Functional Programming
With C# 7.1

CHEAT SHEET

Functional programming is a style that treats computation as the evaluation of mathematical functions and avoids changing-state and mutable data.

Immutable Types

An object whose state cannot be modified after it is created, lowering the risk of side-effects.
https://dotnetfiddle.net/K928pP

```csharp
public class Rectangle
{
    public int Length { get; set; }
    public int Height { get; set; }

    public void Grow(int length, int height)
    {
        Length += length;
        Height += height;
    }
}
Rectangle r = new Rectangle();
r.Length = 5;
r.Height = 10;
r.Grow(10, 10);
// r.Length is 15, r.Height is 20, same instance of r
```

```csharp
public class ImmutableRectangle
{
    int Length { get; }
    int Height { get; }

    public ImmutableRectangle(int length, int height)
    {
        Length = length;
        Height = height;
    }

    public ImmutableRectangle Grow(int length, int height) =>
        new ImmutableRectangle(Length + length, Height + height);
}
ImmutableRectangle r = new ImmutableRectangle(5, 10);
r = r.Grow(10, 10);
// r.Length is 15, r.Height is 20, is a new instance of r
```
Expressions Instead of Statements

Statements define an action and are executed for their side-effect. Expressions produce a result without mutating state.

https://dotnetfiddle.net/ozZIL3

Example

Both of the following code examples produce the same results. The expression produces a result without mutations.

### Statement

```csharp
public static string GetSalutation(int hour) {
    string salutation; // placeholder value
    if (hour < 12)
        salutation = "Good Morning";
    else
        salutation = "Good Afternoon";
    return salutation; // return mutated variable
}
```

### Expression

```csharp
public static string GetSalutation(int hour) =>
    hour < 12 ? "Good Morning" : "Good Afternoon";
```

ValueTuples

Tuple is a more efficient and more productive lightweight syntax to define a data structure that carries more than one value. **Requires NuGet Package System.ValueTuple**

- Represent data without DTO classes
- Lower memory footprint than a class
- Return multiple values from methods without the need for out variables

Example

```csharp
(double lat, double lng) GetCoordinates(string query)
{
    // DO search query ...
    return (lat: 47.6450905056185, lng: 122.130835641356);
}

var pos = GetCoordinates("15700 NE 39th St, Redmond, WA");
pos.lat; // 47.6450905056185
pos.lng; // 122.130835641356
```
**Func Delegates**

Func Delegates encapsulate a method. When declaring a Func, input and output parameters are specified as T1-T16, and TResult.

https://dotnetfiddle.net/EyGLvp

- **Func<TResult>** – matches a method that takes no arguments, and returns value of type TResult.

- **Func<T, TResult>** – matches a method that takes an argument of type T, and returns value of type TResult.

- **Func<T1, T2, TResult>** – matches a method that takes arguments of type T1 and T2, and returns value of type TResult.

- **Func<T1, T2, ..., TResult>** – and so on up to 16 arguments, and returns value of type TResult.

**Example**

Both of the following code examples produce the same results. The expression produces a result without mutations.

```csharp
Func<int, int> addOne = n => n + 1;
Func<int, int, int> addNums = (x, y) => x + y;
Func<int, bool> isZero = n => n == 0;

Console.WriteLine(addOne(5)); // 6
Console.WriteLine(isZero(addNums(-5, 5))); // True

int[] a = {0, 1, 0, 3, 4, 0};
Console.WriteLine(a.Count(isZero)); // 3
```

**Higher Order Functions / Functions as Data**

A function that accepts another function as a parameter, or returns another function.

https://dotnetfiddle.net/jhn5BZ

**Example**

**method signature**

```csharp
int IEnumerable.Count<T>(Func<T, Bool> predicate)
```

**Source code for Count()**

```csharp
int count = 0;
foreach (TSource element in source)
{   checked // overflow exception check
    {   if (predicate(element)) // func<T,Bool> invoked
        {   count++;
        }
    }
}
return count;
```

**usage**

```csharp
bool[] bools = { false, true, false, false };
int f = bools.Count(bln => bln == false); // out = 3
int t = bools.Count(bln => bln == true);  // out = 1
```
Method Chaining (~Pipelines)

Since C# lacks a Pipeline syntax, pipelines in C# are created with design patterns that allow for methods to chain. The result of the method chain should produce the desired value and type.

http://demos.telerik.com/aspnet-mvc/grid

Example

Example, Telerik Grid HTML Helper

Extension Methods

Extension methods are a great way to extend method chains and add functionality to a class.

Tip

Add the [DebuggerNonUserCodeAttribute] attribute to utility extension methods for easier debugging.

You can read more about this attribute at davefancher.com:


Example

Tip

// Extends the StringBuilder class to accept a predicate

public static StringBuilder AppendWhen(
    this StringBuilder sb, string value,
    bool predicate) =>
    predicate ? sb.Append(value) : sb;

Usage

string htmlButton = new StringBuilder()
    .Append("<button")
    .AppendWhen(" disabled", isDisabled)
    .Append(">Click me</button>")
    .ToString();
Yield

Using `yield` to define an iterator removes the need for an explicit extra class (the class that holds the state for an enumeration.

You consume an iterator method by using a foreach statement or LINQ query.

Yield is the basis for many LINQ methods.

https://dotnetfiddle.net/D4tgdG

LINQ

The gateway to functional programming in C#. LINQ makes short work of most imperative programming routines that work on arrays and collections.

Methods by Category

Quantify
All, Any, Contains

Filter
Where, OfType

Project/Transform
Select, SelectMany, Zip

Criteria/Set
Distinct, Except, Intersect, Union

Sorting
OrderBy, OrderByDescending, ThenBy, ThenByDescending, Reverse

Aggregation
Aggregate, Average, Count, LongCount, Max, Min, Sum

Partition/Join
Skip, SkipWhile, Take, TakeWhile, Join, GroupJoin

Grouping
GroupBy, ToLookup
Thread-Safe Collections

Since Functional programming promotes thread safety via immutability, these Thread-Safe Collections important to know.

The .NET Framework 4 introduces the System.Collections.Concurrent namespace, which includes several collection classes that are both thread-safe and scalable. Multiple threads can safely and efficiently add or remove items from these collections, without requiring additional synchronization in user code.

Blocking Collection<T>
Provides bounding and blocking functionality for any type that implements IProducerConsumerCollection<T>.

IProducerConsumerCollection<T>
The interface that a type must implement to be used in a BlockingCollection.

Concurrent Queue<T>
Thread-safe implementation of a FIFO (first-in, first-out) queue.

Concurrent Dictionary<TKey, TValue>
Thread-safe implementation of a dictionary of key-value pairs.

Concurrent Stack<T>
Thread-safe implementation of a LIFO (last-in, first-out) stack.

Concurrent Bag<T>
Thread-safe implementation of an unordered collection of elements.
Resources

Functional Programming Self Guided Workshop
Functional Programming vs. Imperative Programming (C#)
Refactoring Data Grids with C# Extension Methods
Better Code with Functional Programming
Functionally Similar – Comparing Underscore.js to LINQ
Giving Clarity to LINQ Queries by Extending Expressions
Channel 9's Visual Studio Toolbox: Functional Programming in C#

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Worldwide Headquarters

Progress, 14 Oak Park, Bedford, MA 01730 USA
Tel: +1 781 280-4000  Fax: +1 781 280-4095
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