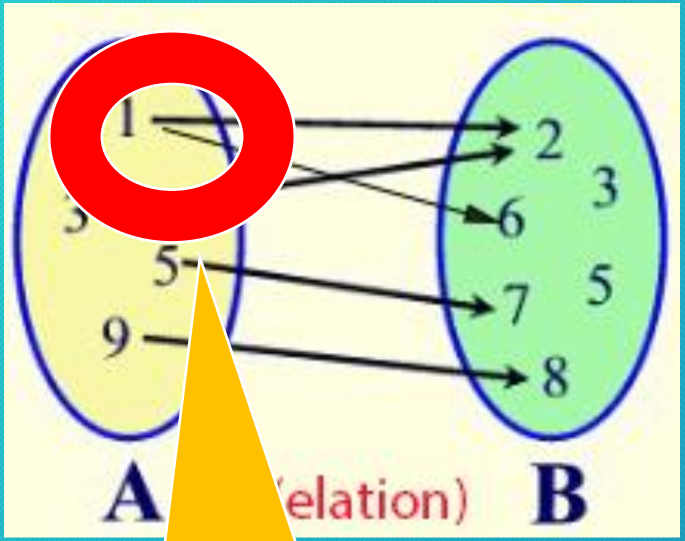
PROGRAMMING IN HASKELL

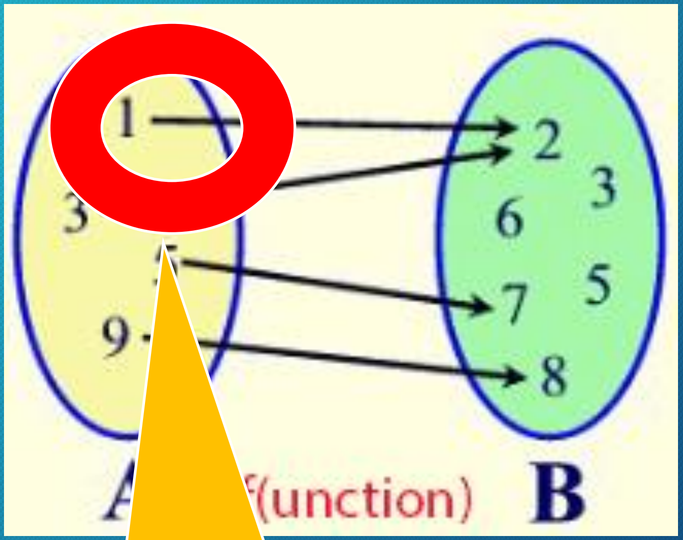
Topic 4 - Defining Functions

You may remember …..

The nature of functions



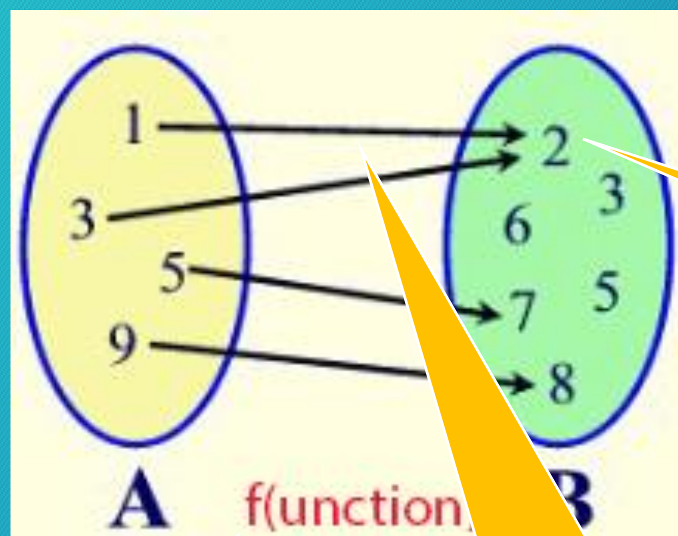
R = { .. (1,2), (1, 6), ..}
A relation may have many mappings from the domain.



f = { .. (1,2), (3, 6), ..}
A function has one mapping from each element in the domain

The nature of functions

So, in mathematical terms, we apply a function to a value of type A and it returns a value of type B.



One unique value returned

f: A -> B
f = {..(1,2) .. }

f (1) = 2

The nature of functions.. maths

- So, 2 being returned from the application of f to 1 is the ***effect*** of the function f.
- In mathematical functions, nothing else happens when f is called/applied.
- We say 'there are no side-effects'

The nature of functions.. Programming, e.g. Java

- We use the term **methods**.

- Methods can be
  - Accessors/read (e.g. getters)

  - Mutators/ read/write (e.g. setters)

The nature of functions.. accessors and mutators


```
class Spot{
  float xCoord, yCoord;

  // constructors…
  // display method…
  // colour methods…
  // move methods…
}
```

Simple class with two fields!

The nature of functions.. accessors

```
public float getXCoord(){
     return xCoord;
  }
```

This changes no state and simply returns a value

This is the **effect** of the function

This function has no **side-effects**. It is ***pure***

The nature of functions.. mut

This only changes state and returns no value

```
public void  setXCoord (float xCoord){
    this.xCoord = xCoord;
 }
```

This function has only **side-effects.**

This function has no **effect**

The nature of functions.. muta

This changes state and returns a value

```
public float  setXCoord (float xCoord){
    this.xCoord = xCoord;
    return this.xCoord;
 }
```

This function has an **effect**

This function also has **side-effects.**

Purity in Haskell

In Haskell, functions are pure. This means that functions have only effects, no side-effects.

Thus

- We do not deal with state.
- Functions simply take arguments and return a value. The application or running of a function does not change the **outside world** in any way.

Conditional Expressions

As in most programming languages, functions can be defined using <u>conditional expressions</u>.

```
myAbs :: Int → Int
myAbs n = if n ≥ 0 then n else -n
```

myAbs takes an integer n and returns n if it is non-negative and -n otherwise.

When calling this on a negative number we need to parenthesise e.g. myAbs (-7)

Conditional expressions can be nested:


```
mySignum :: Int → Int
mySignum n = if n < 0 then -1 else
                 if n == 0 then 0 else 1
```

In Haskell, conditional expressions must always have an else branch, which avoids any possible ambiguity problems with nested conditionals.

Guarded Equations

As an alternative to conditionals, functions can also be defined using <u>guarded equations</u>.

```
myAbs n | n ≥ 0     = n
        | otherwise = -n
```

As previously, but using guarded equations.

Guarded Equations

Guarded equations can be used to make definitions involving multiple conditions easier to read:

```
mySignum n | n < 0      = -1
           | n == 0     = 0
           | otherwise = 1
```

The catch all condition <u>otherwise</u> is defined in the prelude by otherwise = True.

Case statement

As an alternative to conditionals, functions can also be defined using <u>case statements</u>

```
addOneIfOdd n = case odd n of
      True -> f n
      False -> n
      where f n = n+1
```

Use if this will return one of small number of possible values.

Pattern Matching

Many functions have a particularly clear definition using pattern matching on their arguments.

```
not :: Bool → Bool
not False = True
not True  = False
```

not maps False to True, and True to False.

Pattern Matching

Functions can often be defined in many different ways using pattern matching. For example

```
(&&) :: Bool → Bool → Bool
True  && True  = True
True  && False = False
False && True  = False
False && False = False
```

can be defined more compactly by

```
True && True = True
_    && _    = False
```

Using wildcard _

Pattern Matching

However, the following definition is more efficient, because it avoids evaluating the second argument if the first argument is False:

```
True  && b = b
False && _ = False
```

The underscore symbol _ is a wildcard pattern that matches any argument value.

Pattern Matching

- Patterns are matched in order. For example, the following definition always returns False:

```
_    && _    = False
True && True = True
```

- Patterns may not repeat variables. For example, the following definition gives an error:

```
b && b = b
_ && _ = False
```

Use of where with Guards

- Want to avoid calculating the same value over and over.
- Calculate this intermediate value once, store and use often
- Use the where clause
- The scope of the variables defined in the where section of a function is the function itself. (clean)
- We can also use where bindings to pattern match

Use of where with Guards(2)

Look at a function to 'calculate' your annual salary

```
annualSalaryCalc :: (RealFloat a) => a -> a -> String
annualSalaryCalc hourlyRate weekHoursOfWork
    | hourlyRate * (weekHoursOfWork * 52) <= 40000 = "Poor child, try to get another job"
    | hourlyRate * (weekHoursOfWork * 52) <= 120000 = "Money, Money, Money!"
    | hourlyRate * (weekHoursOfWork * 52) <= 200000 = "Ri¢hie Ri¢h"
    | otherwise = "Hello Elon Musk!"
```

Would be useful to name the

`hourlyRate* weekHoursOfWork * 52`

value

Use of where with Guards and patterns (3)


```
annualSalaryCalc' :: (RealFloat a) => a -> a -> String
annualSalaryCalc' hourlyRate weekHoursOfWork
    | annualSalary <= smallSalary = "Poor child, try to get another job"
    | annualSalary <= mediumSalary = "Money, Money, Money!”
    | annualSalary <= highSalary = "Ri¢hie Ri¢h"
    | otherwise = "Hello Elon Musk!"
    where
      annualSalary = hourlyRate * (weekHoursOfWork * 52)
      (smallSalary, mediumSalary, highSalary) = (40000, 120000, 200000)
```

The let expression

Let expressions are similar to where bindings

```
cylinder :: Double -> Double -> Double
cylinder r h =
   let  sideArea = 2 * pi * r * h
        topArea = pi * r ^ 2
   in sideArea + 2 * topArea
```

Example using let

```
cylinder :: Double -> Double -> Double
cylinder r h =
    sideArea + 2 * topArea
    where sideArea = 2 * pi * r * h
              topArea = pi * r ^ 2
```

Example using where

List Patterns - the (:) operator

Internally, every non-empty list is constructed by repeated use of an operator (:) called "<u>cons</u>" that adds an element to the start of a list.

[1]

Is the same as 1: []

[1,2]

Is the same as 1:(2:[]).

[1,2,3,4]

Is the same as 1:(2:(3:(4:[]))).

Patterns in functions

Functions on lists can be defined using x:xs patterns.

```
head :: [a] → a
head (x:_) = x

tail :: [a] → [a]
tail (_:xs) = xs
```

head and tail map any non-empty list to its first and remaining elements.

Notes:

- x:xs patterns match <u>non-empty</u> lists:

```
> head []
*** Exception: No head for empty lists!
```

- This can be effected by writing as part of the function def:

```
head :: [a] → a
head[] = error “No head for empty lists!”
head (x:_) = x
```

Note - parenthesise!

- x:xs patterns must be parenthesised, because application has priority over (:). For example, the following definition gives an error:

```
head x:_ = x
```

Operator Sections

An operator written between its two arguments can be converted into a curried function written before its two arguments by using parentheses.

For example:

```
> 1+2
3

> (+) 1 2
3
```

Operator Sections

This convention also allows one of the arguments of the operator to be included in the parentheses.

For example:

```
> (1+) 2
3

> (+2) 1
3
```

In general, if ⊕ is an operator then functions of the form (⊕), (x⊕) and (⊕y) are called sections.

Why Are Sections Useful?

Useful functions can sometimes be constructed in a simple way using sections. For example:

- `(1+)` - successor function
- `(1/)` - reciprocation function
- `(*2)` - doubling function
- `(/2)` - halving function


ANY
QUESTIONS?