**Understand Recursion in C#**

Function calling itself is called Recursion. Or, in simple words, we can say that recursion is a process in which a function calls itself repeatedly until some specified condition has been satisfied. It is similar to a loop, in the loop, as long as the loop condition is satisfied, the loop executes and in the same manner, as long as the condition is satisfied, the function will call itself.

using System;

namespace RecursionDemo

{

class Program

{

static void Main(string[] args)

{

int x = 3;

fun(x);

Console.ReadKey();

}

static void fun(int n)

{

if (n > 0)

{

fun(n - 1); //Function calling itself

Console.WriteLine($"{n} ");

}

}

}

}



**Call by Value and Call by Reference in C#**

##### **Call By Value With Value Type in C#**

In .NET Framework, by default, all the objects are called by value, not called by reference. So, whether it is a Value Type (Primitive data types like int, char, double, etc.) or Reference Data Type (class, interface, delegate, string, etc.), they will be called by value by default. Let us understand Call by Value in C# with some examples. In the following example, I am using the value data type.

namespace FunctionsDemo

{

class Program

{

static void Main(string[] args)

{

int a = 15;

int b = a;

b = 30;

Console.WriteLine(a);

Console.ReadKey();

}

}

}



If your answer is 15, then you are absolutely right because **int** is a value data type, and by default, it is passed by value, which means for the above code, the variable “a” has stored the value 15 in it. When we create the variable b and assign it a, the value of a is copied to b, and after that, if we change b, it will not affect a. This is because we have copied the value of a to b.

##### **Call by Value with Reference Types in C#**

namespace FunctionsDemo

{

class Program

{

static void Main(string[] args)

{

Employee Emp1 = new Employee();

Emp1.EmployeeID = 1001;

Emp1.Name = "James";

Employee Emp2 = Emp1;

Emp1.Name = "Smith";

Console.WriteLine($"Emp1 Name = {Emp1.Name}");

Console.WriteLine($"Emp2 Name = {Emp2.Name}");

Console.ReadKey();

}

}

public class Employee

{

public int EmployeeID;

public string Name;

}

##### }

##### 

##### When we assign Emp1 to Emp2, the reference of the object memory location that Emp1 is holding is copied to Emp2. Now we have two copies of reference, but they both point to the same memory location. So, changing the Name property’s value will change the object’s value in memory, which we have references in Emp1 and Emp2. So, “Smith” will be printed on the console for both references. So, when you run the above code, you will get the following output.

##### **Call By Reference with Value Type in C#**

namespace FunctionsDemo

{

class Program

{

static void Main(string[] args)

{

int a = 15;

UpdateValue(ref a);

Console.WriteLine(a);

Console.ReadKey();

}

static void UpdateValue(ref int b)

{

b = 30;

}

}

}



It will print 30 on the console. This is because of the ref keyword. In the above example, when the UpdateValue method is called, the incoming parameter b has the same memory address as a, which is passed as the argument. That’s why modifying the value of b would also reflect the change in a. In this case, a new memory location is not created for method parameter b. Here, you can say b just as an alias of a or an alternative name of a. So, if we make any changes using variable b, it will also reflect in variable a.

##### **Call by Reference with Reference Types in C#**

using System;

namespace FunctionsDemo

{

class Program

{

static void Main(string[] args)

{

Employee Emp1 = new Employee();

Emp1.EmployeeID = 1001;

Emp1.Name = "James";

UpdateName(ref Emp1);

Console.WriteLine($"Emp1 Name = {Emp1.Name}");

Console.ReadKey();

}

public static void UpdateName(ref Employee Emp2)

{

Emp2.Name = "Kamal";

}

}

public class Employee

{

public int EmployeeID;

public string Name;

}

}



Now, when the UpdateName method sets the Emp2 to Kamal, this also sets the Emp1 to Kamal. This is because of Call By Reference. So, in this case, the reference of Emp1 is passed to the method, and hence a new reference is not created for Emp2. So, here, you can consider Emp2 as an alias of Emp1 or an alternative name for Emp1.

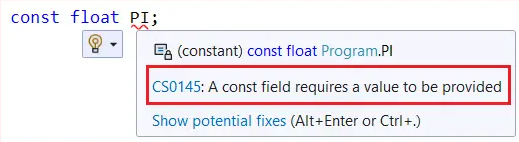
**Const, Read-Only and Static Variable in C#**

Const Variables in c#

In C#, if we declare a variable by using the const keyword, then it is a constant variable and the value of the constant variable can’t be modified once after its declaration. So, it is mandatory to initialize the constant variable at the time of its declaration only. Suppose, you want to declare a constant PI in your program, then you can declare the constant variable as follows:

**const float PI = 3.14f;**

If you are not initializing the const variable at the time of its declaration, then you will get a compiler error as shown in the below image.



Read-Only Variables in C#

When we declare a variable by using the readonly keyword, then it is known as a read-only variable and these variables can’t be modified like constants but after initialization. That means it is not mandatory to initialize a read-only variable at the time of its declaration, they can also be initialized under the constructor. That means we can modify the read-only variable value only within a constructor.

using System;

namespace ReadOnlyDemo

{

class Program

{

readonly int number = 5;

//You can also initialize through constructor

public Program()

{

number = 20;

}

static void Main(string[] args)

{

Program obj = new Program();

Console.WriteLine(obj.number);

//You cannot change the value of a readonly variable once it is initialized

//The following statement will give us compile time error

//obj.number = 20;

Console.ReadLine();

}

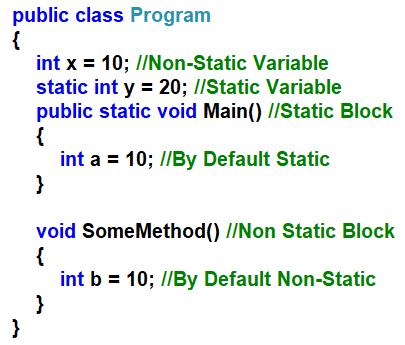
}

}



Static Variables in C#

Whenever we declare a variable by using the static modifier or when we declare a variable inside of any static block then those variables are considered static variables whereas the rest of the others are considered non-static variables.



If you want a variable to have the same value throughout all instances of a class then you need to declare that variable as a static variable. So, the static variables are going to hold the application-level data which is going to be the same for all the objects.

**Boxing and Unboxing in C#**

**Boxing:** Boxing is the process of converting a value type (like int, double, struct) to a reference type (object). When a value type is boxed, a new object is allocated to the heap, and the value is copied into it.

**Unboxing:** Unboxing is the reverse process of boxing, where a value is extracted from an object. It involves explicitly converting a reference type (object) into a value type. This operation also involves a copy operation, where the value is copied from the heap into the stack.

namespace BoxingUnboxingDemo

{

class Program

{

static void Main(string[] args)

{

int x = 10;

object y = x; //Boxing

int z = (int)y; //Unboxing

}

}

}

**What is an Exception in C#?**

An Exception is a class in C# which is responsible for abnormal termination of the program when runtime errors occur while running the program.  So, these errors (runtime) are very dangerous because whenever the runtime errors occur in the programs, the program gets terminated abnormally on the same line where the error gets occurred without executing the next line of code.

**Note:** Most people are saying Runtime Errors are Exceptions which is not true. Exceptions are classes that are responsible for abnormal termination of the program when runtime errors occur.

1. IndexOutOfRangeException
2. FormatException
3. NullReferenceException
4. DivideByZeroException
5. FileNotFoundException
6. SQLException,
7. OverFlowException, etc.

##### ****What happens if an Exception is Raised in the Program in C#?****

When an Exception is raised in C#, the program execution is terminated abnormally. That means the statements placed after the exception-causing statements are not executed but the statements placed before that exception-causing statement are executed by CLR.

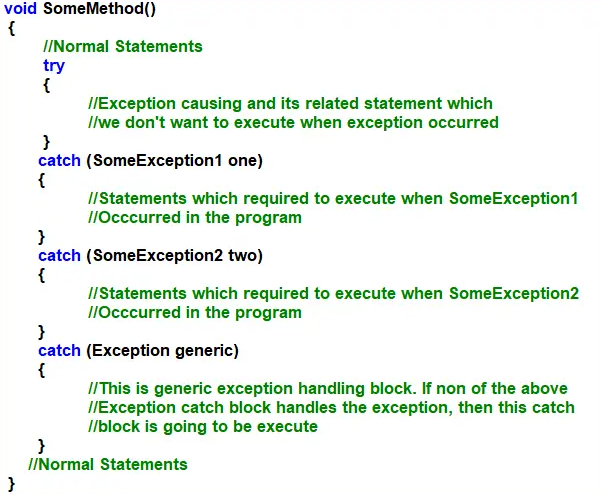
##### ****What CLR does when an Exception Occurred in the program?****

The CLR creates the exception class object that is associated with that logical mistake (exception) and terminates the program execution by throwing that exception object by using the throw keyword. So, we can say an exception is an event that occurs during the execution of a program that disrupts the normal flow of instruction execution.

**What is Exception Handling in C#?**

The process of catching the exception for converting the CLR given exception message to an end-user understandable message and for stopping the abnormal termination of the program whenever runtime errors are occurring is called Exception Handling in C#. Once we handle an exception under a program we will be getting the following advantages

1. We can stop the Abnormal Termination
2. We can perform any corrective action that may resolve the problem.
3. Displaying a user-friendly error message, so that the user can resolve the problem provided if it is under his control.



**Why do we need Exception Handling in C#?**

We need Exception Handling in C# because of the following two reasons.

1. To stop the Abnormal Termination of the program
2. To provide users with understandable messages when an exception is raised. So that users can make a decision without the developer’s help.

**Delegates**

A delegate in C# is similar to a function pointer in C or C++.  It means they hold the reference of a method inside a delegate object. The delegate object can then be passed to code which can call the referenced method, without having to know at compile time which method will be invoked. Unlike function pointers in C or C++, delegates are object-oriented, type-safe, and secure.

The syntax to create a delegate in C# is very much like the abstract method declaration. In abstract method declaration, we use the abstract keyword whereas, in delegate, we need to use the delegate keyword. The syntax for defining a delegate in C# is as follows:

**<Access Modifier> delegate <Return Type> <Delegate Name> (Parameter List);**

Example

**using System;**

public delegate void MyDelegate(string s);

class MyClass

{

public static void Hello(string s)

{

Console.WriteLine(" Hello, {0}!", s);

}

public static void Goodbye(string s)

{

Console.WriteLine(" Goodbye, {0}!", s);

}

public static void Main()

{

MyDelegate a, b, c, d;

// Create the delegate object a that references

// the method Hello:

a = new MyDelegate(Hello);

// Create the delegate object b that references

// the method Goodbye:

b = new MyDelegate(Goodbye);

// The two delegates, a and b, are composed to form c:

c = a + b;

// Remove a from the composed delegate, leaving d,

// which calls only the method Goodbye:

d = c - a;

Console.WriteLine("Invoking delegate a:");

a("A");

Console.WriteLine("Invoking delegate b:");

b("B");

Console.WriteLine("Invoking delegate c:");

c("C");

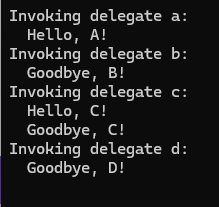
Console.WriteLine("Invoking delegate d:");

d("D");

Console.ReadKey();

}

}



**What are Generics in C#?**

Generics are the most powerful feature of C# 2.0. Generics allow you to define type-safe data structures, without committing to actual data types. This results in a significant performance boost and higher quality code, because you get to reuse data processing algorithms without duplicating type-specific code.

In other words, we can say that the Generics allow us to create classes using angular brackets specifying the data type of its members.

**Advantages of Generics in C#**

* **It Increases the Reusability of the Cod**e: For example, you can create a generic method to add two numbers. This method can be used to add two integers as well as two float numbers without any modification to the code.
* **Generics are Type-Safe:** Generics are type safety, especially in the case of collections. When using generics, we need to define the type of objects to be passed to a collection. This helps the compiler to ensure that only those object types that are defined in the definition can be passed to the collection. We will get the compile-time error if we try to use a different type of data rather than the one, we specified in the definition.
* **Generic Provides Better Performance**: It gives better performance compared to non-Generics because they reduce the need for boxing, unboxing, and typecasting of variables or objects.

using System;

namespace GenericsDemo

{

//MyGenericClass is a Generic Class

//Here T specifies the Data Types of the class Members

class MyGenericClass<T>

{

//Generic variable

//The data type is generic i.e. T

private T GenericMemberVariable;

//Generic Constructor

//Constructor accepts one parameter of Generic type i.e. T

public MyGenericClass(T value)

{

GenericMemberVariable = value;

}

//Generic Method

//Method accepts one Generic type Parameter i.e. T

//Method return type also Generic i.e. T

public T GenericMethod(T GenericParameter)

{

Console.WriteLine($"Parameter type: {typeof(T).ToString()}, Value: {GenericParameter}");

Console.WriteLine($"Return type: {typeof(T).ToString()}, Value: {GenericMemberVariable}");

return GenericMemberVariable;

}

}

}

using System;

namespace GenericsDemo

{

class Program

{

static void Main()

{

MyGenericClass<int> integerGenericClass = new MyGenericClass<int>(10);

int val1 = integerGenericClass.GenericMethod(200);

Console.WriteLine(val1);

MyGenericClass<string> stringrGenericClass = new MyGenericClass<string>("Kamal");

string val2 = stringrGenericClass.GenericMethod("Pratap");

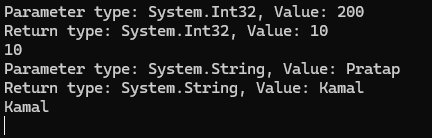
Console.WriteLine(val2);

Console.ReadKey();

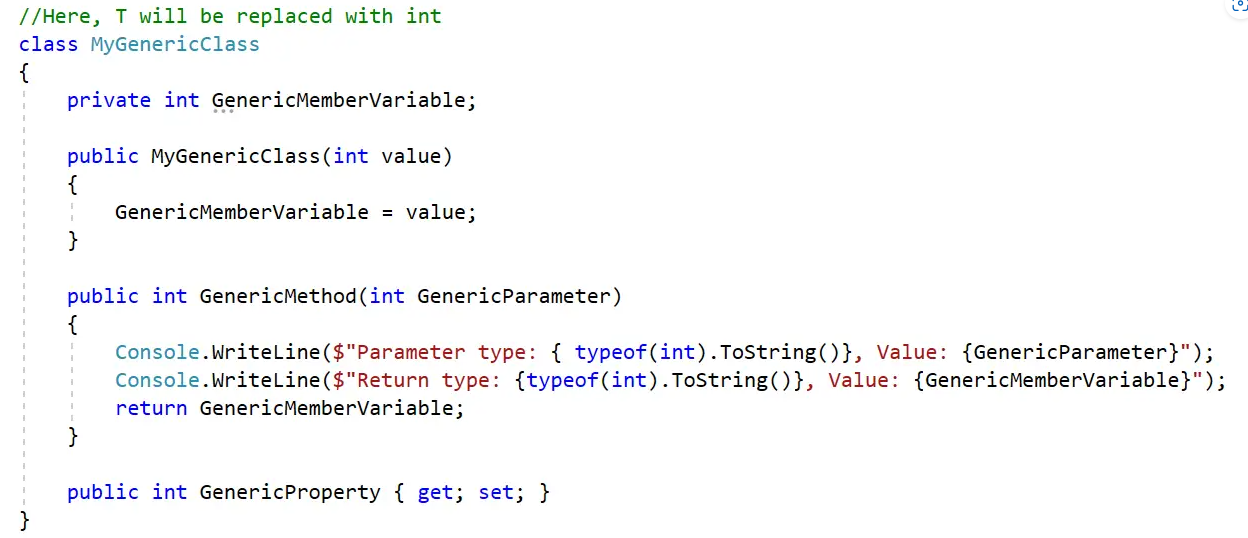
}

}

}



So, while creating the instance of this MyGenericClass class, we need to specify the type and the compiler will assign that type to T. In the following example, we use int as the data type. Once we create an instance of the MyGenericClass, then we are invoking the GenericMethod method. As we have specified the T as int while creating the instance, we do not need to specify the same while invoking the class members.



**What are Lambda Expressions in C#?**

The Lambda Expression in C# is the shorthand for writing the Anonymous Function. So, we can say that the Lambda Expression is nothing but to simplify the anonymous function in C# and we also discussed that Anonymous Functions are related to delegate and they are created by using the delegate keyword.

##### **Understand Delegate using Method in C#**

In the below example, we are creating one delegate and one method with the same signature and then registering the method with the delegate instance and when we invoke the delegate, the method which is registered with the delegate is going to be executed.

using System;

namespace LambdaExpressionDemo

{

public class LambdaExpression

{

public delegate string GreetingsDelegate(string name);

public static string Greetings(string name)

{

return "Hello " + name + " welcome to Dotnet Tutorials";

}

static void Main(string[] args)

{

GreetingsDelegate obj = new GreetingsDelegate(LambdaExpression.Greetings);

string GreetingsMessage = obj.Invoke("Pranaya");

Console.WriteLine(GreetingsMessage);

Console.ReadKey();

}

}

}



##### **Delegate using Anonymous Method in C#**

In the previous example, we used a named block while creating the delegate instance. Instead of a named block, we can also give an unnamed block which is called Anonymous Method. The anonymous methods are created using the delegate keyword and when we invoke the delegate, the anonymous method is going to be executed. Please have a look at the following example. This is the same example as the previous example and this example is also going to give you the same output. Here, instead of a named block, we are using an unnamed block.

using System;

namespace LambdaExpressionDemo

{

public class LambdaExpression

{

public delegate string GreetingsDelegate(string name);

static void Main(string[] args)

{

GreetingsDelegate obj = delegate (string name)

{

return "Hello @" + name + " welcome to Dotnet Tutorials";

};

string GreetingsMessage = obj.Invoke("Pranaya");

Console.WriteLine(GreetingsMessage);

Console.ReadKey();

}

}

}

##### **Create Lambda Expressions in C#**

##### Let us rewrite the previous example using the Lambda Expression in C#. And this time also, you will get the same output.

using System;

namespace LambdaExpressionDemo

{

public class LambdaExpression

{

public delegate string GreetingsDelegate(string name);

static void Main(string[] args)

{

GreetingsDelegate obj = (name) =>

{

return "Hello @" + name + " welcome to Dotnet Tutorials";

};

string GreetingsMessage = obj.Invoke("Pranaya");

Console.WriteLine(GreetingsMessage);

Console.ReadKey();

}

public static string Greetings(string name)

{

return "Hello @" + name + " welcome to Dotnet Tutorials";

}

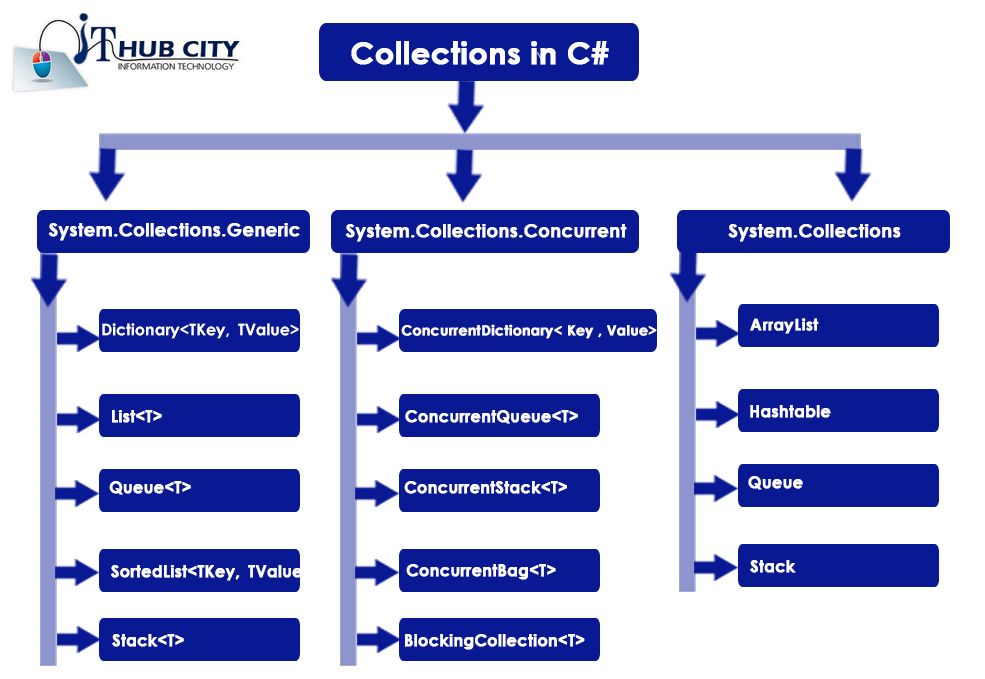
}

}

**What is a Collection in C#**

The **Collections in C#** are a set of predefined classes that are present in the **System.Collections** namespace that provides greater capabilities and functionalities than the traditional arrays. The collections in C# are reusable, more powerful, and more efficient and most importantly they have been designed and tested to ensure quality and performance.

##### **Types of Collections in C#**



Array List Example

using System;

using System.Collections;

namespace ColletionDemo

{

public class ColletionDemo

{

static void Main(string[] args)

{

//Adding elements to ArrayList using Add() method

ArrayList arrayList1 = new ArrayList();

arrayList1.Add(101); //Adding Integer Value

arrayList1.Add("James"); //Adding String Value

arrayList1.Add("James"); //Adding Duplicate Value

arrayList1.Add(" "); //Adding Empty

arrayList1.Add(true); //Adding Boolean

arrayList1.Add(4.5); //Adding double

arrayList1.Add(null); //Adding null

for (int i = 0; i < arrayList1.Count; i++)

{

Console.WriteLine(arrayList1[i]);

}

Console.WriteLine("Other Method");

foreach (var item in arrayList1)

{

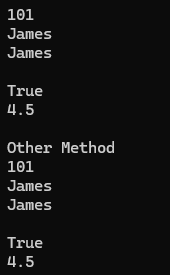
Console.WriteLine(item);

}

}

}

}



Hash Table Example

using System;

using System.Collections;

namespace ColletionDemo

{

public class ColletionDemo

{

static void Main(string[] args)

{

Hashtable hashtable = new Hashtable();

//Adding elements to the Hash table using key value pair

hashtable.Add("EId", 1001); //Here key is Eid and value is 1001

hashtable.Add("Name", "James"); //Here key is Name and value is James

hashtable.Add("Salary", 3500); //Here key is Salary and value is 3500

hashtable.Add("Location", "Mumbai"); //Here key is Location and value is Mumbai

hashtable.Add("EmailID", "a@a.com"); //Here key is EmailID and value is a@a.com

//Printing the keys and their values using foreach loop

Console.WriteLine("Printing Hashtable using Foreach Loop");

foreach (object obj in hashtable.Keys)

{

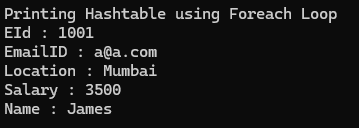
Console.WriteLine(obj + " : " + hashtable[obj]);

}

}

}

}



##### **Dictionary Collection in C#**

using System;

using System.Collections.Generic;

using System.Linq;

namespace GenericDictionaryDemo

{

class Program

{

static void Main()

{

//Creating a Dictionary with Key and value both are string type

Dictionary<string, string> dictionaryCountries = new Dictionary<string, string>();

//Adding Elements to the Dictionary using Add Method of Dictionary class

dictionaryCountries.Add("UK", "London, Manchester, Birmingham");

dictionaryCountries.Add("USA", "Chicago, New York, Washington");

dictionaryCountries.Add("IND", "Mumbai, Delhi, Bhubaneswar");

//Accessing Dictionary Elements using For Each Loop

Console.WriteLine("Accessing Dictionary Elements using For Each Loop");

foreach (KeyValuePair<string, string> KVP in dictionaryCountries)

{

Console.WriteLine($"Key:{KVP.Key}, Value: {KVP.Value}");

}

Console.ReadKey();

}

}

}

**List<T> Collection in C#**

using System;

using System.Collections.Generic;

namespace GenericListCollectionDemo

{

class Program

{

static void Main()

{

//Creating a Generic List of string type to store string elements

List<string> countries = new List<string>();

//Adding String Elements to the Generic List using the Add Method

countries.Add("INDIA");

countries.Add("USA");

//The following Two Statements will give compile time error as element is not string type

//countries.Add(100);

//countries.Add(true);

//Creating Another Generic List Collection of String Type

List<string> newCountries = new List<string>();

//Adding Elements using Add Method

newCountries.Add("JAPAN");

newCountries.Add("UK");

//Adding the newCountries collection into countries collection using AddRange Method

countries.AddRange(newCountries);

//Accessing Generic List Elements using ForEach Loop

Console.WriteLine("Accessing Generic List using For Each Loop");

foreach (var item in countries)

{

Console.WriteLine(item);

}

//Accessing Generic List Elements using For Loop

Console.WriteLine("\nAccessing Generic List using For Loop");

for (int i = 0; i < countries.Count; i++)

{

var element = countries[i];

Console.WriteLine(element);

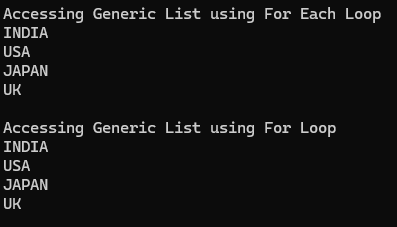
}

Console.ReadKey();

}

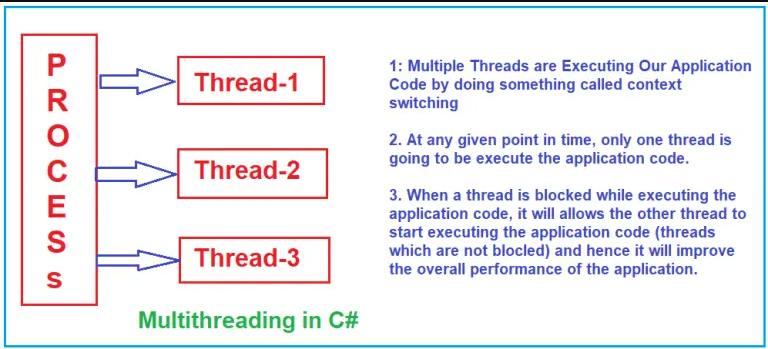
}

}

****

**Multithreading in C#**

Multithreading in C# refers to the ability of the C# programming language and the .NET Framework to create and manage multiple threads of execution within a single process. Threads are lightweight, independent sequences of instructions that can run concurrently, allowing you to perform multiple tasks simultaneously. Multithreading is a powerful concept in C# and is used to achieve various goals, such as improving application responsiveness, parallelizing tasks, and efficiently utilizing multi-core processors.

****

using System.Threading;

using System;

namespace ThreadingDemo

{

class Program

{

static void Main(string[] args)

{

Console.WriteLine("Main Thread Started");

//Creating Threads

Thread t1 = new Thread(Method1)

{

Name = "Thread1"

};

Thread t2 = new Thread(Method2)

{

Name = "Thread2"

};

Thread t3 = new Thread(Method3)

{

Name = "Thread3"

};

//Executing the methods

t1.Start();

t2.Start();

t3.Start();

Console.WriteLine("Main Thread Ended");

Console.Read();

}

static void Method1()

{

Console.WriteLine("Method1 Started using " + Thread.CurrentThread.Name);

for (int i = 1; i <= 5; i++)

{

Console.WriteLine("Method1 :" + i);

}

Console.WriteLine("Method1 Ended using " + Thread.CurrentThread.Name);

}

static void Method2()

{

Console.WriteLine("Method2 Started using " + Thread.CurrentThread.Name);

for (int i = 1; i <= 5; i++)

{

Console.WriteLine("Method2 :" + i);

if (i == 3)

{

Console.WriteLine("Performing the Database Operation Started");

//Sleep for 10 seconds

Thread.Sleep(10000);

Console.WriteLine("Performing the Database Operation Completed");

}

}

Console.WriteLine("Method2 Ended using " + Thread.CurrentThread.Name);

}

static void Method3()

{

Console.WriteLine("Method3 Started using " + Thread.CurrentThread.Name);

for (int i = 1; i <= 5; i++)

{

Console.WriteLine("Method3 :" + i);

}

Console.WriteLine("Method3 Ended using " + Thread.CurrentThread.Name);

}

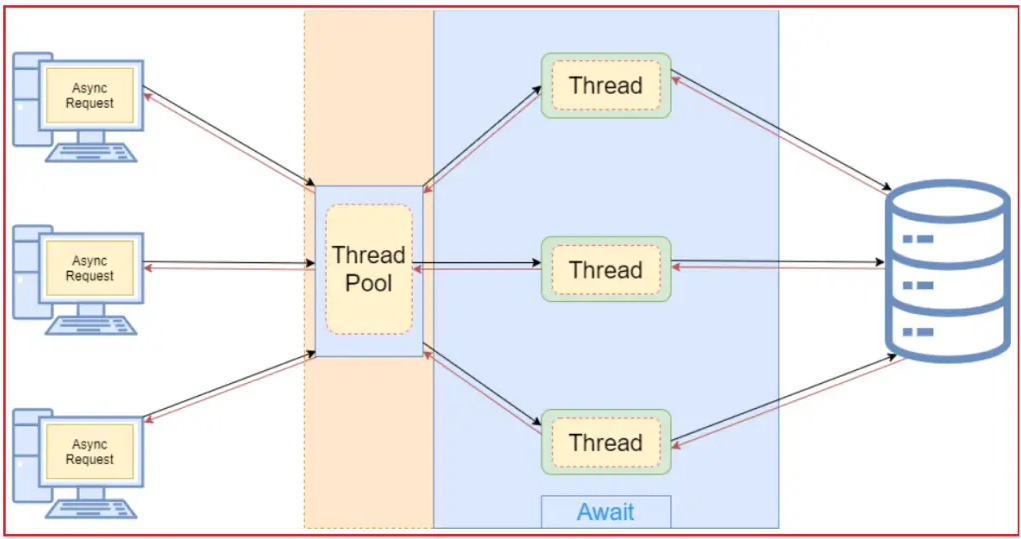
}

}

****

**Asynchronous Programming in C#**

Asynchronous programming in C# is a method of performing tasks without blocking the main or calling thread. This is especially beneficial for I/O-bound operations (like reading from a file, fetching data from the web, or querying a database), where waiting for the task to be completed might waste valuable CPU time that could be better spent doing other work. For a better understanding, please have a look at the following diagram.

****

using System;

using System.Threading.Tasks;

namespace AsynchronousProgramming

{

class Program

{

static void Main(string[] args)

{

Console.WriteLine("Main Method Started......");

SomeMethod();

Console.WriteLine("Main Method End");

Console.ReadKey();

}

public async static void SomeMethod()

{

Console.WriteLine("Some Method Started......");

//Thread.Sleep(TimeSpan.FromSeconds(10));

await Task.Delay(TimeSpan.FromSeconds(10));

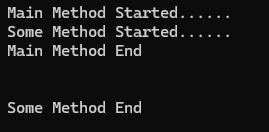
Console.WriteLine("\n");

Console.WriteLine("Some Method End");

}

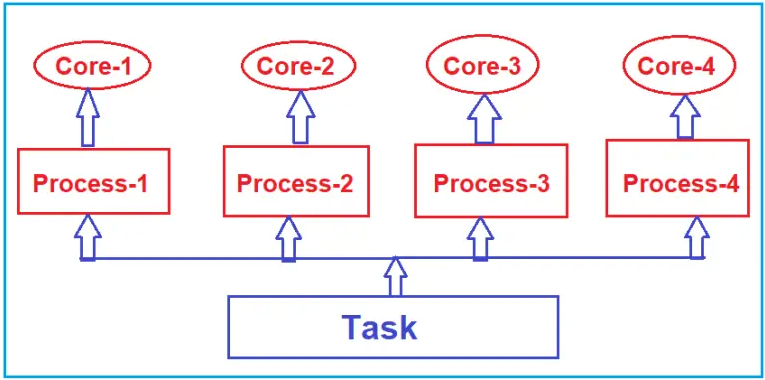
}

}



**Parallel Programming in C#**

Parallel programming in C# is the process of using concurrency to execute multiple computations simultaneously to improve the performance and responsiveness of software. For a better understanding, please have a look at the below diagram. As you can see, the same task will be executed by multiple processes, multiple cores where each process has multiple threads to execute the application code.

****

**Ref vs Out Keywords in C#**

The REF and OUT keywords in C# are used for passing the arguments to a method as a reference type. By default, arguments are passed to a method by value. By using these REF and OUT keywords in C#, we can pass arguments by reference. In this case, any changes made to these arguments in the method body will be reflected in those variable when the control returns to the calling method.

##### **Differences Between OUT and REF Keyword in C#**

So, the first point that you need to remember is when you want multiple outputs from a function, then you need to use the ref and out parameters in C#. If you look out and ref, both are closely doing the same thing. Then what are the differences between them? Let us understand the differences with an example.

using System;

namespace RefvsOutDemo

{

class Program

{

static void Main(string[] args)

{

//Calling the Method with the REF arguments

int AdditionRef = 0;

int SubtractionRef = 0;

MathRef(200, 100, ref AdditionRef, ref SubtractionRef);

Console.WriteLine($"AdditionRef: {AdditionRef}");

Console.WriteLine($"SubtractionRef: {SubtractionRef}");

//Call the Method with the OUT arguments

int AdditionOut = 0;

int SubtractionOut = 0;

MathOut(200, 100, out AdditionOut, out SubtractionOut);

Console.WriteLine($"AdditionOut: {AdditionOut}");

Console.WriteLine($"SubtractionOut: {SubtractionOut}");

Console.ReadKey();

}

//Creating Method with Ref Parameters

public static void MathRef(int number1, int number2, ref int Addition, ref int Subtraction)

{

Addition = number1 + number2; //This will Update the Addition variable inside the Main method

Subtraction = number1 - number2; //This will Update the Subtraction variable inside the Main method

}

//Creating Method with out Parameters

public static void MathOut(int number1, int number2, out int Addition, out int Subtraction)

{

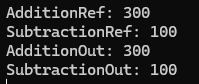
Addition = number1 + number2; //This will Update the Addition variable inside the Main method

Subtraction = number1 - number2; //This will Update the Subtraction variable inside the Main method

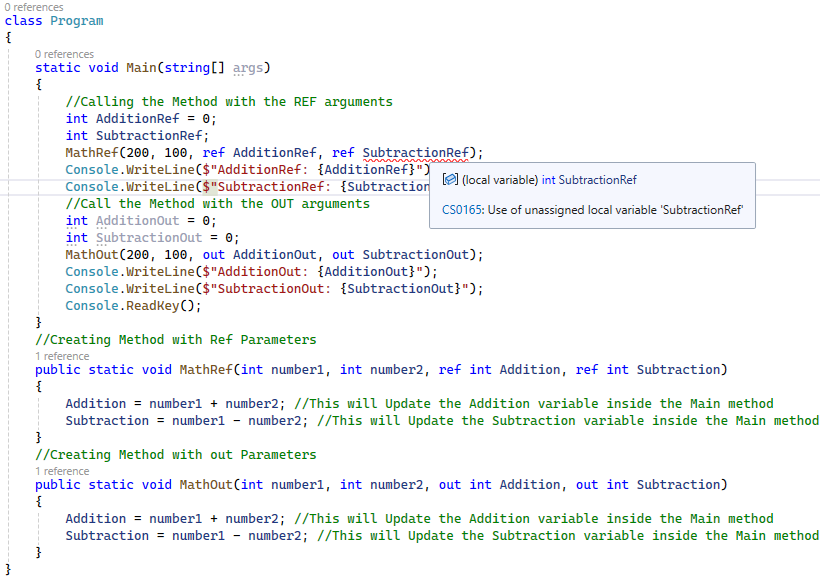
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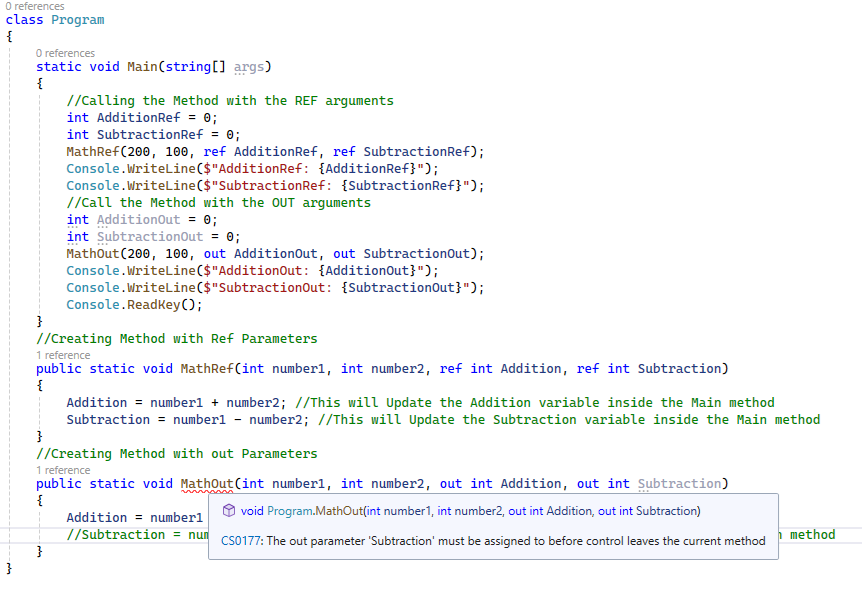
}

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When we are passing the ref parameter as arguments, it is mandatory to initialize the ref parameter before passing it to the method else we will get compile time error. This is because with the ref parameter, updating the value inside the method is optional. So, before passing the ref parameter, it should be initialized.

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When we call a method with the “out” variable, the method has to update the out variable inside the function and it is mandatory. But this is not mandatory if you are using the ref variable

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