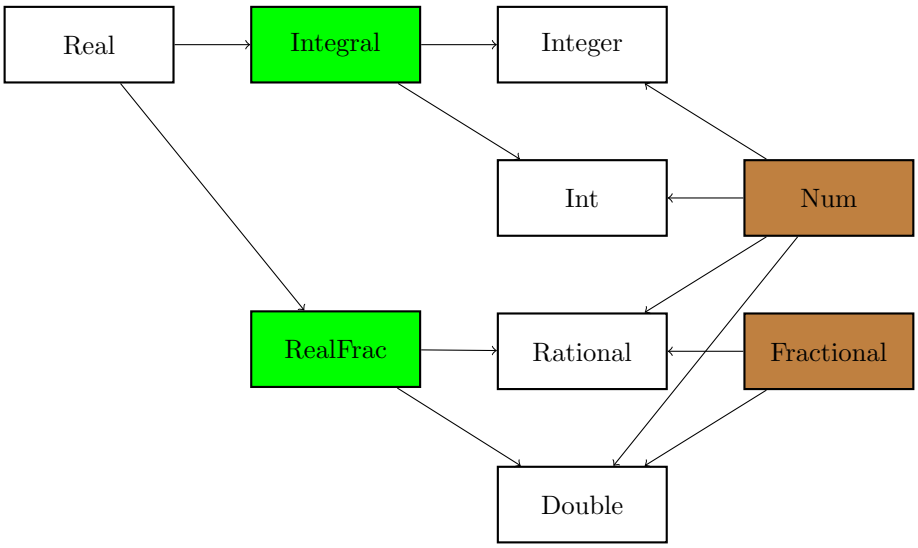


```
-- Ring
class Num a where
    (+):: a -> a -> a
    (/):: a -> a -> a
    (*):: a -> a -> a
    abs:: a -> a
    signum:: a -> a
    negate:: a -> a

-- Field
class (Num a)=> Fractional a where
    (/):: a -> a -> a

class (Num a, Ord a)=> Real a where

-- Integral Domain, Euclidean Domain
-- div, mod, gcd, lcm, etc
class (Real a, Enum a)=> Integral where
```

1 converting from and between integral-types(integer-like types)

- Integer - which are arbitrary-precision integer
- Int - which fixed-width machine-specific integers, its range of Int is -2^{31} to $+2^{31} - 1$

```
-- convert Integral to Num
fromIntegral::(Integral a, Num b)=>a->b
```

2 converting from and between fractional-types

```
-- convert from Rational to Fractional
fromRational::(Fractional a)=>Rational->a
-- convert from Real to Rational
toRational::(Real a)=>a->Rational
-- use Int with '/' division
let n1 = 3::Int
let n2 = 4::Int
n1 / n2 -- error
fromIntegral n1 / fromIntegral n2

class (Num a)=> Fractional a where
    (/)::a -> a -> a

-- Fractional is subclass of Num?
-- dose Fractional use upperclass(Num) function: (+) (*) etc ?
-- convert Int to Integer with fromIntegral ? this is very weird
```

3 converting from and between real-types

- Rational - which are arbitrary-precision fractions
- Double - which are double-precision float-point numbers

```
-- convert from Real to Fractional
realToFrac::(Real a, Fractional b)=>a->b
-- convert from Rational to Fractional
fromRational::(Fractional a)=>Rational->a
```

4 converting from and between floating-point precision types

```
-- converting between float and double can be done using GHC-specific functions in the G
-- Float <=> Double
float2Double::Float -> Double
double2Float::Double -> Float
```

5 unboxed and boxed types

- unboxed type[value]: Int, Float, Double(int, float, double in C)
- boxed type[pointer]: int*, void* (pointer in C)

It is easier to explain with low-level language like C. Unboxed types are like int float, double, etc. Boxed types are like int*, float*, double*, etc. If you have got the int, you always know the value as it's represented in the bit-pattern, thereforce, it is not lazy. It must be strict too, as all values of int are valid and not bottom.
However, given an int* you may choose to dereference the pointer late to get the actual value (thus lazy), and it is possible to have invalid pointer.(it contains BOTTOM, i.e. non-strict)