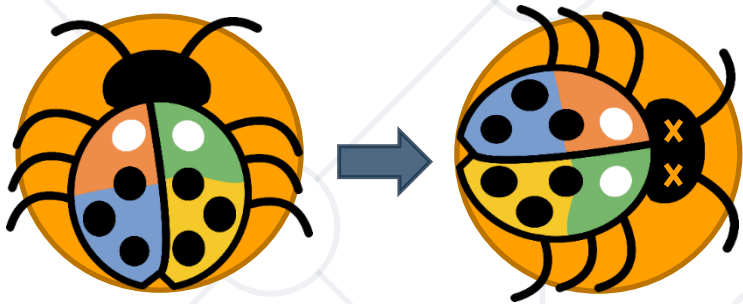


Unit Testing

Building Rock-Solid Software



SoftUni Team
Technical Trainers



SoftUni



Software University

<https://softuni.bg>

1. Seven Testing Principles
2. What is Unit Testing?
3. Unit Testing Frameworks
4. NUnit
 - NUnit Setup
 - Test Classes and Test Methods
 - 3A-s Pattern
5. Good Practices



sli.do

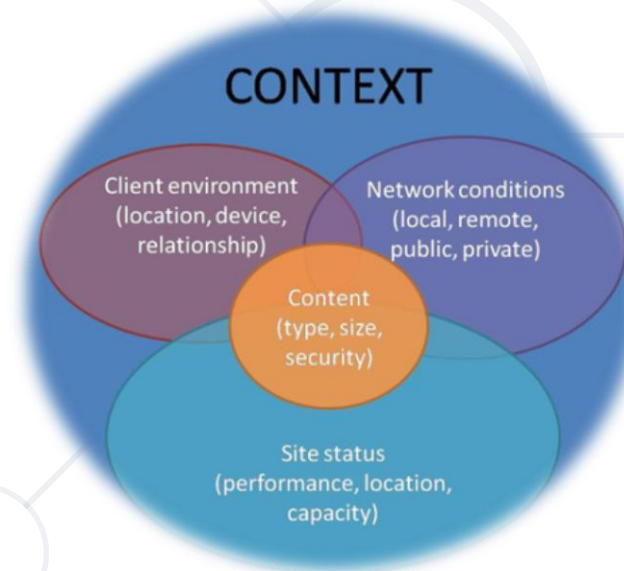
#csharp-advanced



Seven Testing Principles

Seven Testing Principles (1)

- Testing is context dependent
 - Testing is done differently in **different contexts**
- Example:
 - Safety-critical software is tested **differently** from an e-commerce site



Seven Testing Principles (2)

- Exhaustive testing is **impossible**
 - All combinations of inputs and preconditions are usually almost **infinite number**
 - Testing everything is not feasible
 - Except for trivial cases
 - Risk analysis and priorities should be used to focus testing efforts
- E.g.: Big list of naughty strings

A QA Tester walks into a bar:

He orders a beer.

He orders 3 beers.

He orders 2976412836 beers.

He orders 0 beers.

He orders -1 beer.

He orders q beers.

He orders nothing.

Él ordena una cerveza.

He orders a deer.

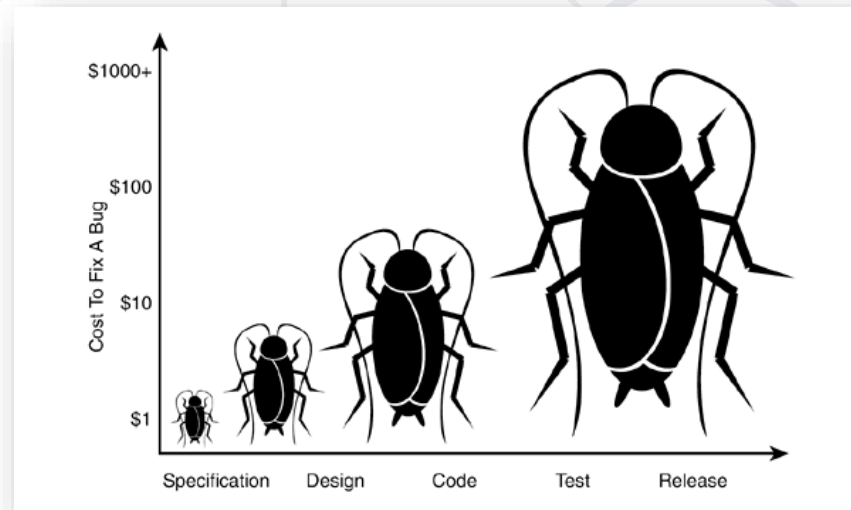
He tries to leave without paying.

He starts ordering a beer, then throws himself through the window half way through.

He orders a beer, gets his receipt, then tries to go back.

Seven Testing Principles (3)

- Early testing is **always preferred**
 - Testing activities shall be started as early as possible
 - And shall be focused on defined objectives
 - The later a bug is found – the more it costs!



Seven Testing Principles (4)

- Defect clustering
 - Testing effort shall be focused **proportionally**
 - To the expected and later observed defect density of modules
 - A **small number** of modules usually contains **most of the defects** discovered (80/20 principle)
 - Responsible for most of the operational failures

Seven Testing Principles (5)

- Pesticide paradox
 - Same tests repeated **over and over again** tend to **lose their effectiveness**
 - Previously **undetected** defects remain **undiscovered**
 - New and modified test cases should be developed

Seven Testing Principles (6)

- Testing shows presence of defects
 - Testing can **show that defects are present**
 - Cannot prove that there are no defects
 - Appropriate testing **reduces** the probability for defects

Seven Testing Principles (7)

- Absence-of-errors fallacy
 - **Finding** and **fixing** defects itself does not help in these cases:
 - The system built is unusable
 - Does not fulfill the users' needs and expectations



Software Used to Test Software

What is Unit Testing?

- **Unit test** == a piece of code that **tests specific functionality** in certain software component (unit)

```
sum(arr)  
✓ sum([1,2]) == 3  
✓ sum([-2]) == -2  
1) sum([]) == 0  
2 passing (10ms)  
1 failing
```

```
int Sum(int[] arr)  
{  
    int sum = arr[0];  
    for (int i=1; i<arr  
        .Length; i++)  
        sum += arr[i];  
    return sum;  
}
```

```
void Test_SumTwoNumbers() {  
    if (Sum(new int[]{1, 2}) != 3)  
        throw new Exception("1+2 != 3");  
}
```

```
void Test_SumEmptyArray() {  
    if (Sum(new int[] { }) != 0)  
        throw new Exception("sum [] != 0");  
}
```

- **Unit tests**

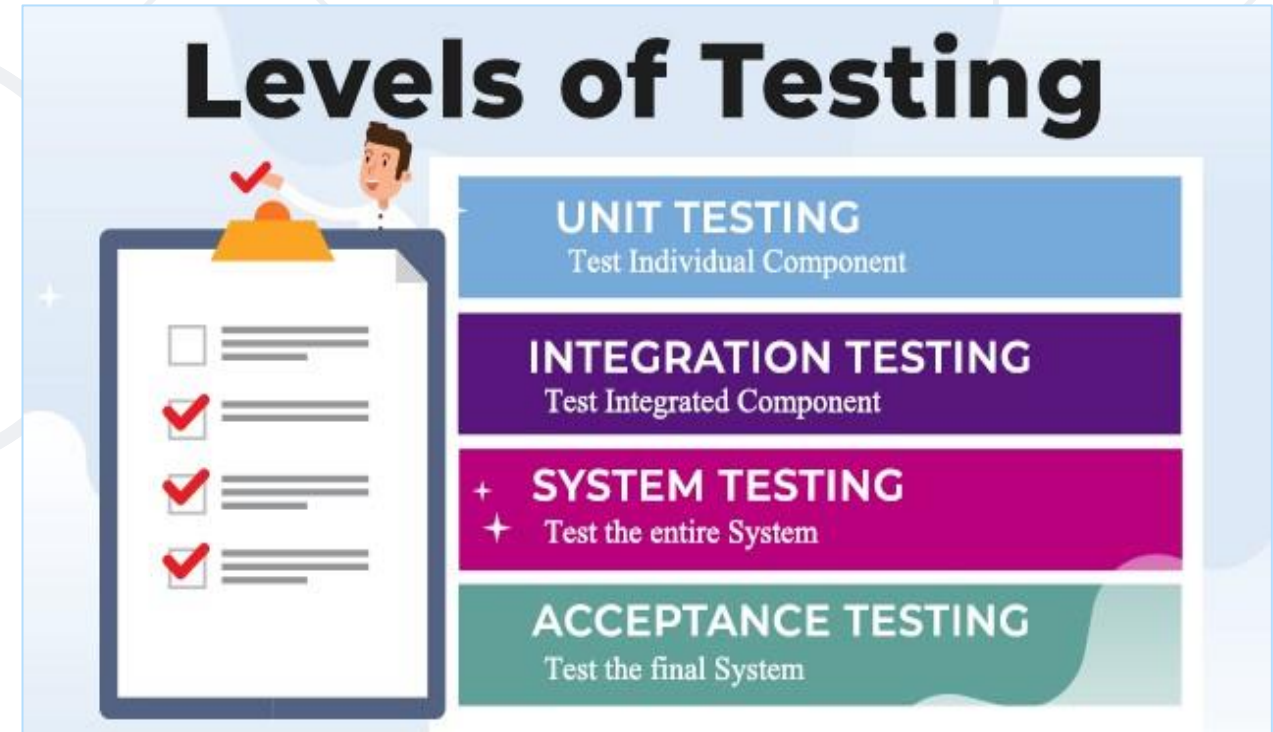
- Test a **single component** (mocking the dependencies)
- NUnit, JUnit, PyUnit, Mocha

- **Integration tests**

- Test an **interaction** between components, e. g. **API tests**

- **System tests / acceptance tests / end-to-end tests**

- Test the **entire system**, e. g. Selenium, Appium, Cypress, Playwright





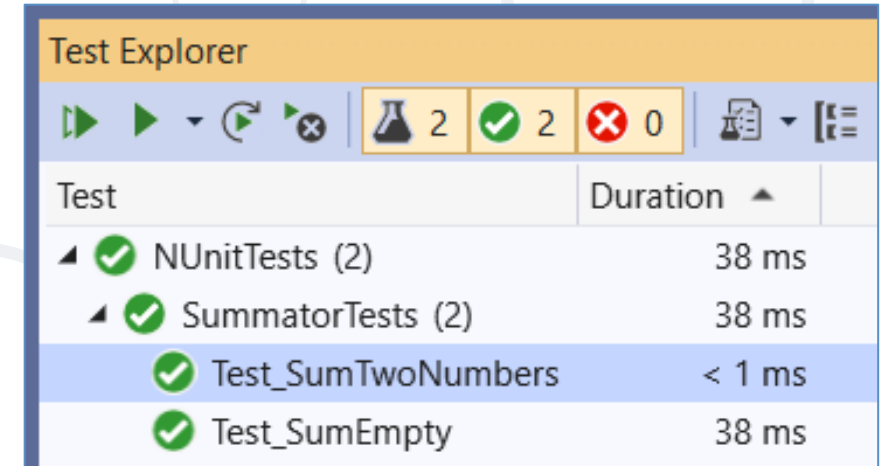
Unit Testing Frameworks

- **Testing frameworks** provide foundation for test automation
 - Consists of **libraries**, code **modules** and **tools** for test automation
 - **Structure the tests** into hierarchical or other form
 - **Implement** test cases, **execute the tests** and **generate reports**
 - **Assert** the execution results and exit conditions
 - Perform initialization at **startup** and cleanup at **shut down**
- **Examples** of testing frameworks:
 - NUnit, xUnit, MSTest (C#), JUnit (Java), Mocha (JS), PyUnit (Python)

- **Testing frameworks** simplify automated testing and reporting
 - Example: **NUnit** testing framework for C#

```
using NUnit.Framework;

public class SummatorTests
{
    [Test]
    public void Test_SumTwoNumbers() {
        var sum = Sum(new int[] { 1, 2 });
        Assert.AreEqual(3, sum);
    }
}
```



Test	Duration
▲ ✓ NUnitTests (2)	38 ms
▲ ✓ SummatorTests (2)	38 ms
✓ Test_SumTwoNumbers	< 1 ms
✓ Test_SumEmpty	38 ms

- **Unit testing framework** == automated testing framework == testing framework == test framework
 - Many names for similar concepts → why?
- Testing frameworks like **JUnit** and **NUnit** were initially designed for **unit testing**, but nothing limits them to wider use
- With additional libraries, NUnit and JUnit are used for:
 - **Integration testing, API testing, Web service testing**
 - **End-to-end testing, Web UI testing, mobile testing, etc.**



NUnit: First Steps

Setup and First Test

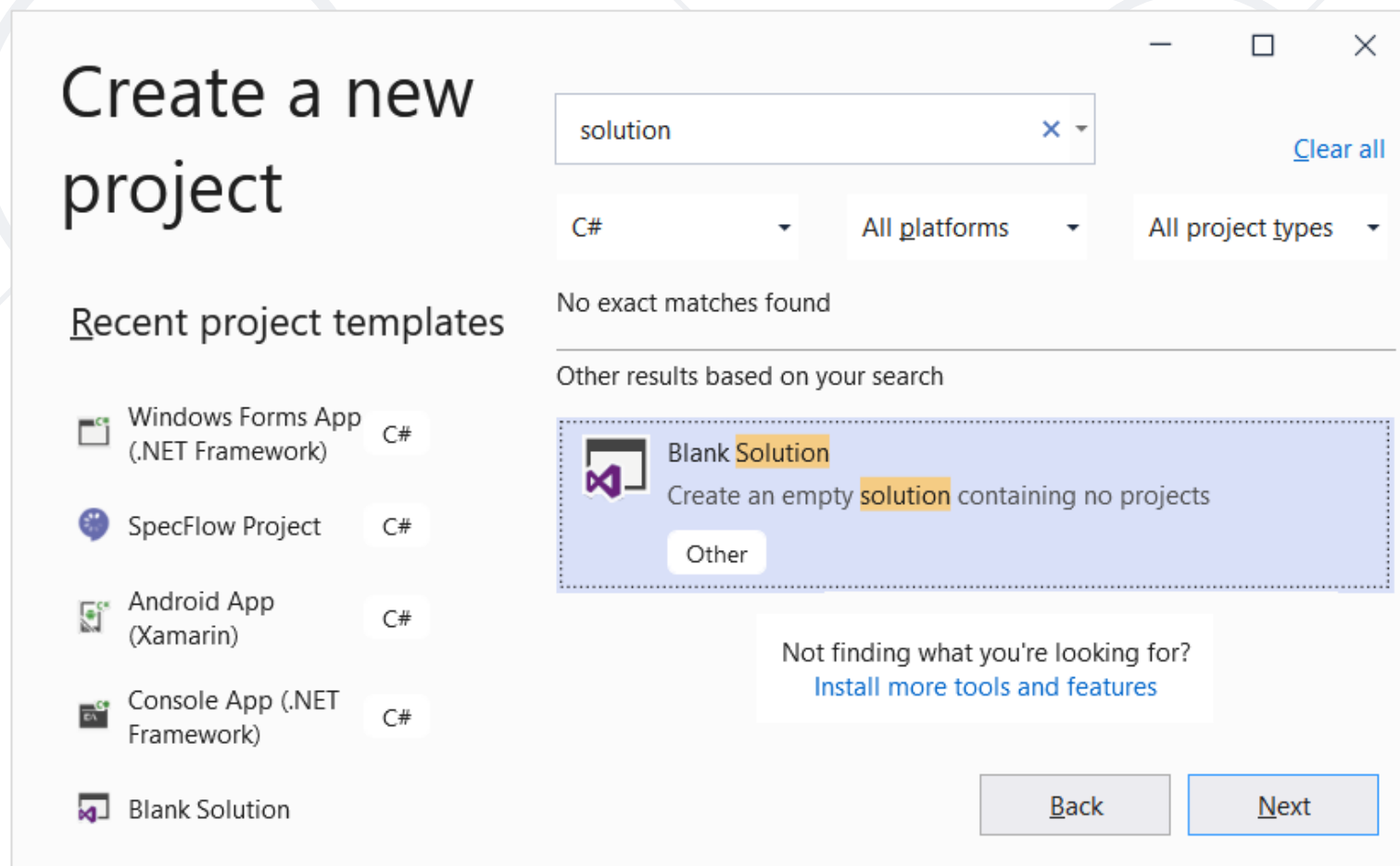
NUnit: Overview

- **NUnit** == popular C# testing framework
 - Supports test suites, test cases, before & after code, startup & cleanup code, timeouts, expected errors, ...
 - Like **JUnit** (for Java)
 - Free, open-source
 - Powerful and mature
 - Wide community
 - Built-in support in Visual Studio
 - Official site: nunit.org



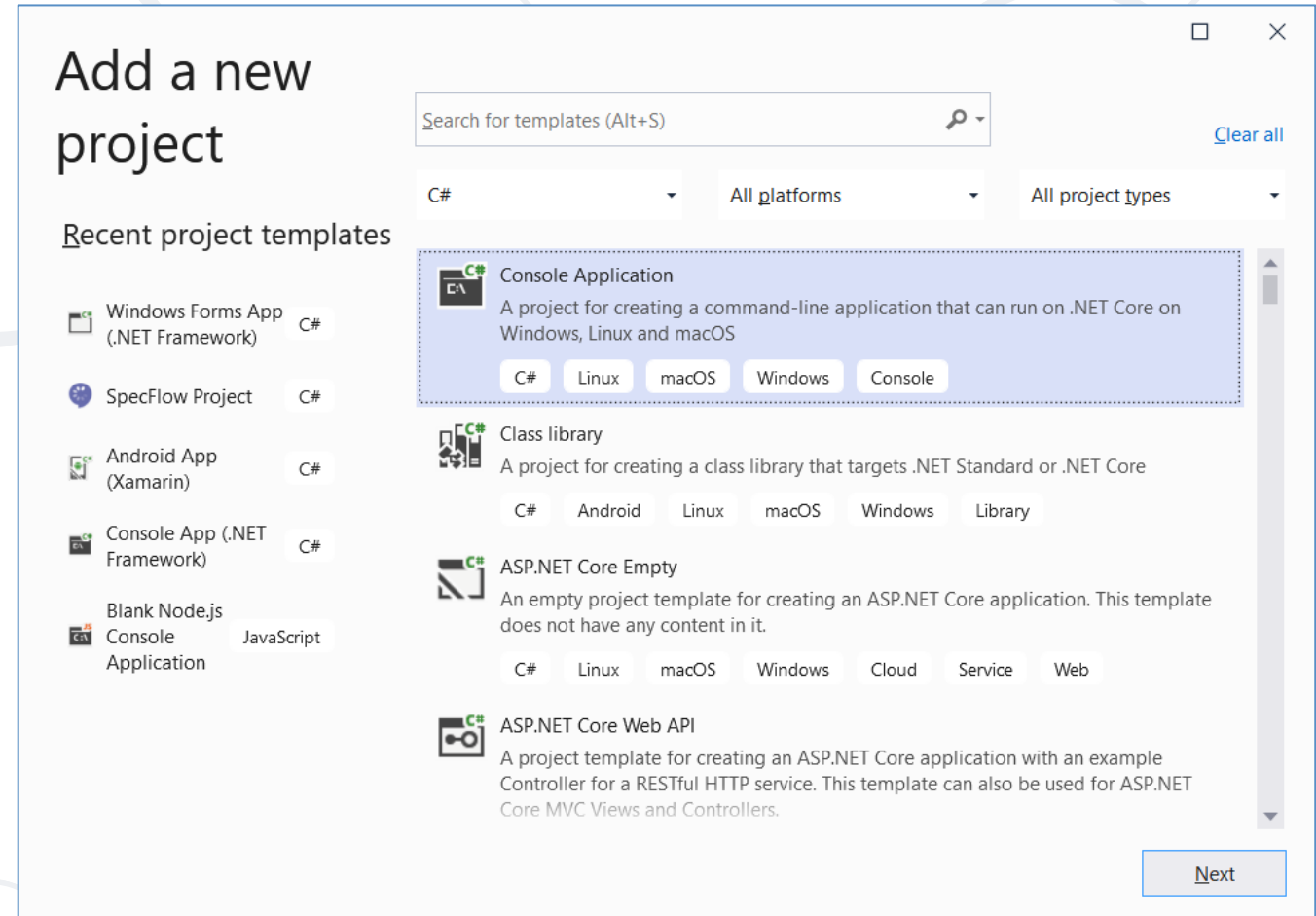
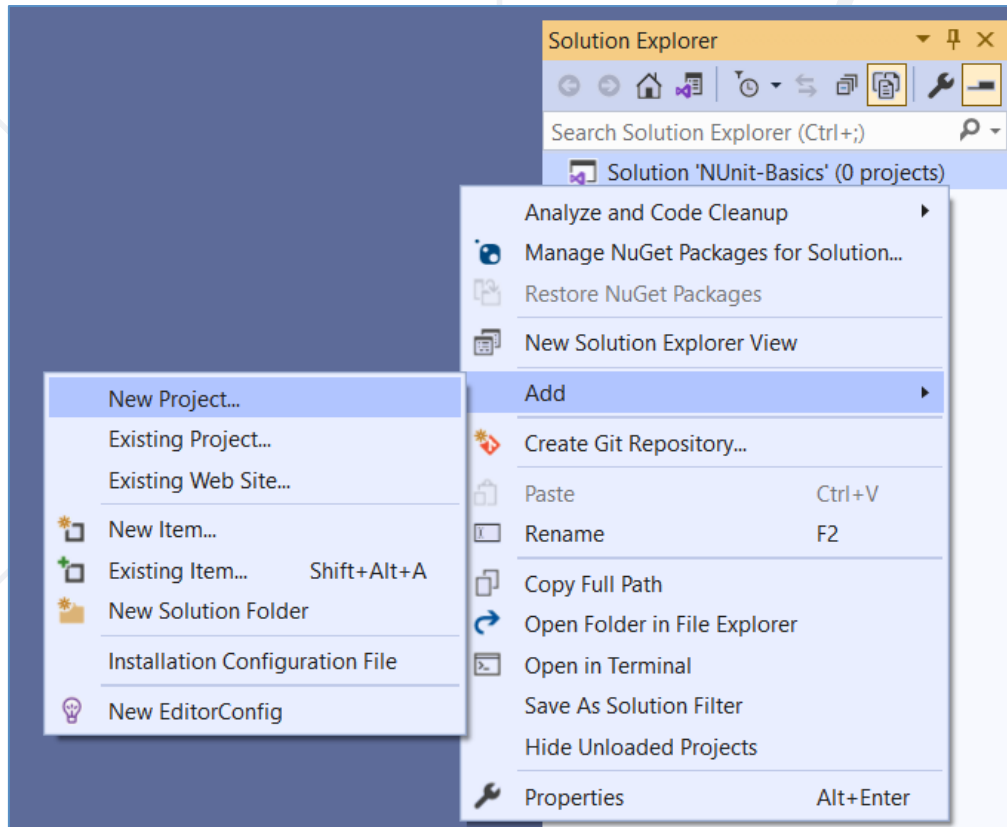
Creating a Blank Solution

- Create a **blank solution** in Visual Studio
 - It will hold the **project for testing**
 - And the **unit test project (tests)**

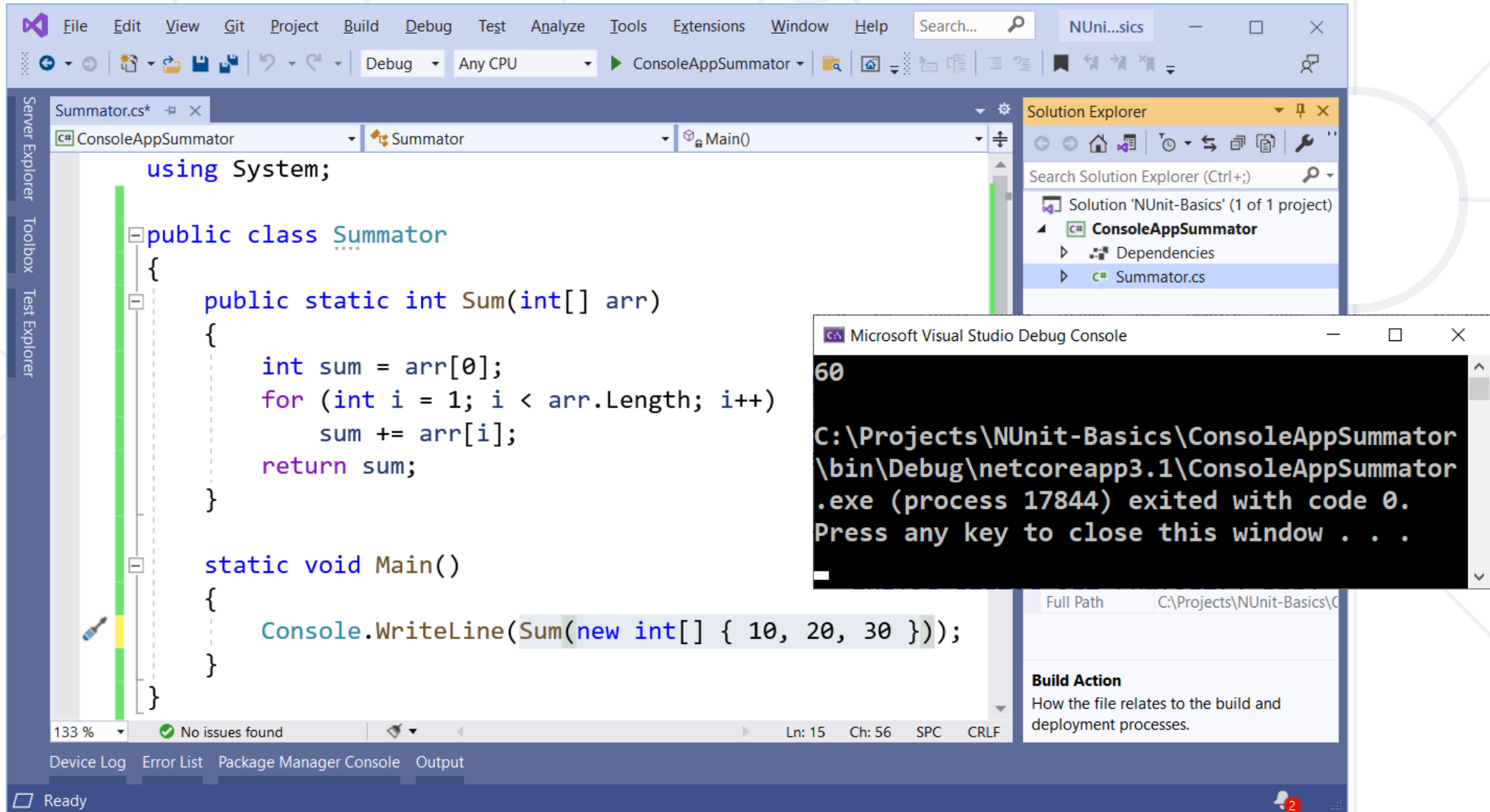


Creating a Project for Testing

- Create a **console-based app**, to hold the **code for testing**



Creating a Project for Testing (2)



Summator.cs*

```
using System;

public class Summator
{
    public static int Sum(int[] arr)
    {
        int sum = arr[0];
        for (int i = 1; i < arr.Length; i++)
            sum += arr[i];
        return sum;
    }

    static void Main()
    {
        Console.WriteLine(Sum(new int[] { 10, 20, 30 }));
    }
}
```

Solution Explorer

Search Solution Explorer (Ctrl+;)

Solution 'NUnit-Basics' (1 of 1 project)

- ConsoleAppSummator
 - Dependencies
 - Summator.cs

Microsoft Visual Studio Debug Console

60

C:\Projects\NUnit-Basics\ConsoleAppSummator\bin\Debug\netcoreapp3.1\ConsoleAppSummator.exe (process 17844) exited with code 0. Press any key to close this window . . .

Full Path C:\Projects\NUnit-Basics\

Build Action

How the file relates to the build and deployment processes.

133 % No issues found Ln: 15 Ch: 56 SPC CRLF

Device Log Error List Package Manager Console Output

Ready

Creating an NUnit Project

Create a new project

Recent project templates

- ASP.NET Core Web Application C#
- Console App (.NET Core) C#
- Windows Forms App (.NET) C#
- NUnit Test Project (.NET Core) C#
- Console App (.NET Framework) C#
- Windows Forms App (.NET Framework) C#

NUnit

[Clear all](#)

C#

All platforms

All project types



xUnit Test Project (.NET Core)

A project that contains xUnit.net tests that can run on .NET Core on Windows, Linux and MacOS.

C#

Windows

Linux

macOS

Test



NUnit Test Project (.NET Core)

A project that contains NUnit tests that can run on .NET Core on Windows, Linux and MacOS.

C#

Linux

macOS

Windows

Desktop

Test

Web



xUnit Test Project (.NET Core)

A project that contains xUnit.net tests that can run on .NET Core on Windows, Linux and MacOS.

C#

Windows

Linux

macOS

Test

[Next](#)

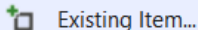
New Project...

Existing Project...

Existing Web Site...



New Item...



Existing Item...

Shift+Alt+A



New Solution Folder

Installation Configuration File



New EditorConfig

Ar



M



Re



Ne



Ac



Cr



Pa



Re



Co



Op



Op



Alt+Enter

Save As Solution Filter

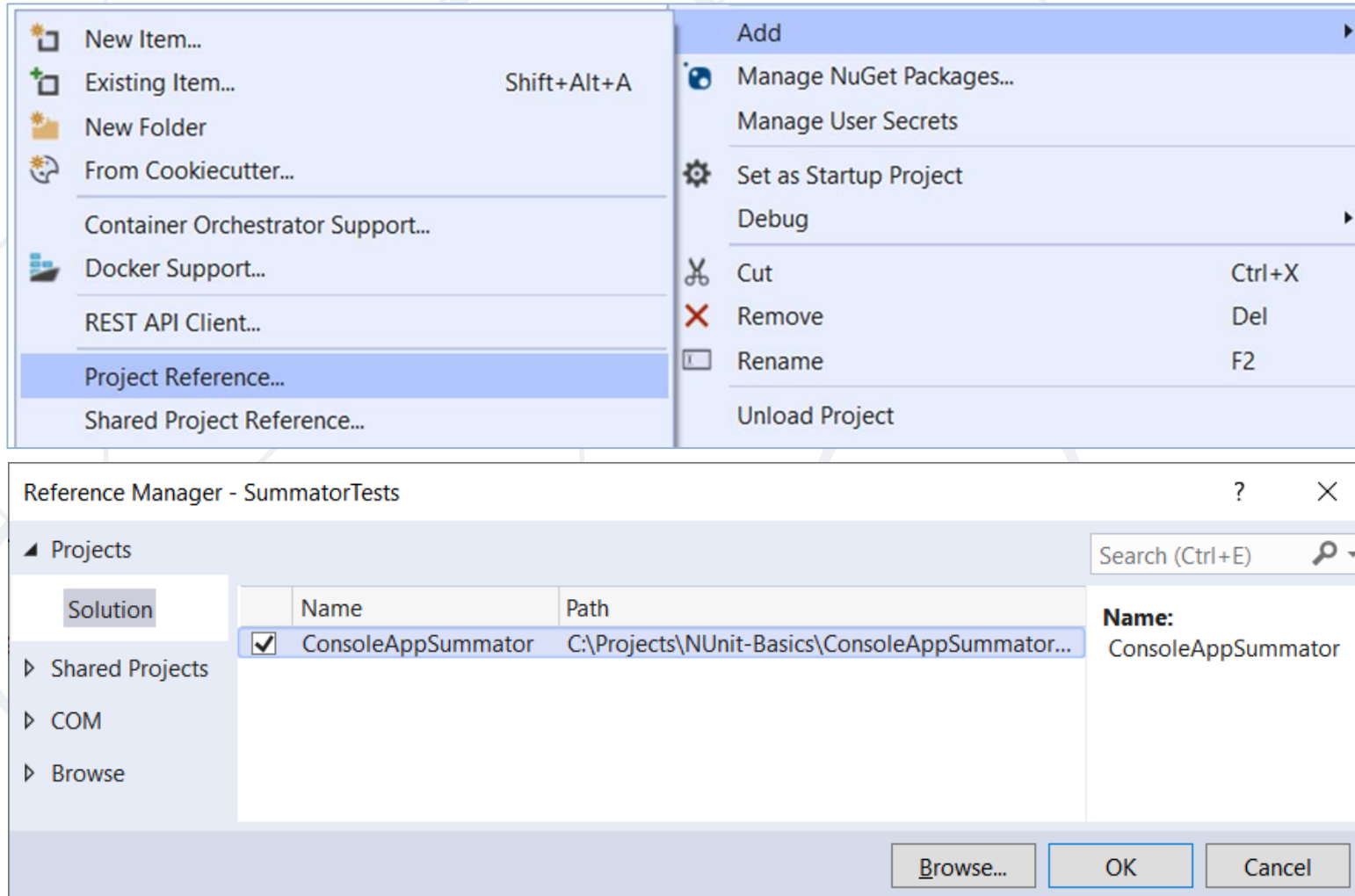
Hide Unloaded Projects

Properties

Alt+Enter

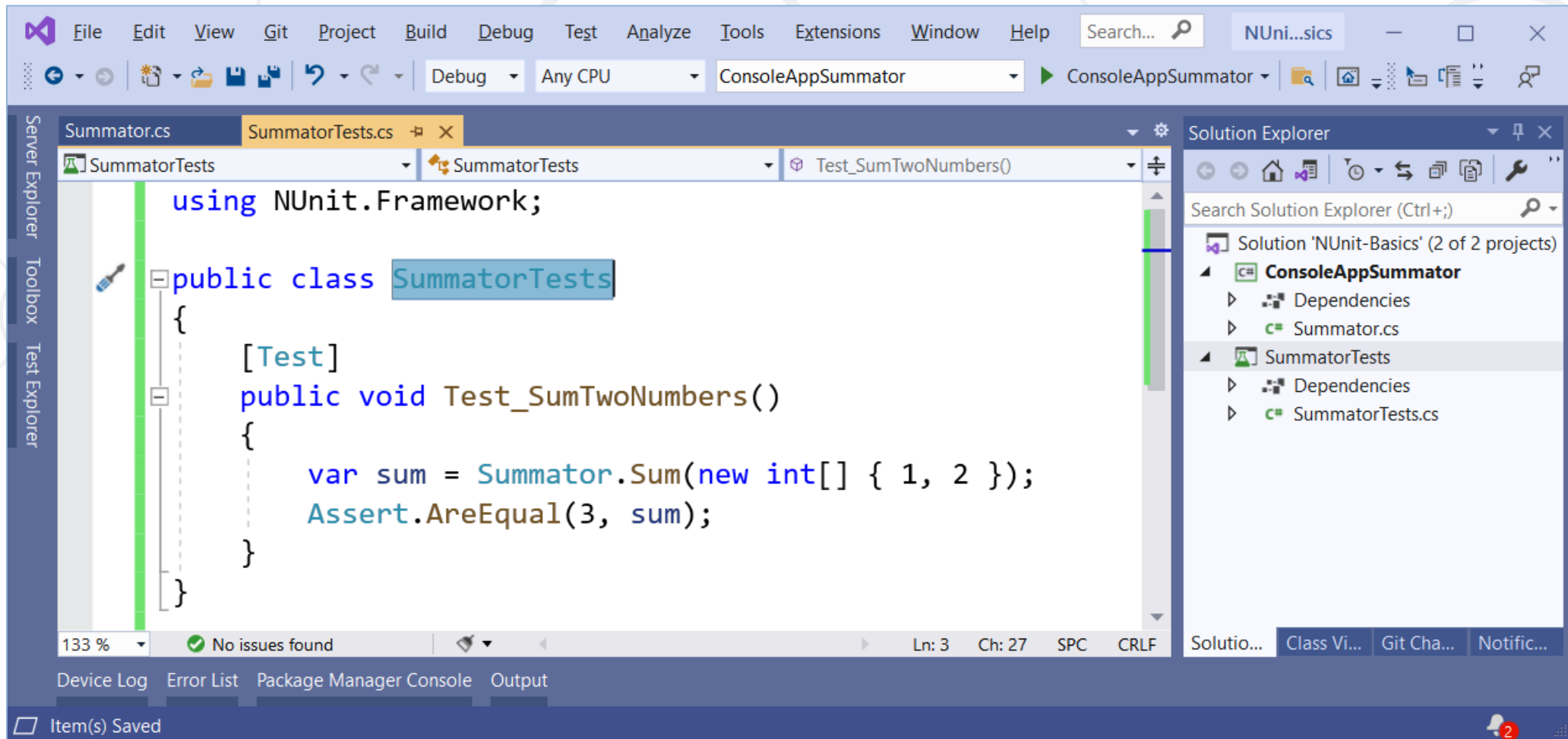
Adding Project Reference

- Add **Project Reference** to the target project for testing:



Writing the First Test

- Writing the first **NUnit** test method:



The screenshot shows the Visual Studio IDE with the following details:

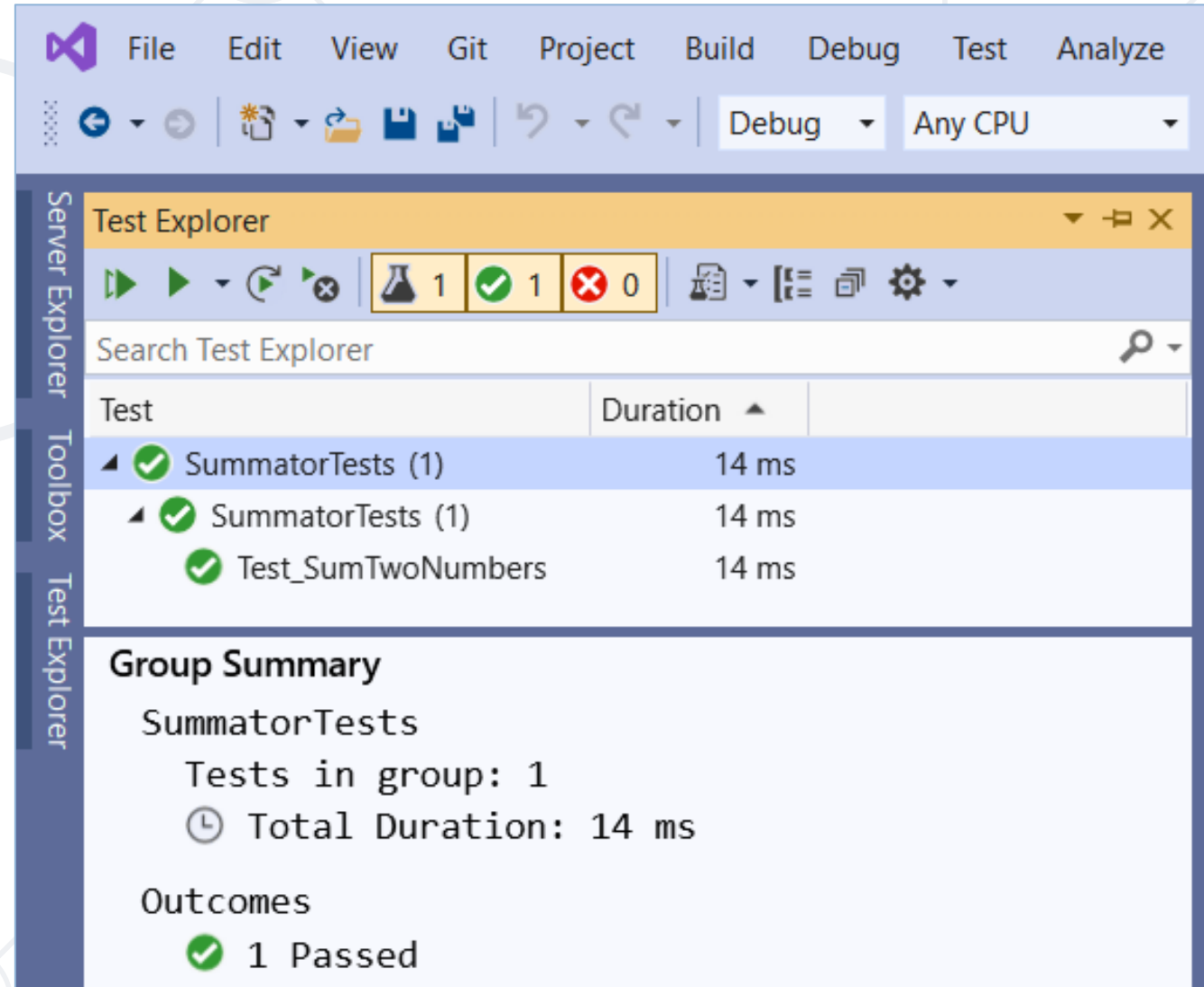
- File Explorer:** Shows the project structure with 'ConsoleAppSummator' and 'SummatorTests' projects.
- Code Editor:** Displays the `SummatorTests.cs` file. The code is as follows:

```
using NUnit.Framework;

public class SummatorTests
{
    [Test]
    public void Test_SumTwoNumbers()
    {
        var sum = Summator.Sum(new int[] { 1, 2 });
        Assert.AreEqual(3, sum);
    }
}
```
- Test Explorer:** Shows the test method `Test_SumTwoNumbers()` with a green status bar indicating it passed.
- Output Window:** Shows the message "No issues found".
- StatusBar:** Indicates "Item(s) Saved" and "Ln: 3 Ch: 27 SPC CRLF".

Running the Tests

- The **[Test Explorer]** tool in Visual Studio
 - Show the **[Test Explorer]**:
 - **[Ctrl + E] + T**
 - Visualizes the **hierarchy** of tests
 - **Executes** tests
 - **Reports** results

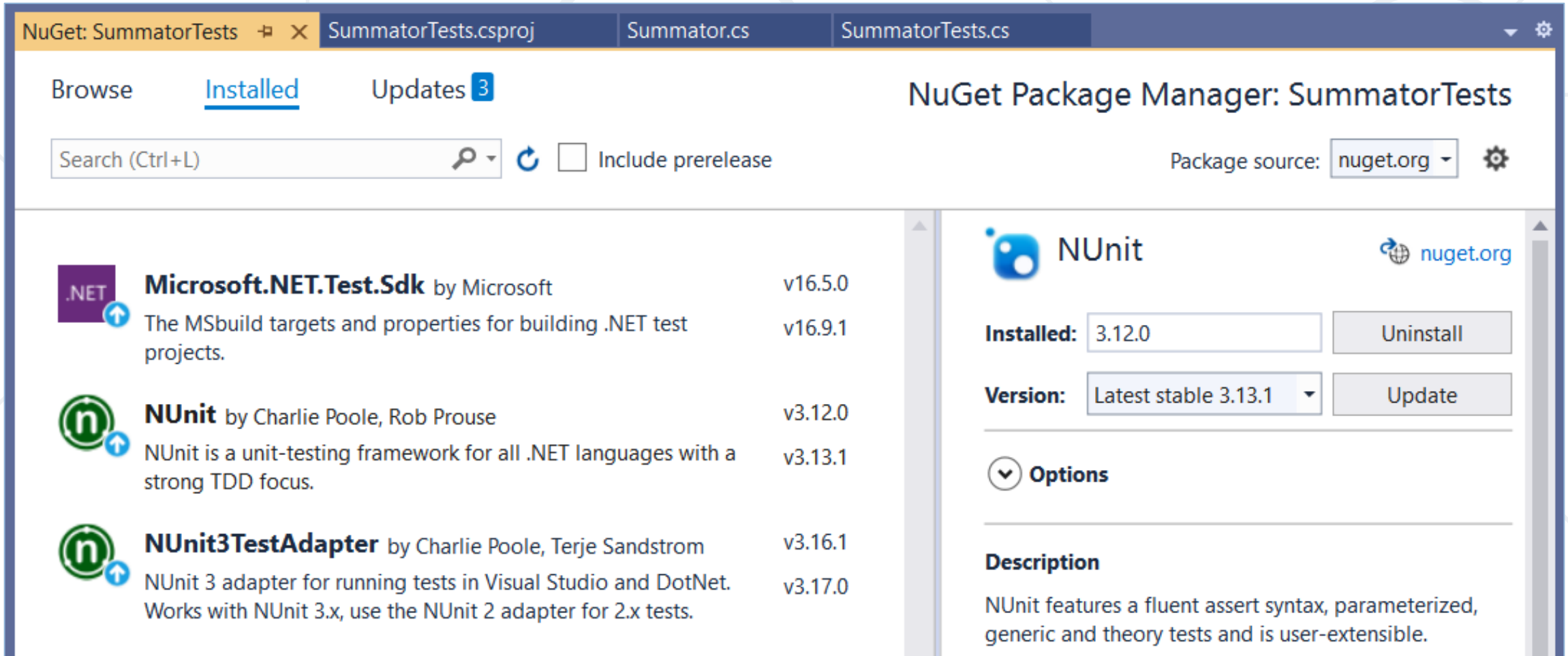




NUnit: Basics

Test Classes and Test Methods

- **NuGet packages**, required to run NUnit tests in Visual Studio



The screenshot shows the NuGet Package Manager window for the project 'SummatorTests'. The 'Installed' tab is selected, showing a list of installed packages. The 'NUnit' package is highlighted, and its details are shown on the right.

Package Name	Author	Version
Microsoft.NET.Test.Sdk	Microsoft	v16.5.0
NUnit	Charlie Poole, Rob Prouse	v3.12.0
NUnit3TestAdapter	Charlie Poole, Terje Sandstrom	v3.16.1

NUnit by Charlie Poole, Rob Prouse
NUnit is a unit-testing framework for all .NET languages with a strong TDD focus.

Installed: 3.12.0 **Uninstall**

Version: Latest stable 3.13.1 **Update**

Options

Description
NUnit features a fluent assert syntax, parameterized, generic and theory tests and is user-extensible.

Test Classes and Test Methods

- Test classes hold test methods:

```
using NUnit.Framework;
```

Import NUnit

```
[TestFixture]
```

Optional notation

```
public class SummatorTests  
{
```

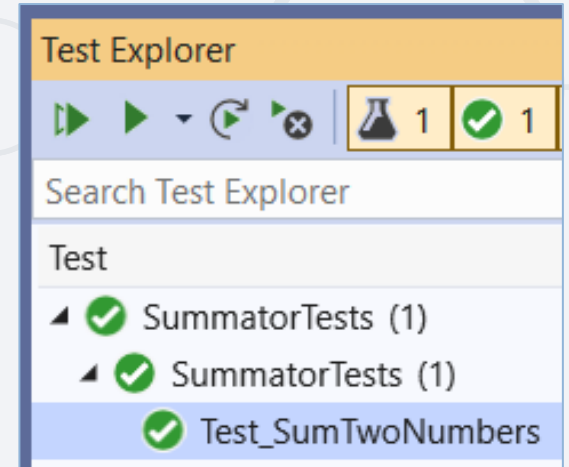
Test class

```
[Test]
```

Test method

```
public void Test_SumTwoNumbers() {  
    var sum = Sum(new int[] { 1, 2 });  
    Assert.AreEqual(3, sum);  
}
```

Assertion



Initialization and Cleanup Methods

```
private Summator summator;
```

```
[SetUp] // or [OneTimeSetUp]
```

```
public void TestInitialize()
```

```
{
```

```
    this.summator = new Summator();
```

```
}
```

```
[TearDown] // or [OneTimeTearDown]
```

```
public void TestCleanup()
```

```
{
```

```
    // ...
```

```
}
```

Executes **before**
each test

Executes **after**
each test

Problem: NUnit Test

- Create console application project
- Add BankAccount class
- Create NUnit Project
- Test the BankAccount class

Solution: NUnit Test (1)

- Create a console **application**
 - Add BankAccount class for us to test

BankAccount
+Amount : decimal
+BankAccount(decimal)

- Create a new **NUnit Test Project**
 - Name it like the project you are testing, but with **".Tests"** suffix
- Open **Test Explorer** (Ctrl + E, T or Test->Windows->TestExplorer)

Solution: NUnit Test (2)

- Write your first test

[TestFixture]

Attribute that marks a class that contains tests

```
public class BankAccountTests  
{
```

[Test]

Test Method

```
    public void AccountInitializeWithPositiveValue() {  
        BankAccount account = new BankAccount(2000m);  
        Assert.That(account.Amount, Is.EqualTo(2000m));  
    }  
}
```

Assert class comes with NUnit

The "AAA" Testing Pattern

- Automated tests usually follow the **"AAA" pattern**
 - **Arrange**: prepare the **input** data and entrance conditions
 - **Act**: invoke the **action** for testing
 - **Assert**: check the **output** and exit conditions

```
[Test]
public void Test_SumNumbers()
{
    // Arrange
    var nums = new int[] {3, 5};

    // Act
    var sum = Sum(nums);

    // Assert
    Assert.AreEqual(8, sum);
}
```



How to Write Good Tests

Unit Testing Best Practices

- **Test names** should answer the question "*what's inside?*"
 - Should use **business domain terminology**
 - Should be **descriptive** and **readable**

```
IncrementNumber() {}  
Test1() {}  
TestTransfer() {}
```



```
Test_DepositAddsMoneyToBalance() {}  
Test_DepositNegativeShouldNotAddMoney() {}  
Test_TransferSubtractsFromSourceAddsToDestAccount() {}
```



- Test cases must be **repeatable**
 - Tests should behave the same if you run them many times
 - The expected results must be **consistent** and easily verified
- Test cases should **have no dependencies**
 - The order of test execution should never be important
 - Input data and entrance conditions should be set in the test
 - Test cases may depend on the test initialization only: **[SetUp]**
 - Tests should **cleanup** properly any resources used

Automated Tests: Good Practices (2)

- **Single scenario** per test case, not multiple

```
[Test]
public void Test_Collections_RemoveAtStart()
{
    var names = new Collection<string>("Peter", "Maria", "Steve", "Mia");
    var removed = names.RemoveAt(0);
    Assert.That(removed, Is.EqualTo("Peter"));
    var removed2 = names.RemoveAt(0);
    Assert.That(removed2, Is.EqualTo("Maria"));
    var removed3 = names.RemoveAt(0);
    Assert.That(removed3, Is.EqualTo("Steve"));
    var removed4 = names.RemoveAt(0);
    Assert.That(removed4, Is.EqualTo("Mia"));
}
```

```
[Test]
public void Test_Collections_RemoveAtStart()
{
    var names = new Collection<string>("Peter", "Maria", "Steve", "Mia");
    var removed = names.RemoveAt(0);
    Assert.That(removed, Is.EqualTo("Peter"));
    var removed2 = names.RemoveAt(0);
    Assert.That(removed2, Is.EqualTo("Maria"));
    var removed3 = names.RemoveAt(0);
    Assert.That(removed3, Is.EqualTo("Steve"));
    var removed4 = names.RemoveAt(0);
    Assert.That(removed4, Is.EqualTo("Mia"));
}
```

```
[Test]
public void Test_Collections_RemoveAtEnd()
{
    var names = new Collection<string>("Peter", "Maria", "Steve", "Mia");
    var removed = names.RemoveAt(3);
    Assert.That(removed, Is.EqualTo("Mia"));
    var removed2 = names.RemoveAt(2);
    Assert.That(removed2, Is.EqualTo("Steve"));
    var removed3 = names.RemoveAt(1);
    Assert.That(removed3, Is.EqualTo("Maria"));
    var removed4 = names.RemoveAt(0);
    Assert.That(removed4, Is.EqualTo("Peter"));
}
```

```
[Test]
public void Test_Collections_RemoveAtMiddle()
{
    var names = new Collection<string>("Peter", "Maria", "Steve", "Mia");
    var removed = names.RemoveAt(1);
    Assert.That(removed, Is.EqualTo("Maria"));
    Assert.That(names.ToString(), Is.EqualTo("[Peter, Steve, Mia]"));
}
```

- **Private methods** should be tested indirectly
 - By testing the **public methods** with certain inputs and entrance conditions, that will invoke the target private methods
 - Check the **code coverage** to ensure all code is tested!
- Example:

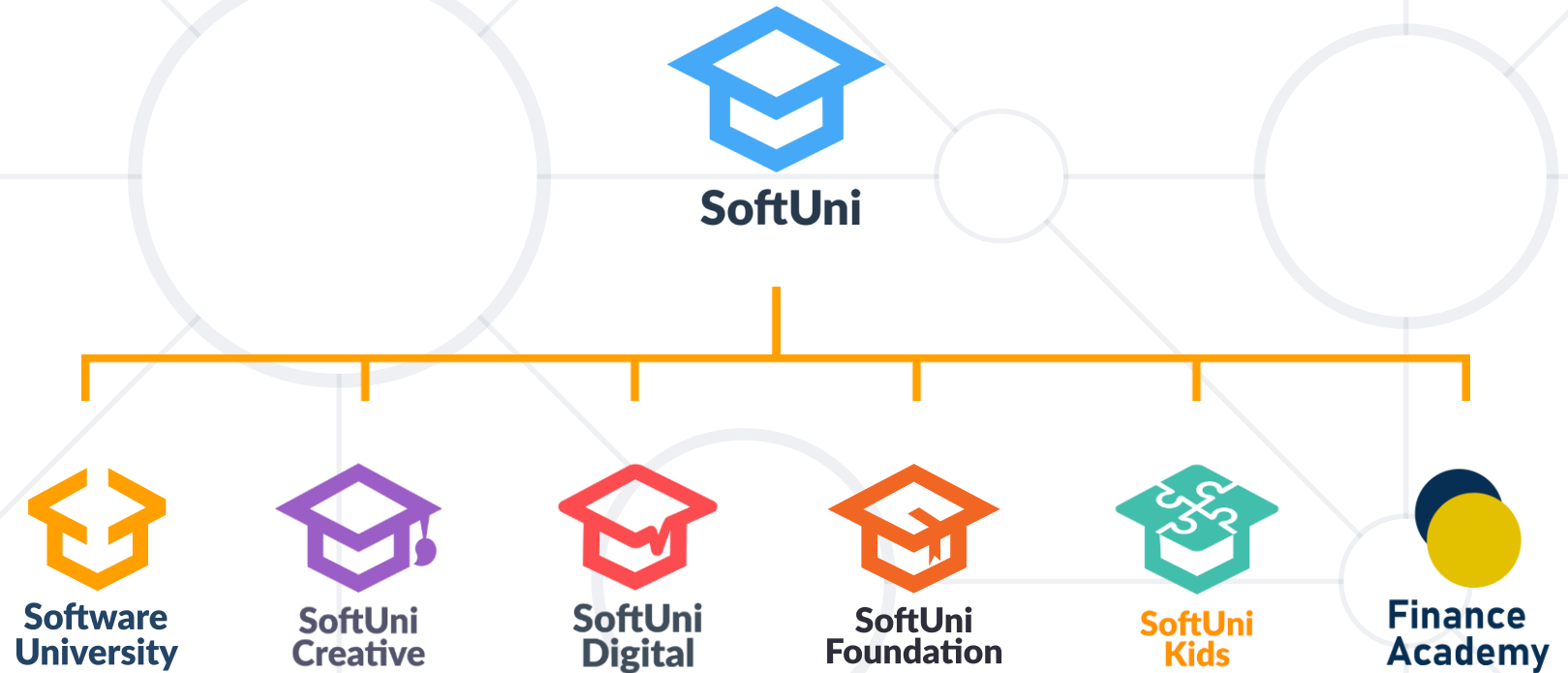
```
public void Add(T item)
{
    this.EnsureCapacity();
    this.items[this.Count] = item;
    this.Count++;
}
```

```
private void EnsureCapacity()
{
    if (this.Count == this.Capacity)
    {
        // Grow the capacity 2 times and move the items
        T[] oldItems = this.items;
        this.items = new T[2 * oldItems.Length];
        for (int i = 0; i < this.Count; i++)
            this.items[i] = oldItems[i];
    }
}
```


- **Unit testing** == automated testing of single component (unit)
- **Testing framework** == foundation for writing tests
- **NUnit** == automated testing framework for C#
- The **AAA pattern**: Arrange, Act, Assert



Questions?



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