

```
Our list is:
[1,2,3,4,5]
The multiplication of the list elements is:
120
```

Elem Function

This function is used to check whether the supplied list contains a specific element or not. Accordingly, it either returns a **true** or a **false**.

The following code checks whether the supplied list of elements contains the value 986.

```
main = do
 let x = [1,45,155,1785]
 putStrLn "Our list is:"
 print (x)
 putStrLn "Does it contain 986?"
 print (elem 986 (x))
```

It will produce the following output –

```
Our list is:
[1,45,155,1785]
Does it contain 986?
False
```

Haskell - Function Composition

Function Composition is the process of using the output of one function as an input of another function. It will be better if we learn the mathematics behind **composition**. In mathematics, **composition** is denoted by **f{g(x)}** where **g()** is a function and its output in used as an input of another function, that is, **f()**.

Function composition can be implemented using any two functions, provided the output type of one function matches with the input type of the second function. We use the dot operator (.) to implement function composition in Haskell.

Look at the following example code. Here, we have used function composition to calculate whether an input number is even or odd.

```
eveno :: Int -> Bool
noto :: Bool -> String

eveno x = if x `rem` 2 == 0
 then True
else False
noto x = if x == True
 then "This is an even Number"
else "This is an ODD number"

main = do
 putStrLn "Example of Haskell Function composition"
 print ((noto.eveno)(16))
```

Here, in the **main** function, we are calling two functions, **noto** and **eveno**, simultaneously. The compiler will first call the function **"eveno()"** with **16** as an argument. Thereafter, the compiler will use the output of the **eveno** method as an input of **noto()** method.

Its output would be as follows –

```
Example of Haskell Function composition
"This is an even Number"
```

Since we are supplying the number 16 as the input (which is an even number), the **eveno()** function returns **true**, which becomes the input for the **noto()** function and returns the output: "This is an even Number".

Haskell - Modules

Like JAVA where all the classes are bound into a folder called **package**. Similarly, Haskell can be considered as a collection of **modules**.

Haskell is a functional language and everything is denoted as an expression, hence a Module can be called as a collection of similar or related types of functions.

You can **import** a function from one module into another module. All the "import" statements should come first before you start defining other functions.

List Module

List provides some wonderful functions to work with **list** type data. Once you import the List module, you have a wide range of functions at your disposal.

```
import Data.List

main = do
 putStrLn("Different methods of List Module")
 print(intersperse '.' "Haskell Tutorials")
 print(intercalate " " ["Lets","Start","with","Haskell"])
 print(splitAt 7 "HaskellTutorial")
 print (sort [8,5,3,2,1,6,4,2])
```

That is because these functions are available in the List module. After importing the List module, the Haskell compiler made all these functions available in the global namespace. Hence, we could use these functions.

Our code will yield the following output –

```
Different methods of List Module
"H.a.s.k.e.l.l. .T.u.t.o.r.i.a.l.s"
"Lets Start with Haskell"
("Haskell","Tutorial")
[1,2,2,3,4,5,6,8]
```

Char Module

The **Char** module has plenty of predefined functions to work with the Character type.

```
import Data.Char

main = do
 putStrLn("Different methods of Char Module")
 print(toUpper 'a')
 print(words "Let us study tonight")
 print(toLower 'A')
```

OUTPUT:

```
Different methods of Char Module
'A'
["Let","us","study","tonight"]
'a'
```

Map Module

Map is an unsorted value-added pair type data type. It is a widely used module with many useful functions. The following example shows how you can use a predefined function available in the Map module.

```
import Data.Map (Map)
import qualified Data.Map as Map --required for GHCI

myMap :: Integer -> Map Integer [Integer]
myMap n = Map.fromList (map makePair [1..n])
 where makePair x = (x, [x])

main = print(myMap 3)
```

It will produce the following output –

fromList [(1,[1]),(2,[2]),(3,[3])]

Set Module

The Set module has some very useful predefined functions to manipulate mathematical data. A set is implemented as a binary tree, so all the elements in a set must be unique.

```
import qualified Data.Set as Set

text1 = "Hey buddy"
text2 = "This tutorial is for Haskell"

main = do
 let set1 = Set.fromList text1
 set2 = Set.fromList text2
 print(set1)
 print(set2)
```

OUTPUT:

fromList " Hbdeuy"
fromList " HTaefhiklorstu"

Custom Module

Let's see how we can create a custom module that can be called at other programs. To implement this custom module, we will create a separate file called **"custom.hs"** along with our **"main.hs"**.

Let us create the custom module and define a few functions in it.

custom.hs

```
module Custom (
 showEven,
 showBoolean
) where

showEven:: Int-> Bool
```

```
showEven x = do

if x 'rem' 2 == 0
 then True
else False
showBoolean :: Bool->Int
showBoolean c = do

if c == True
 then 1
else 0
```

Custom module is ready. Now, let us import it into a program.

main.hs

```
import Custom

main = do
 print(showEven 4)
 print(showBoolean True)
```

Our code will generate the following output –

```
True
1
```

The **showEven** function returns **True**, as "4" is an even number. The **showBoolean** function returns "1" as the Boolean function that we passed into the function is "True".

Haskell - Input & Output

For this topic Please refer lecture notes.

Hw= putStrLn “Hello”

Hw : : IO()

Command Prompt - ghci

```
C:\Users\Aaysha\Desktop\H1>ghci f5.hs
GHCi, version 8.6.5: http://www.haskell.org/ghc/  :? for help
[1 of 1] Compiling Main             ( f5.hs, interpreted )
Ok, one module loaded.
*Main> :main
8
*Main> :q
Leaving GHCi.

C:\Users\Aaysha\Desktop\H1>ghci
GHCi, version 8.6.5: http://www.haskell.org/ghc/  :? for help
Prelude> hw =putStrLn "Hello"
Prelude> hw :: IO()
Hello
Prelude> hw
Hello
Prelude> :type hw
hw :: IO ()
Prelude>
```

IO

()

???? hw Dealing with

Return

Empty Tuple

Type

Environment

Program1

```
hello.hs

main = do
    putStrLn "Please Enter your Age: "
    age <- getLine
    let ageAsNumber = read age::Int
    let newAge = ageAsNumber + 10
    putStrLn ("In ten years, you will be " ++ show newAge ++ " years old!")
```

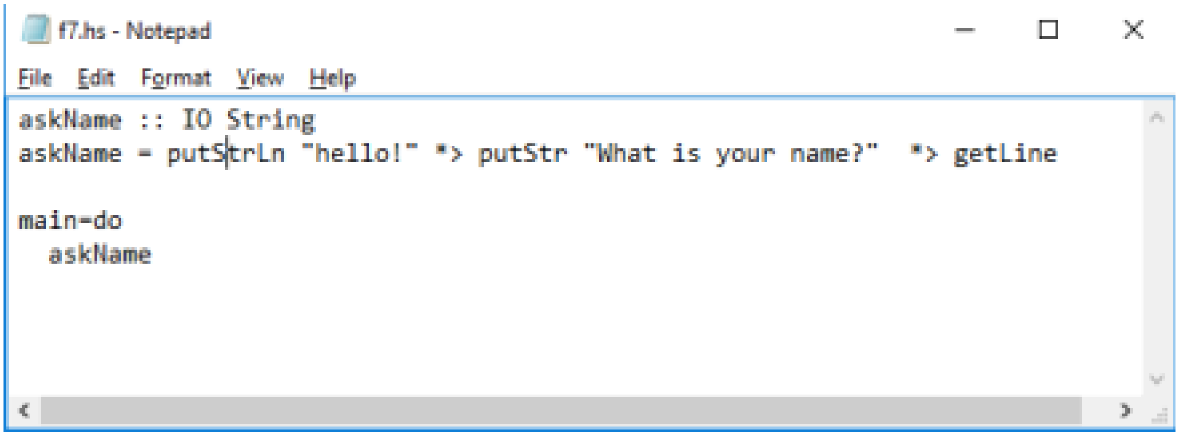
OUTPUT:

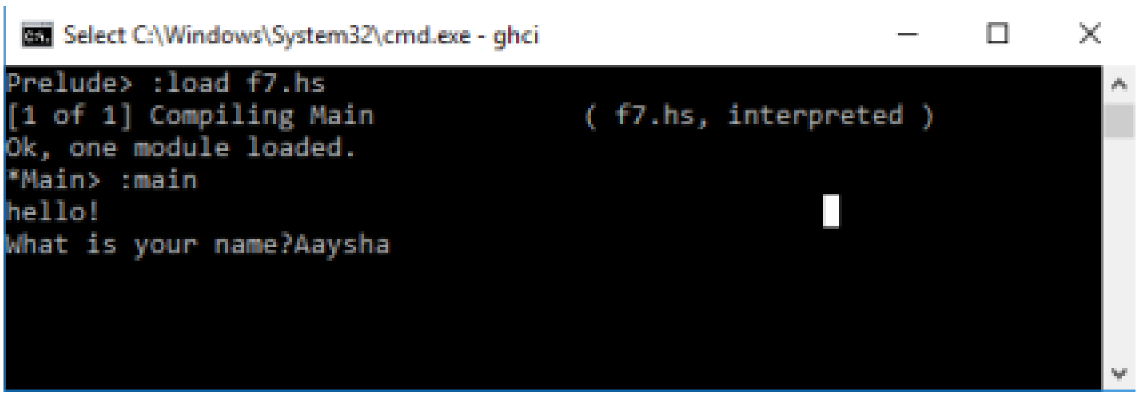
```
*Main> :reload
[1 of 1] Compiling Main             ( hello.hs, interpreted )
Ok, one module loaded.
*Main> :main
Please Enter your Age:
40
In ten years, you will be 50 years old!
*Main>
```

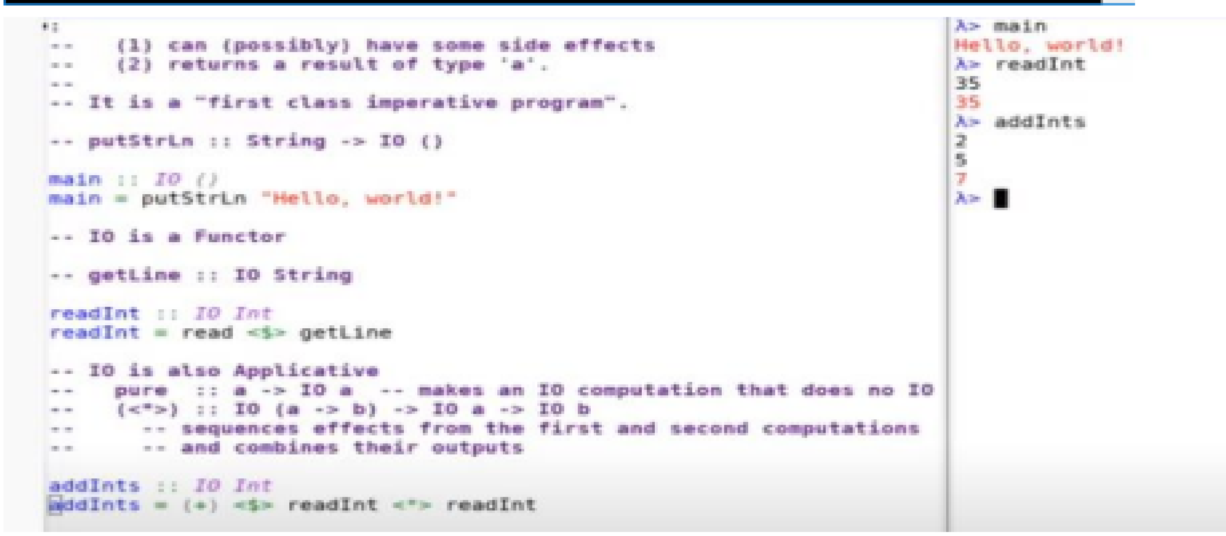
Some More Example:

```
C:\Windows\System32\cmd.exe - ghci
Failed, no modules loaded.
Prelude> :load f6.hs
[1 of 1] Compiling Main             ( f6.hs, interpreted )
Ok, one module loaded.
*Main> :main
a
a
y
y
s
s

*Main>
```

```
f6.hs - Notepad
File  Edit  Format  View  Help
import Control.Monad

main=do
  c <- getChar
  when (c/=' ') $ do
    putChar c
    main
```







We will learn different input and output techniques used in Haskell.

Files and Streams

We have so far hard-coded all the inputs in the program itself. We have been taking inputs from static variables. Now, let us learn how to read and write from an external file.

Let us create a file and name it "abc.txt". Next, enter the following lines in this text file: "Welcome to Haskell. Here, you will get the best resource to learn Haskell."

Next, we will write the following code which will display the contents of this file on the console. Here, we are using the function readFile() which reads a file until it finds an EOF character.

```
main = do
 let file = "abc.txt"
 contents <- readFile file
 putStrLn contents
```

The above piece of code will read the file "abc.txt" as a String until it encounters any End of File character. This piece of code will generate the following output.

```
Welcome to Haskell
Here, you will get the best resource to learn Haskell.
```

Observe that whatever it is printing on the terminal is written in that

file.

Command Line Argument

Haskell also provides the facility to operate a file through the command prompt. Let us get back to our terminal and type **"ghci"**. Then, type the following set of commands –

```
let file = "abc.txt"
writeFile file "I am just experimenting here."
readFile file
```

Here, we have created a text file called "abc.txt". Next, we have inserted a statement in the file using the command **writeFile**. Finally, we have used the command **readFile** to print the contents of the file on the console. Our code will produce the following output –

```
I am just experimenting here.
```

Haskell – Monads

A monad is a way to structure computations in terms of values and sequences of computations using those values.

Monads allow the programmer to build up computations using sequential building blocks, which can themselves be sequences of computations.

The monad determines how combined computations form a new computation and frees the programmer from having to code the combination manually each time it is required

In Haskell, monads play a central role in the I/O system.

They have three properties that make them especially useful:

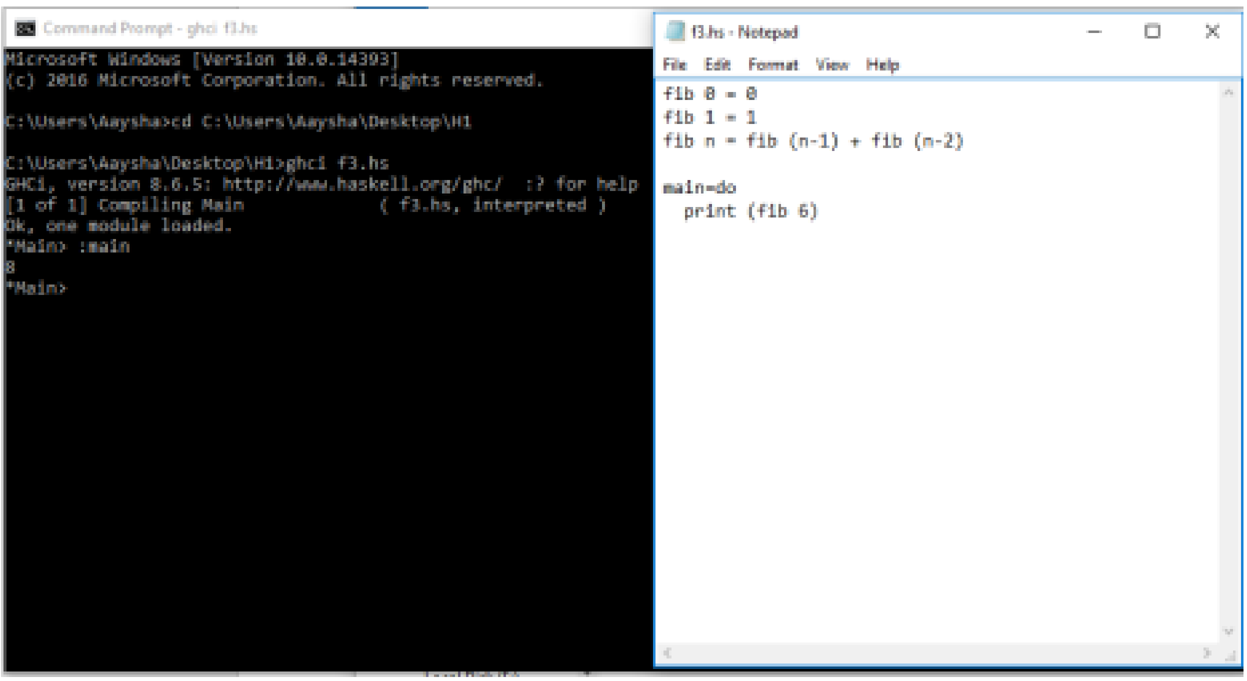
Modularity - They allow computations to be composed from simpler computations and separate the combination strategy from the actual computations being performed.

Flexibility - They allow functional programs to be much more adaptable than equivalent programs written without monads.

Isolation - They can be used to create imperative-style computational structures which remain safely isolated from the main body of the functional program

The Fibonacci sequence

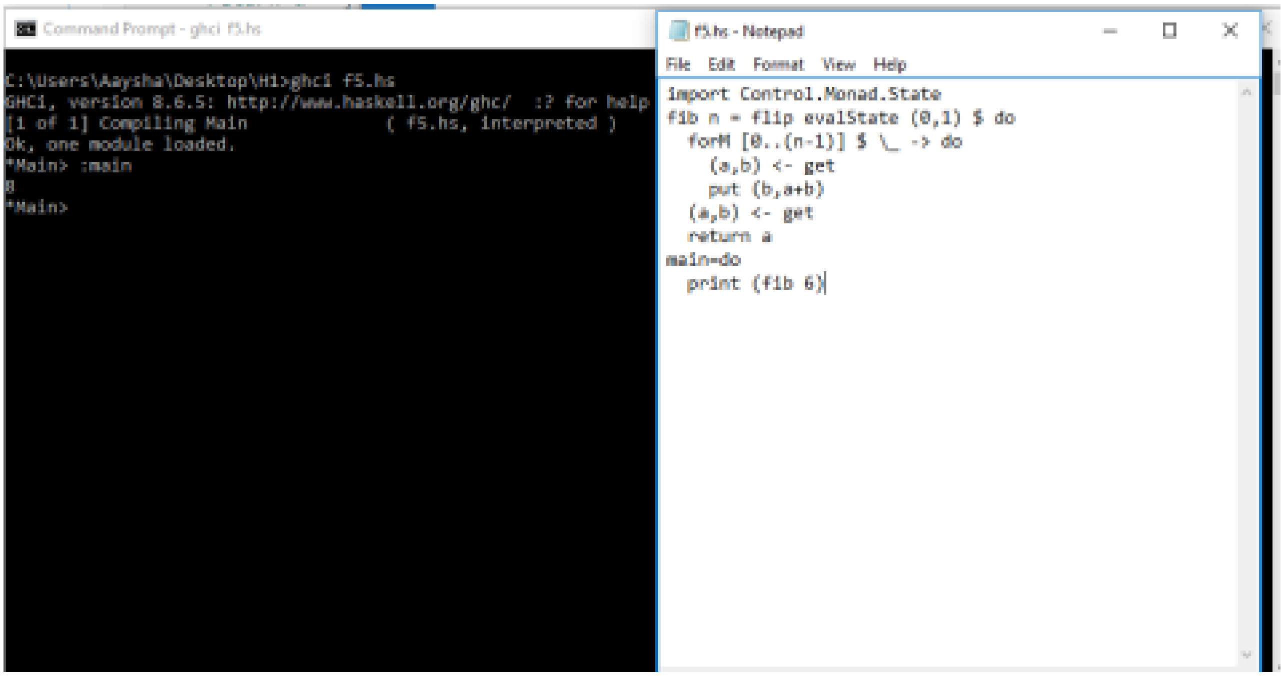
Naive definition



Explanation

- Line 1: We define the condition `F(0)` = `0`.
- Line 2: We define the condition `F(1)` = `1`.
- Line 3: We implement the recursive expression of the algorithm. The name of the function is `fib`.
- Line 5: We invoke the `fib` function with `n` as `8`.

Monadic



We all know Haskell defines everything in the form of functions. In functions, we have options to get our input as an output of the function. This is what a **Monoid** is.

A **Monoid** is a set of functions and operators where the output is independent of its input. Let's take a function (*) and an integer (1). Now, whatever may be the input, its output will remain the same number only. That is, if you multiply a number by 1, you will get the same number.

Here is a Type Class definition of monoid.

```
class Monoid m where
 mempty :: m
 mappend :: m -> m -> m
 mconcat :: [m] -> m
 mconcat = foldr mappend mempty
```

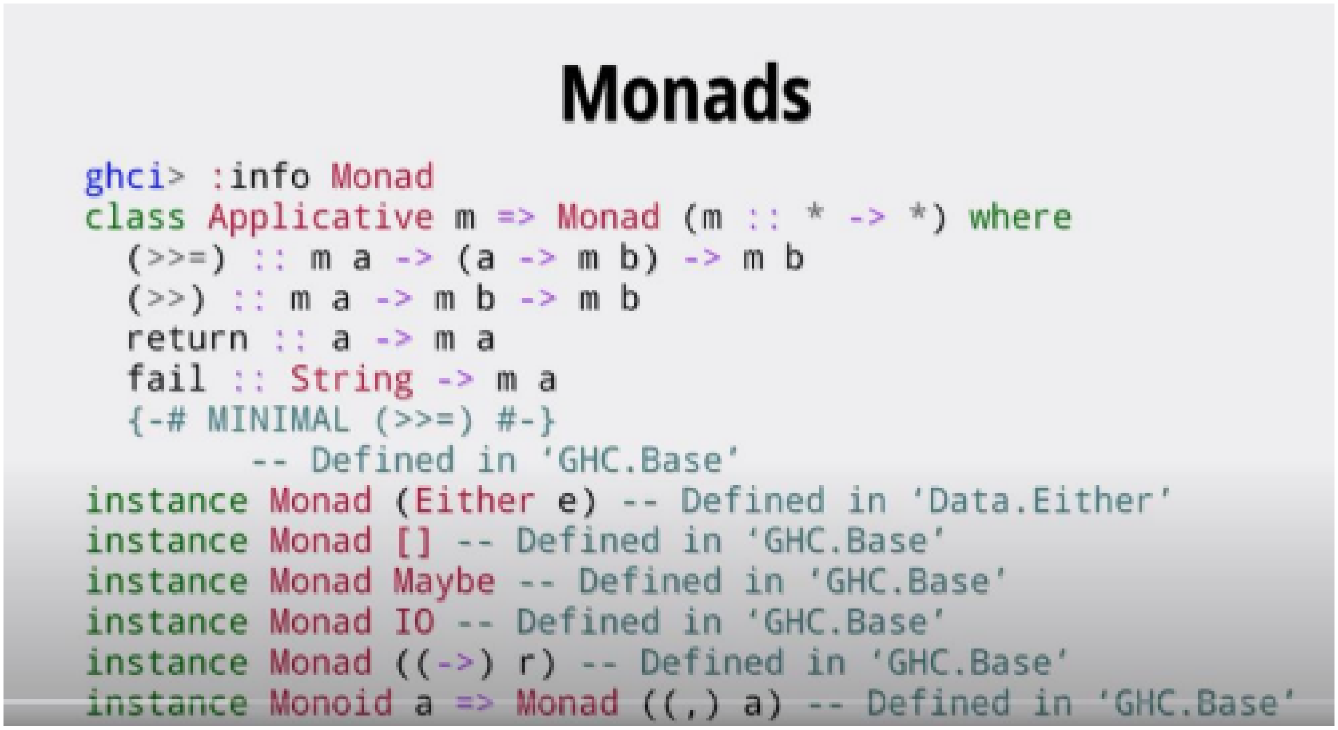
Look at the following example to understand the use of Monoid in Haskell.

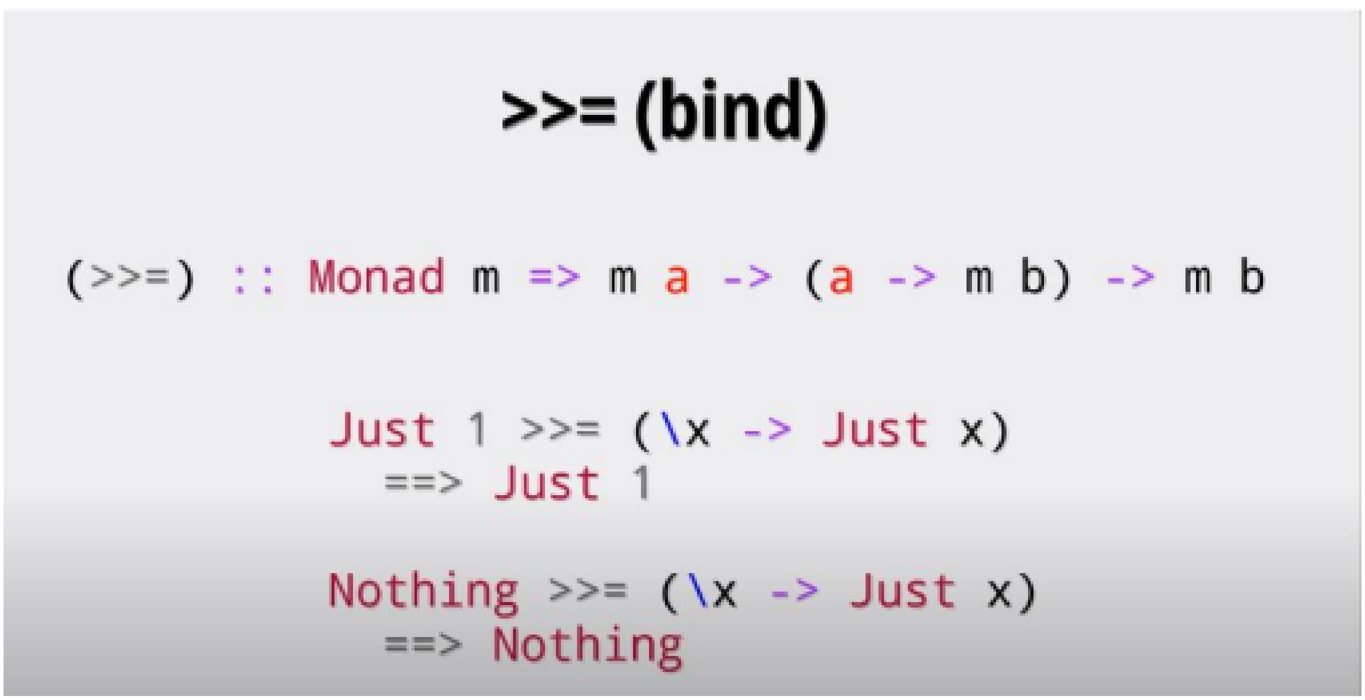
```
multi:: Int->Int
multi x = x * 1
add :: Int->Int
add x = x + 0

main = do
 print(multi 9)
 print (add 7)
```

Our code will produce the following output –

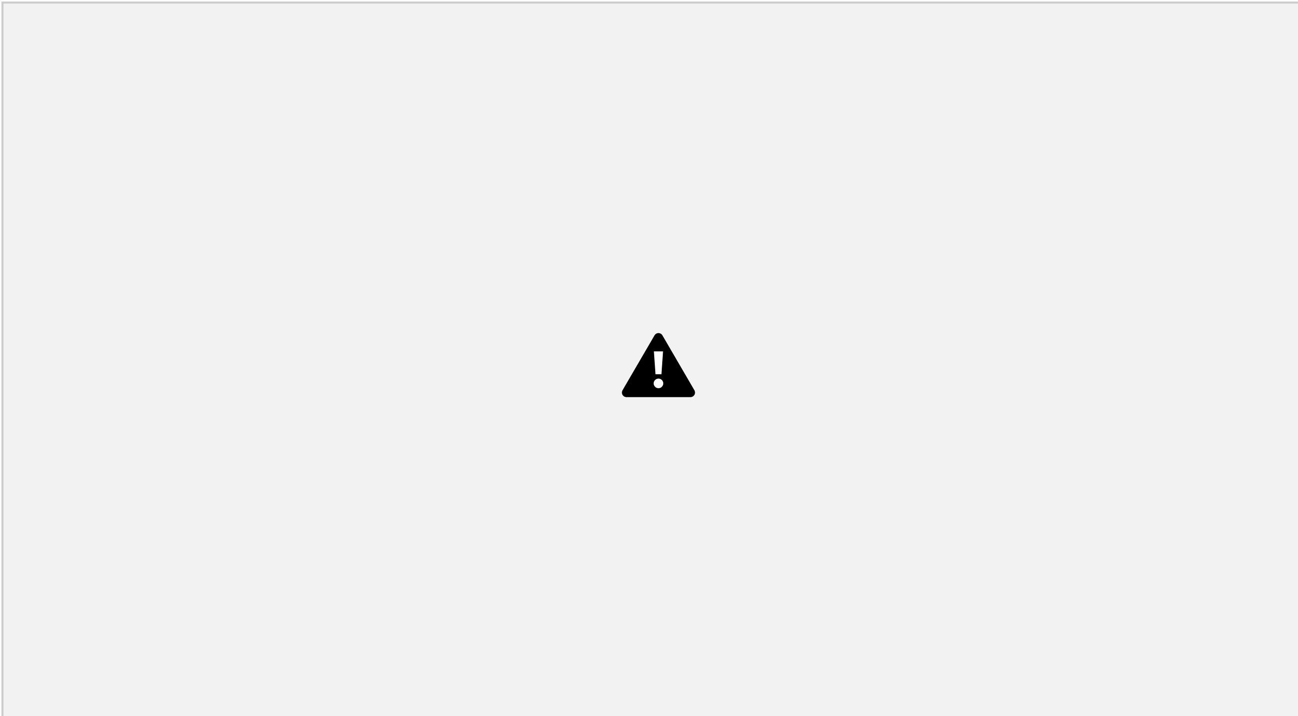
```
9
7
```

Here, the function "multi" multiplies the input with "1". Similarly, the function "add" adds the input with "0". In the both the cases, the output will be same as the input. Hence, the functions **{(*),1}** and **{(+),0}** are the perfect examples of monoids.

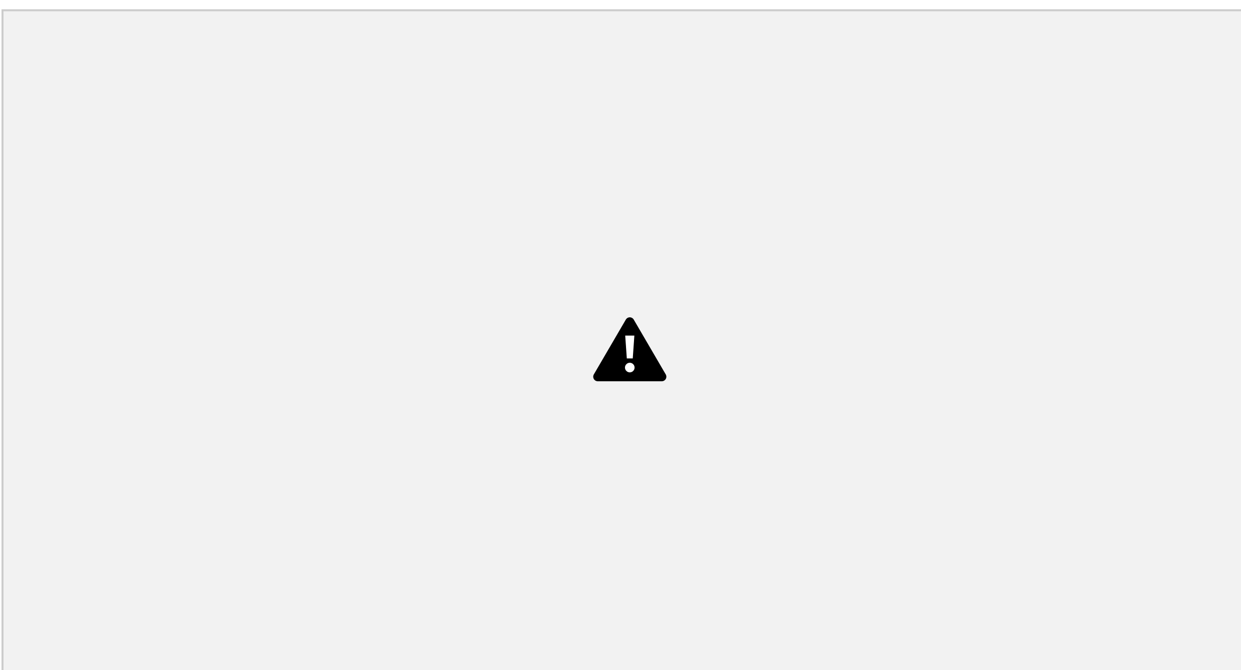




Type changes



Renaming this function



Monads are nothing but a type of Applicative Functor with some extra features. It is a Type class which governs three basic rules known as **monadic rules**.

All the three rules are strictly applicable over a Monad declaration which is as follows –

```
class Monad m where
 return :: a -> m a
 (>>=) :: m a -> (a -> m b) -> m b
 (>>) :: m a -> m b -> m b
 x >> y = x >>= \_ -> y
 fail :: String -> m a
 fail msg = error msg
```

The three basic laws that are applicable over a Monad declaration are –

- **Left Identity Law** – The **return** function does not change the value and it should not change anything in the Monad. It can be expressed as "return >=> mf = mf".
- **Right Identity Law** – The **return** function does not change the value and it should not change anything in the Monad. It can be expressed as "mf >=> return = mf".
- **Associativity** – According to this law, both Functors and Monad instance should work in the same manner. It can be mathematically expressed as "(f >==>g) >=> h =f >= >(g >=h)".

The first two laws iterate the same point, i.e., a **return** should have identity behavior on both sides of the **bind** operator.

We have already used lots of Monads in our previous examples without realizing that they are Monad. Consider the following example where we are using a List Monad to generate a specific list.

```
main = do
 print([1..10] >>= (\x -> if odd x then [x*2] else []))
```

This code will produce the following output –

[2,6,10,14,18]