Datatypes

.NET

*In computer science and computer programming, a data **type** or simple **type** is an attribute of data which tells the compiler or interpreter how the programmer intends to use the data.*

https://en.wikipedia.org/wiki/data_type

Primitive Types in C# vs Java

https://medium.com/omarelgabrys-blog/primitive-data-types-in-c-vs-java-5b8a597eef05#:~:text=
https://docs.microsoft.com/en-us/dotnet/csharp/language-reference/builtin-types/built-in-types

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Typically, the most familiar primitive data types are:
int, object, short, float, double, char, bool. These are called primitive because they are the types used to build other, more complex, data types.

In C#, what are considered primitive data types in other languages are actually objects. When you write:

- int foo = 10;
- string myString = “This is a string”;

The variables foo and myString are Objects. They have helper functions built into C# to manipulate the data. C# is Strongly Typed. The compiler must know the type to be able to supply the helper functions.

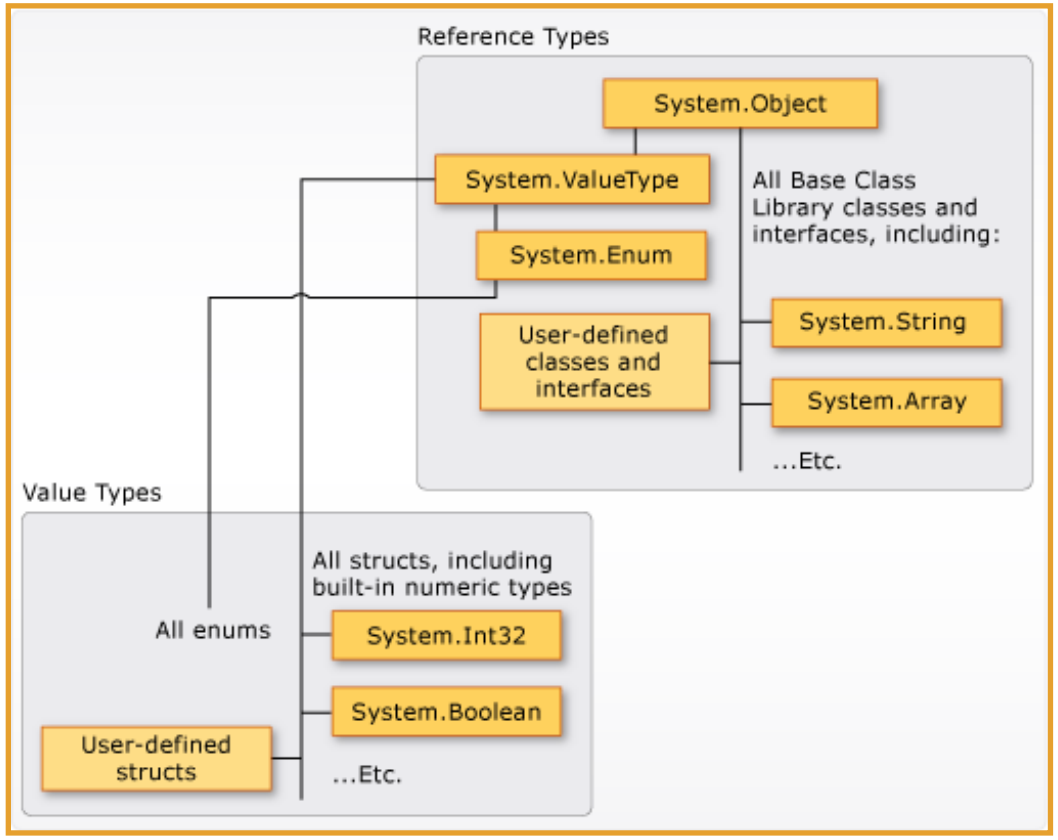
C# Datatypes Structure

https://docs.microsoft.com/en-us/dotnet/csharp/programming-guide/types/

All data types inherit from the base Class ***Object***.

When an ***int*** is declared, you are declaring:

- an instance of the ***struct*** (an object) of type 'int',
- which inherits from ***System.ValueType***,
- which itself inherits from ***System.Object***



DataTypes

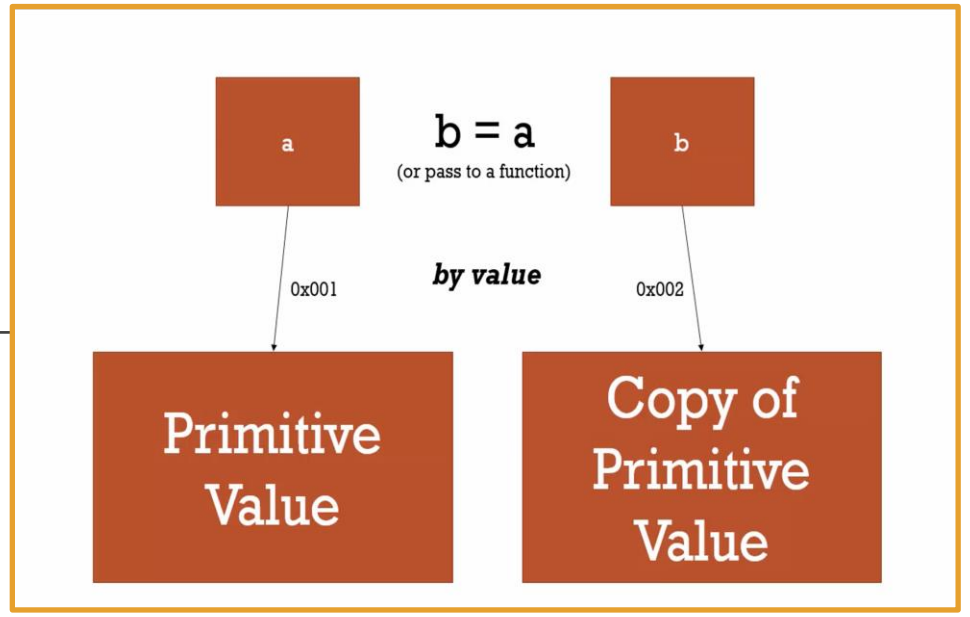
https://docs.microsoft.com/en-us/dotnet/csharp/tour-of-csharp/types-and-variables

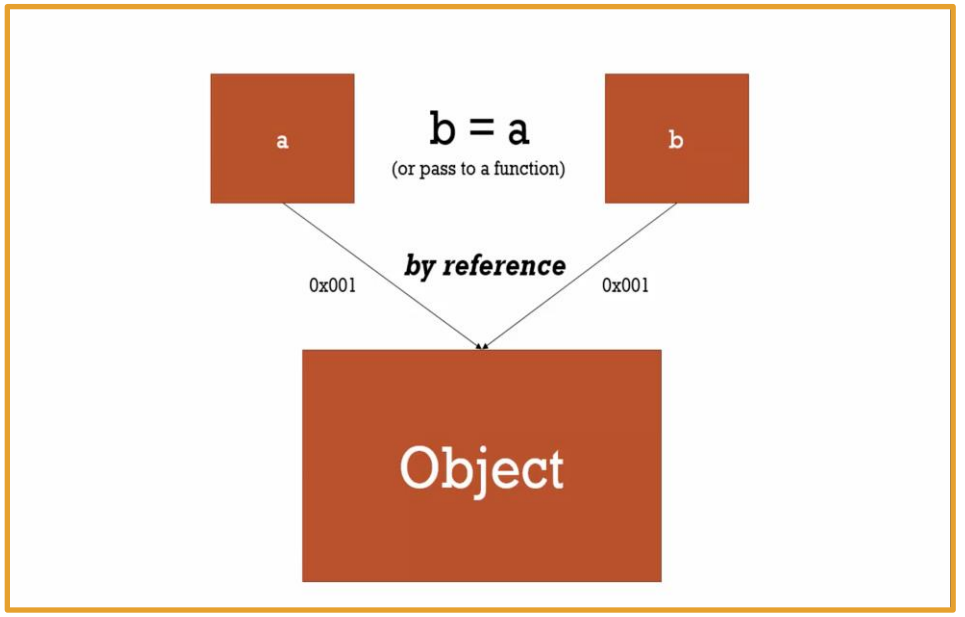
Value *types*:

- These are the built-in data *types:*
  - *char*, *int, bool*, *float*,
  - and user-defined *types* declared with *struct*.
  - Variables of *value* types directly contain their data on the *stack* .

Reference *types*:

- *Class*, *Interface*, *array* and *delegate types* contain other *types*.
- Variables of reference *types* do not contain an instance of the type, but merely a reference to an instance stored on the *heap*.





Value Types – Integral

https://docs.microsoft.com/en-us/dotnet/csharp/language-reference/builtin-types/integral-numeric-types

Integral numeric ***types*** represent ***integer*** numbers. All ***integral*** numeric ***types*** are value ***types***. They are also simple ***types*** and can be initialized with ***literals***.

Signed Integral	Size	Range
Sbyte	Signed 8-bit	-128 - 127
Short	Signed 16-bit integer	-32768 - 32767
Int	Signed 32-bit integer	-2147483648 - 2147483647
Long	Signed 64-bit integer	-9223372036854775808 - 9223372036854775807

Value Types – Integral

https://docs.microsoft.com/en-us/dotnet/csharp/language-reference/builtin-types/integral-numeric-types

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Unsigned Integral	Size	Range
Byte	Unsigned 8-bit integer	0 - 255
Ushort	Unsigned 16-bit integer	0 - 65535
Uint	Unsigned 32-bit integer	0 - 4294967295
Ulong	Unsigned 64-bit integer	0 - 18446744073709551615

Value Types

https://docs.microsoft.com/en-us/dotnet/csharp/language-reference/builtin-types/value-types#built-in-value-types

Unicode Characters	Size	Range
char	16 bit	0 - 65535

boolean	Value
bool	true and false (NOT 0/1)

IEEE binary floating-point	Size	values
float	4 bytes	Approx. 1.5 * 10^-45 - 3.4 * 10^38 with precision of 7 digits.
double	8 bytes	Approx. 5.0 * 10^-324 - 1.7 × 10^308 with precision of 15-16 digits.

High-precision decimal floating-point	Size	Values
decimal	16 bytes	1.0 * 10^-28 - approx. 7.9 * 10^28 with 28-29 significant digits

Value Types – Enum

https://docs.microsoft.com/en-us/dotnet/csharp/language-reference/builtin-types/enum

An ***enum*** is a ***value*** type defined by a set of named constants of the underlying integral numeric type.
To define an enumeration type (***enum***), use the ***enum*** keyword and specify the names of the ***enum*** members.
There exist explicit conversions between the ***enum*** type and its underlying ***integral*** type. If you cast an ***enum*** value to its underlying type, the result is the associated integral value of an ***enum*** member.
Enums are immutable.

```
public enum Season
{
    Spring,
    Summer,
    Autumn,
    Winter
}

public class EnumConversionExample
{
    public static void Main()
    {
        Season a = Season.Autumn;
        Console.WriteLine($"Integral value of {a} is {(int)a}");
                                    // output: Integral value of Autumn is 2

        var b = (Season)1;
        Console.WriteLine(b);  // output: Summer

        var c = (Season)4;
        Console.WriteLine(c);  // output: 4
    }
}
```

Value Types – Struct

https://docs.microsoft.com/en-us/dotnet/csharp/language-reference/builtin-types/struct

A **structure type (struct)** is a ***value*** type that can encapsulate data and related functionality.
Use the ***struct*** keyword to define a structure ***type***.
Structure ***types*** are typically used to design small data-centric ***types*** that provide little or no behavior.

```
public struct Coords
{
    public Coords(double x, double y)
    {
        X = x;
        Y = y;
    }

    public double X { get; }
    public double Y { get; }

    public override string ToString() => $"({X}, {Y})";
}
```

Nullable Value Types

https://docs.microsoft.com/en-us/dotnet/csharp/language-reference/builtin-types/nullable-value-types

Reference Type – Class

https://docs.microsoft.com/en-us/dotnet/csharp/language-reference/keywords/class

Classes are declared using the keyword ***class***. A class can declare class fields, constructors, and methods.

```
class StringTest
{
    static void Main()
    {
        // Create objects by using the new operator:
        Child child1 = new Child("Craig", 11);
        Child child2 = new Child("Sally", 10);

        // Create an object using the default constructor:
        Child child3 = new Child();

        // Display results:
        Console.Write("Child #1: ");
        child1.PrintChild();
        Console.Write("Child #2: ");
        child2.PrintChild();
        Console.Write("Child #3: ");
        child3.PrintChild();
    }
}
```

```
class Child
{
    private int age;
    private string name;

    // Default constructor:
    public Child()
    {
        name = "N/A";
    }

    // Constructor:
    public Child(string name, int age)
    {
        this.name = name;
        this.age = age;
    }

    // Printing method:
    public void PrintChild()
    {
        Console.WriteLine("{0}, {1} years old.", name, age);
    }
}
```

Reference Type – Interface

https://docs.microsoft.com/en-us/dotnet/csharp/language-reference/keywords/interface

An ***interface*** contains definitions for a group of related functionalities that a non-abstract ***class*** or a ***struct*** must implement.
An ***interface*** defines a “contract”.
Any ***class*** or ***struct*** that implements that contract agrees to provide an implementation of the members defined in the ***interface***.

```
interface ISampleInterface
{
    void SampleMethod();
}

class ImplementationClass : ISampleInterface
{
    // Explicit interface member implementation:
    void ISampleInterface.SampleMethod()
    {
        // Method implementation.
    }

    static void Main()
    {
        // Declare an interface instance.
        ISampleInterface obj = new ImplementationClass();

        // Call the member.
        obj.SampleMethod();
    }
}
```

Reference Type – Delegate

https://docs.microsoft.com/en-us/dotnet/csharp/tour-of-csharp/delegates
https://docs.microsoft.com/en-us/dotnet/csharp/language-reference/builtin-types/reference-types

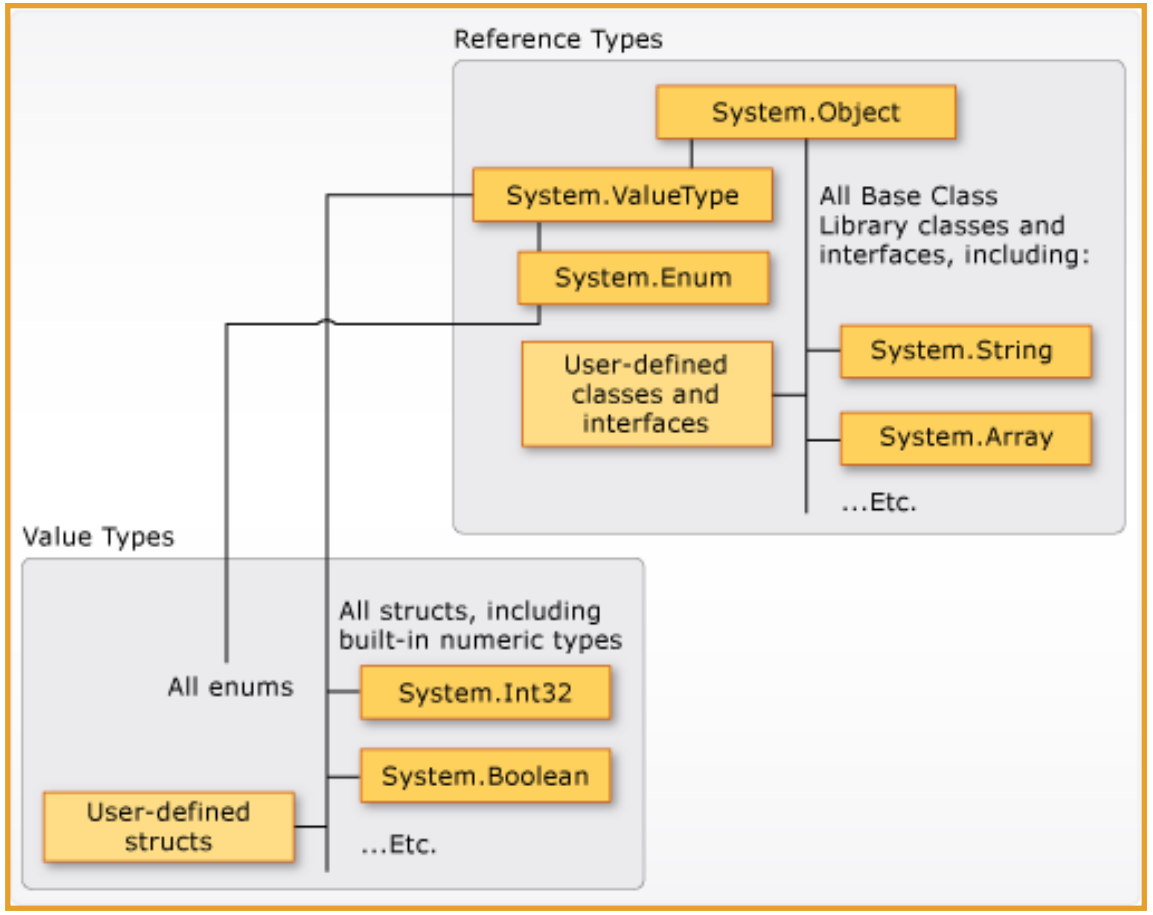
A ***delegate type*** represents references to methods. ***Delegates*** make it possible to treat methods as entities that can be assigned to variables and passed as parameters. ***Delegates*** are similar to function pointers in other programming languages. Unlike function pointers, ***delegates*** are object-oriented and type-safe.

```
using System;
delegate double Function(double x);
class Multiplier
{
    double factor;
    public Multiplier(double factor)
    {
        this.factor = factor;
    }
    public double Multiply(double x)
    {
        return x * factor;
    }
}
class DelegateExample
{
    static double Square(double x)
    {
        return x * x;
    }
    static double[] Apply(double[] a, Function f)
    {
        double[] result = new double[a.Length];
        for (int i = 0; i < a.Length; i++) result[i] = f(a[i]);
        return result;
    }
    static void Main()
    {
        double[] a = {0.0, 0.5, 1.0};
        double[] squares = Apply(a, Square);
        double[] sines = Apply(a, Math.Sin);
        Multiplier m = new Multiplier(2.0);
        double[] doubles =  Apply(a, m.Multiply);
    }
}
```

Reference Type – Object

https://docs.microsoft.com/en-us/dotnet/csharp/language-reference/builtin-types/reference-types

In C#'s ***Unified Type System (UTS)***, all ***types*** inherit (directly or indirectly) from ***System.Object***.
You can assign values of any ***type*** to variables of ***type Object***.
Any ***Object*** variable can be assigned to its default value using ***null***.
When a variable of a value ***type*** is converted to ***Object***, it is boxed*. When a variable of ***type Object*** is converted to a value ***type***, it is unboxed*.



*More on boxing and unboxing later

Reference Type – String

https://docs.microsoft.com/en-us/dotnet/csharp/language-reference/builtin-types/reference-types

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The ***string type*** represents a sequence of zero or more Unicode characters. ***string*** is an alias for System.String.
The addition operator '+' and the equality operators '==' and '!=' are defined to concatenate and compare the values of ***string objects*** (not the references).
Strings are ***immutable***, meaning the contents of a string object cannot be changed after the object is created, although the syntax makes it appear as if you can.

This example displays "True" and then "False" because the content of the strings are equivalent. a and b do not refer to the same string instance.

```
string a = "hello";
string b = "h";
// Append to contents of 'b'
b += "ello";
Console.WriteLine(a == b); // True
Console.WriteLine(object.ReferenceEquals(a, b)); // False
```

Reference Type – String

https://docs.microsoft.com/en-us/dotnet/csharp/language-reference/builtin-types/reference-types

The [ ] operator can be used for readonly access to individual characters of a string or iterating over them in a loop. Index values start at 0 and must be less than the length of the string.

```
string str = "test";
char x = str[2];  // x = 's';
```

```
string str = "test";

for (int i = 0; i < str.Length; i++)
{
  Console.Write(str[i] + " ");
}
// Output: t e s t
```