CO453 Application Programming

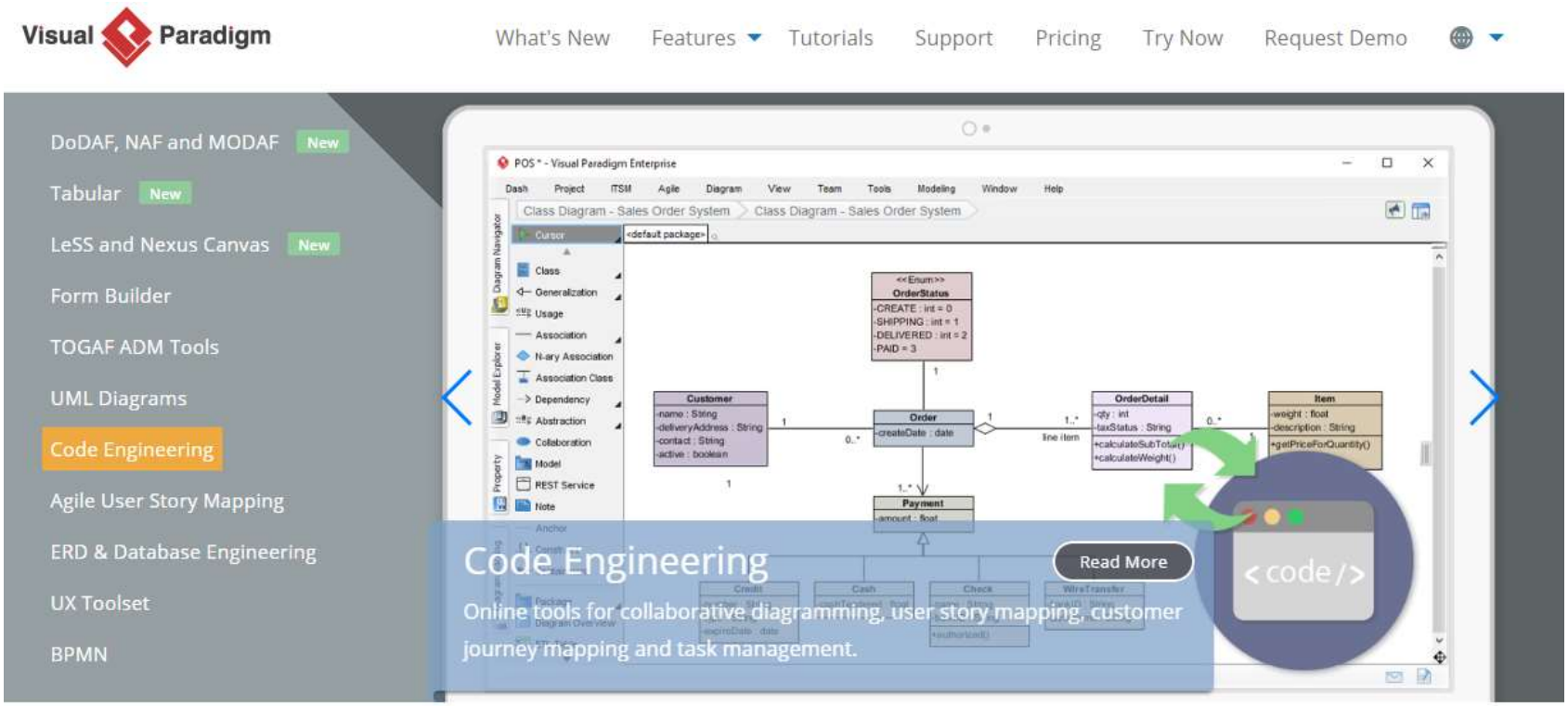
bucks new university

Test Driven Development

App03: Student Grades - Features

1. Enter a mark for each student
2. Convert the marks to grades
3. Display all the marks and grades
4. Calculate and display basic marks statistics
5. Calculate and display a grade profile

Visual Paradigm: Community Edition



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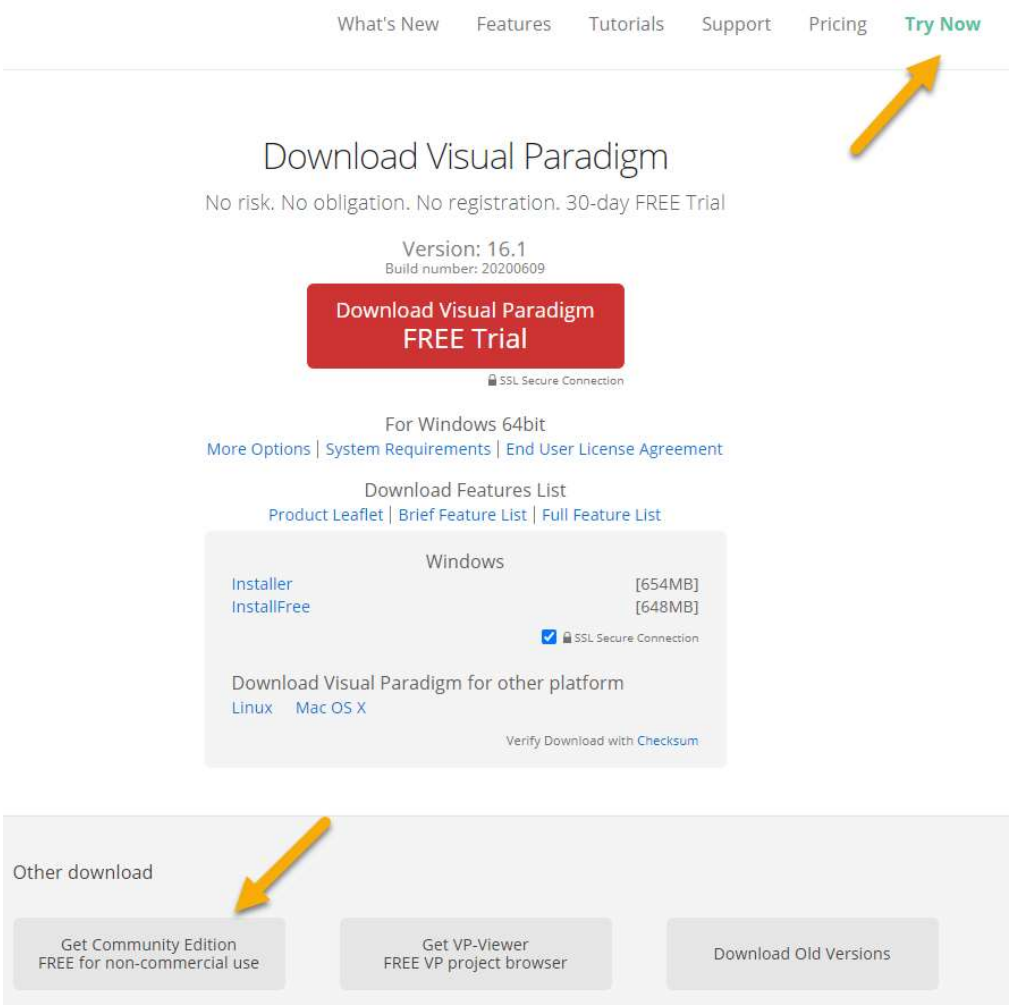
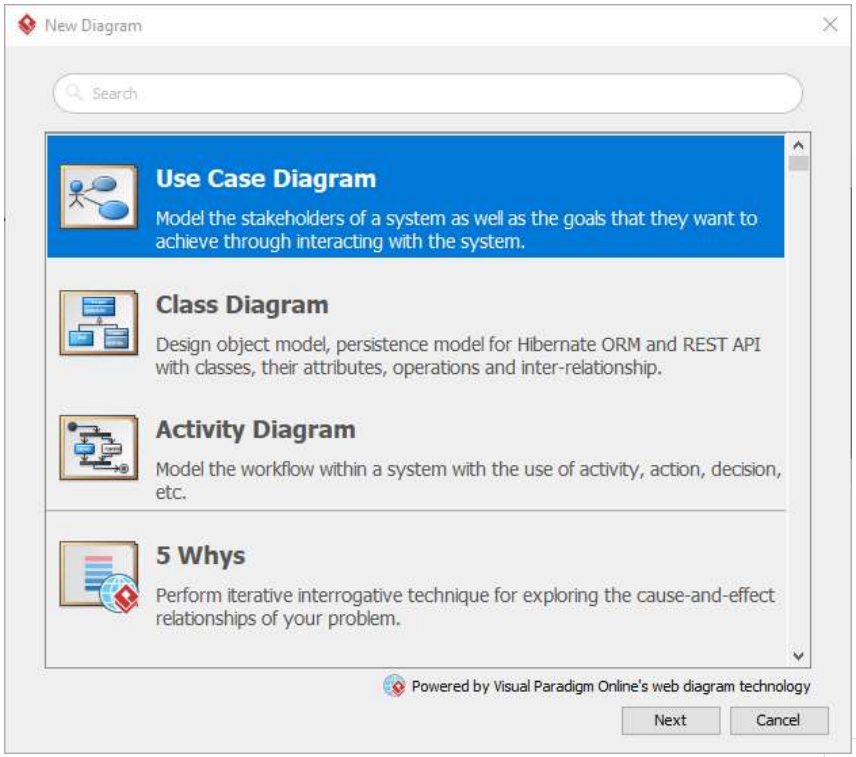
Community Edition

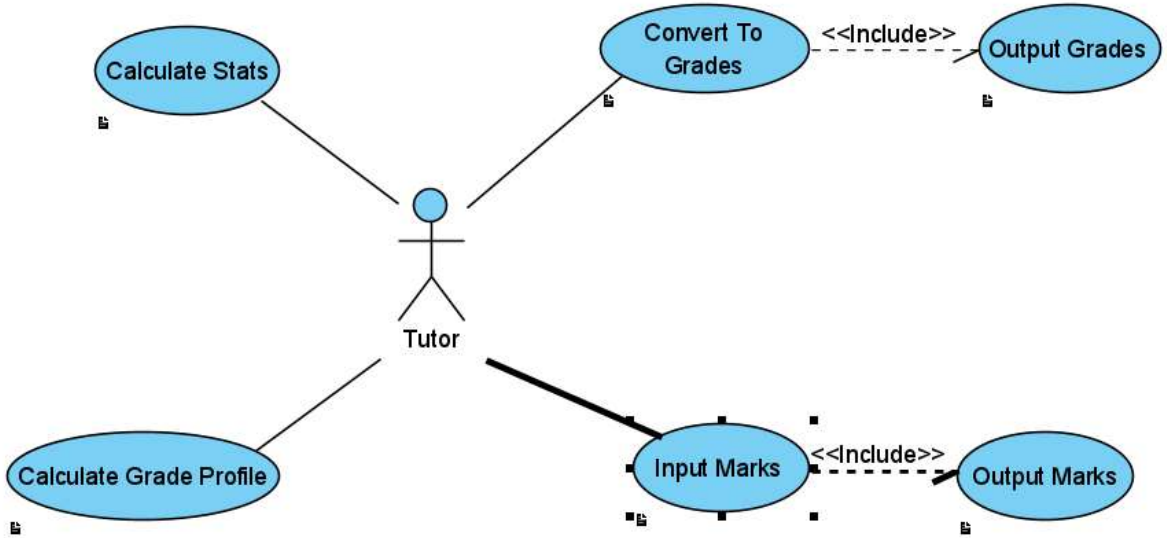


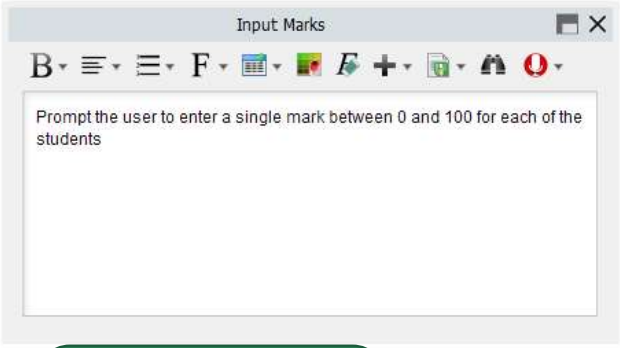
Create a new Project then add a new Use Case Diagram



UML: Use Case Diagram (analysis)

Use Case descriptions should become method comments





Use Cases can become Methods

Student Grades Class

Using public properties makes testing easier

```
/// <summary>
/// Grade A is First Class    : 70 - 100
/// Grade B is Upper Second   : 60 - 69
/// Grade C is Lower Second   : 50 - 59
/// Grade D is Third Class    : 40 - 49
/// Grade F is Fail           :  0 - 39
/// </summary>
0 references
public enum Grades
{
    [Description("Fail")]
    F,
    [Description("Third Class")]
    D,
    [Description("Lower Second")]
    C,
    [Description("Upper Second")]
    B,
    [Description("First Class")]
    A
}
```

What grade is missing?

```
3 references
public class StudentGrades
{
    1 reference
    public string[] Students { get; set; }

    4 references | 0/4 passing
    public int [] Marks { get; set; }

    7 references | 0/1 passing
    public int [] GradeProfile { get; set; }

    1 reference | 0/1 passing
    public double Mean { get; set; }

    1 reference | 0/1 passing
    public int Minimum { get; set; }

    1 reference | 0/1 passing
    public int Maximum { get; set; }
```

StudentGrades Constructor

```
/// <summary>
/// Class Constructor called when an object
/// is created and sets up an array of students.
/// </summary>
3 references
public StudentGrades()
{
    Students = new string[]
    {
        "Daniel","Dylan", "Eric",
        "Georgia", "Hasan","Hamza",
        "Jack", "Liam", "Shan",
        "Shamial"
    };

    GradeProfile = new int[(int)Grade.A + 1];
    Marks = new int[Students.Length];
}
```

- Constructor is used to initialise variables to default values
- Use your own list of students names
- At least 10 student names
- An empty marks array is created
- An empty Grade Profile is created
- (int) casts a Grade to an int

Other Methods

```
/// <summary>
/// Input a mark between 0 - 100 for each
/// student and store it in the Marks array
/// </summary>
0 references
public void InputMarks()
{
    throw new NotImplementedException();
}

/// <summary>
/// List all the students and display their
/// name and current mark
/// </summary>
0 references
public void OutputMarks()
{
    throw new NotImplementedException();
}
```

```
/// <summary>
/// Convert a student mark to a grade
/// from F (Fail) to A (First Class)
/// </summary>
1 reference | 0/1 passing
public Grade ConvertToGrade(int mark)
{
    throw new NotImplementedException();
}

/// <summary>
/// Calculate and display the minimum, maximum
/// and mean mark for all the students
/// </summary>
3 references | 0/3 passing
public void CalculateStats()
{
    throw new NotImplementedException();
}
```

Methods Continued

```
/// <summary>
/// List all the students and display their
/// name, mark and grade
/// </summary>
0 references
public void OutputGrades()
{
    throw new NotImplementedException();
}

/// <summary>
/// Calculate and display the proportion of
/// students achieving each of the grades
/// </summary>
1 reference | 0/1 passing
public void CalculateGradeProfile()
{
    throw new NotImplementedException();
}
```

Test Driven Development (TDD)

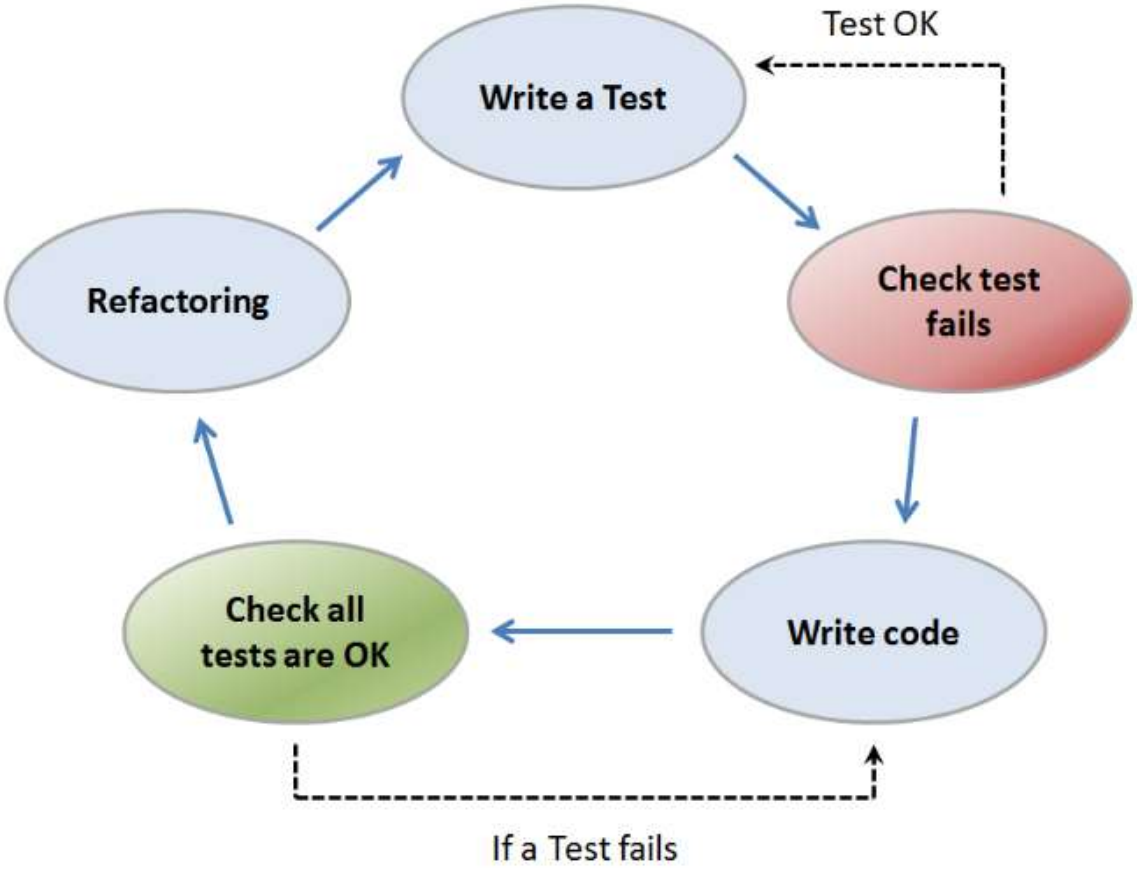


Figure 1 : TDD Cycle

How many tests are needed to check that any mark can be converted to the correct grade?

100 or 12 or 6?

Testing ConvertToGrade()

```
/// <summary>
/// Grade A is First Class    : 70 - 100
/// Grade B is Upper Second   : 60 - 69
/// Grade C is Lower Second   : 50 - 59
/// Grade D is Third Class    : 40 - 49
/// Grade F is Fail           :  0 - 39
/// </summary>
27 references
public enum Grade
{
    F, D, C, B, A
}
```

Only need to check the boundary values

e.g. 70 is lowest A
100 is the highest A
Total = 10

Testing Convert0ToGrade()

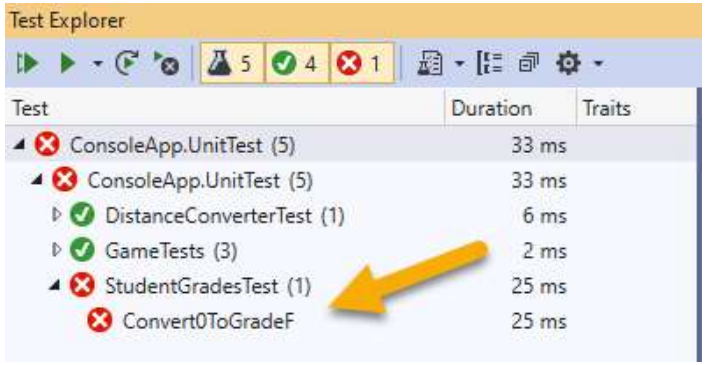
```
[TestClass]
0 references
public class StudentGradesTest
{
    private readonly StudentGrades
        studentGrades = new StudentGrades();
```

Create a new Test Class

Add a test for each grade boundary (10 tests)

```
public void Convert0ToGradeF()
{
    // Arrange
    Grade expectedGrade = Grade.F;

    // Act
    Grade actualGrade = studentGrades.ConvertToGrade(0);

    // Assert
    Assert.AreEqual(expectedGrade, actualGrade);
}
```

Add Test which fails

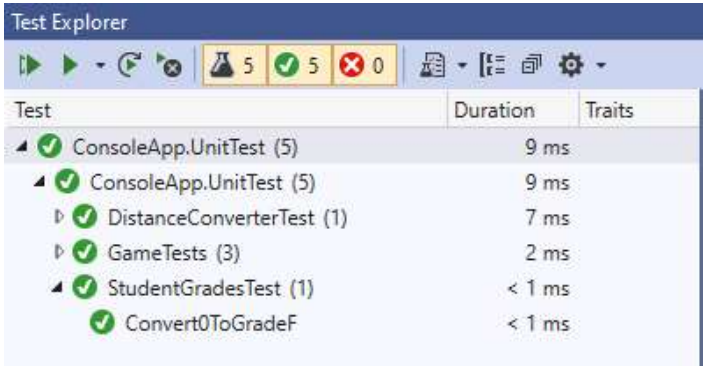


Convert0ToGrade()

```
2 references | 0/1 passing
public Grade ConvertToGrade(int mark)
{
    if (mark >= 0 && mark < 40)
    {
        return Grade.F;
    }
    else
    {
        return Grade.D;
    }
}
```

Add minimum code till the test passes

The **magic** numbers need to be replaced by constants



ConvertToGrade() - Refactored

Refactor magic numbers by using constants

```
7 references
public class StudentGrades
{
    public const int LowestMark = 0;
    public const int HighestMark = 100;

    public const int LowestGradeD = 40;
    public const int LowestGradeC = 50;
    public const int LowestGradeB = 60;
    public const int LowestGradeA = 70;
```

```
2 references | 1/1 passing
public Grade ConvertToGrade(int mark)
{
    if (mark >= LowestMark &&
        mark < LowestGradeD)
    {
        return Grade.F;
    }
    else
    {
        return Grade.D;
    }
}
```

Test Explorer

Test	Duration	Traits
ConsoleApp.UnitTest (5)	9 ms	
ConsoleApp.UnitTest (5)	9 ms	
DistanceConverterTest (1)	7 ms	
GameTests (3)	2 ms	
StudentGradesTest (1)	< 1 ms	
Convert0ToGradeF	< 1 ms	

TestCalculateMean()

```
[TestMethod]
| 0 references
public void TestCalculateMean()
{
    // Arrange

    int[] statsMarks = new int[]
    {
        10, 20, 30, 40, 50, 60, 70, 80, 90, 100
    };

    studentGrades.Marks = statsMarks;

    double expectedMean = 55.0;

    // Act

    studentGrades.CalculateStats();

    // Assert

    Assert.AreEqual(expectedMean, studentGrades.Mean);
}
```

No code exists so the test fails

```
3 references | 0/2 passing
public void CalculateStats()
{
    double total = 0;

    foreach(int mark in Marks)
    {
        total += mark;
    }

    Mean = total / Marks.Length;
}
```

TestCalculateMin()

```
[TestClass]
0 references
public class StudentGradesTest
{
    private readonly StudentGrades
        studentGrades = new StudentGrades();

    private readonly int[] StatsMarks = new int[]
    {
        10, 20, 30, 40, 50, 60, 70, 80, 90, 100
    };
```

```
public void TestCalculateMin()
{
    // Arrange
    studentGrades.Marks = StatsMarks;
    int expectedMin = 10;

    // Act
    studentGrades.CalculateStats();

    // Assert
    Assert.AreEqual(expectedMin, studentGrades.Minimum);
}
```

studentGrades and statsMarks moved so that they can be used by more than one test method

CalculateStats()

3 references | 3/3 passing

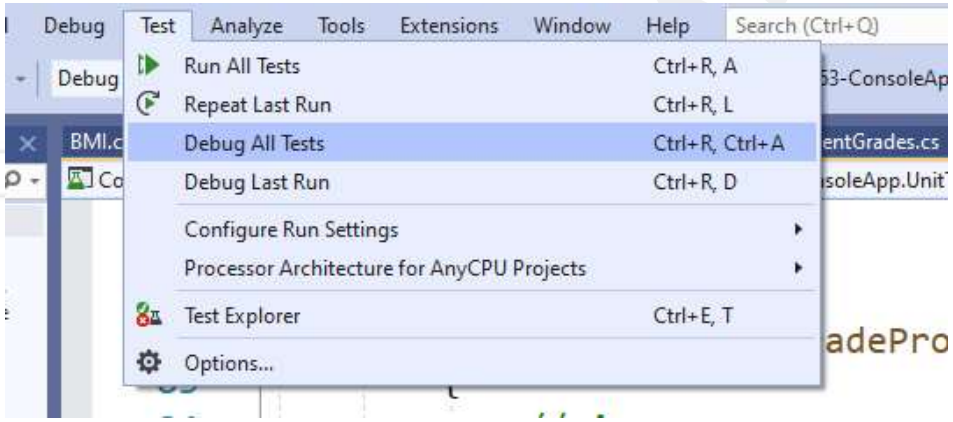
```
public void CalculateStats()
{
    Minimum = Marks[0];
    Maximum = Marks[0];

    double total = 0;

    foreach(int mark in Marks)
    {
        if (mark > Maximum) Maximum = mark;
        if (mark < Minimum) Minimum = mark;
        total += mark;
    }

    Mean = total / Marks.Length;
}
```

Code for Calculate Stats is added until it passes

Test	Duration	Traits
ConsoleApp.UnitTest (7)	12 ms	
ConsoleApp.UnitTest (7)	12 ms	
DistanceConverterTest (1)	8 ms	
GameTests (3)	3 ms	
StudentGradesTest (3)	1 ms	
Convert0ToGradeF	1 ms	
TestCalculateMean	< 1 ms	
TestCalculateMin	< 1 ms	

Debugging – Add a Breakpoint

```
117     public void CalculateStats()
118     {
119         Minimum = Marks[0];
120         Maximum = Marks[0];
121
122         double total = 0;
123
124         foreach(int mark in Marks)
125         {
126             if (mark > Maximum) Maximum = mark;
127             if (mark < Minimum) Minimum = mark;
128             total += mark;
129         }
130
131         Mean = total / Marks.Length;
132     }
```



Debugging – Inspecting variables

```
117         public void CalculateStats()
118         {
119             Minimum = Marks[0];
120             Maximum = Mark
121
122             double total = (
123
124             foreach(int mar  rks)
125             {
126                 if (mark > M  ) Maximum = mark;
127                 if (mark < Minimum) Minimum = mark;
128                 total += mark;
129             }
```

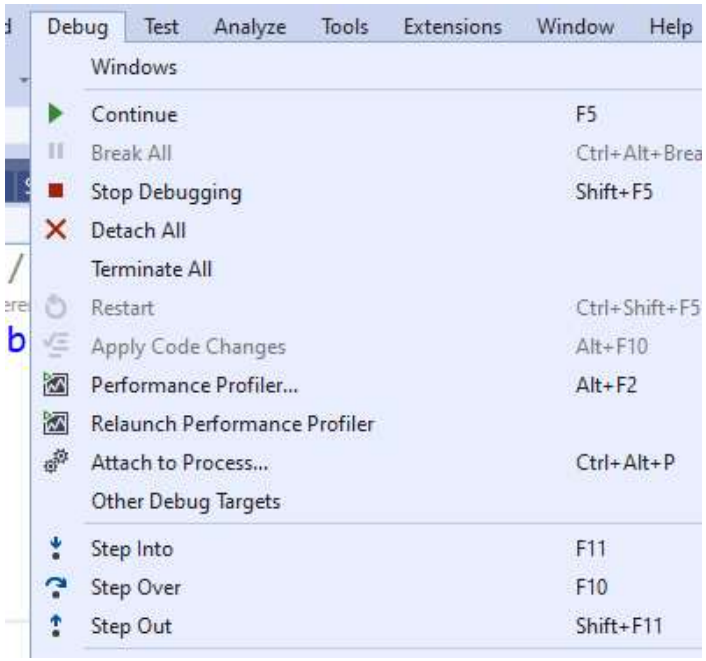
Marks	{int[10]}
[0]	10
[1]	20
[2]	30
[3]	40
[4]	50
[5]	60
[6]	70
[7]	80
[8]	90
[9]	100

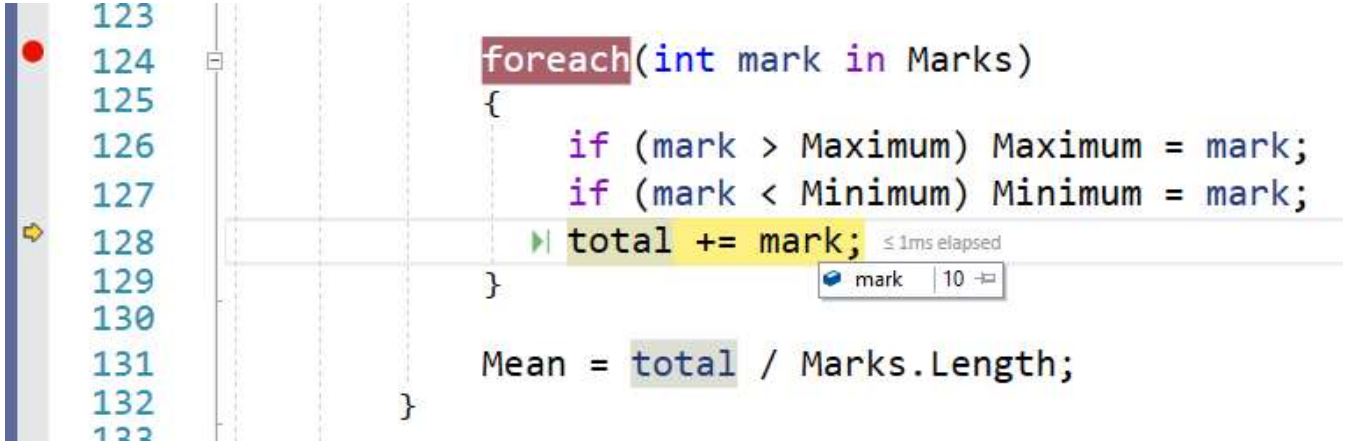
Locals

Search (Ctrl+E) Search Depth: 3

Name	Value
this	{CO453_Consol
Grade	X
GradeProfile	{int[7]}
Marks	{int[10]}
Maximum	10
Mean	0
Minimum	10
Students	{string[10]}
Static members	
total	0

Debugging – Stepping Over





TestCalculateGradeProfile

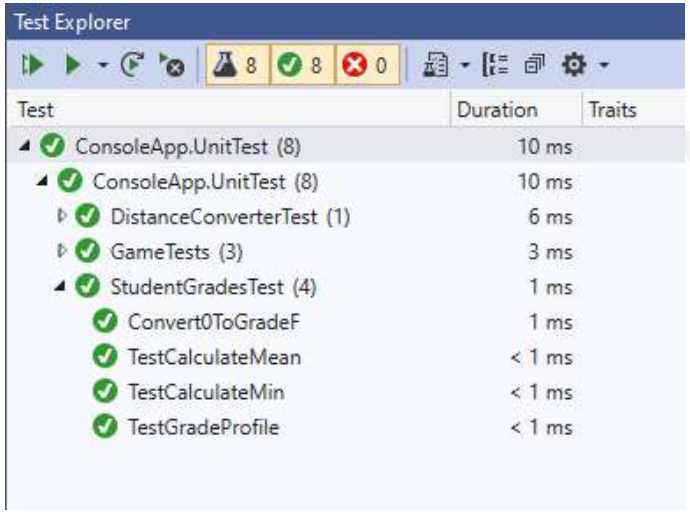
```
[TestClass]
0 references
public class StudentGradesTest
{
    private readonly StudentGrades
        studentGrades = new StudentGrades();

    private readonly int[] StatsMarks = new int[]
    {
        10, 20, 30, 40, 50, 60, 70, 80, 90, 100
    };
```

```
[TestMethod]
0 references
public void TestGradeProfile()
{
    // Arrange

    studentGrades.Marks = StatsMarks;
    bool expectedProfile = false;

    // Act
    studentGrades.CalculateGradeProfile();

    expectedProfile = ((studentGrades.GradeProfile[0] == 3) &&
                       (studentGrades.GradeProfile[1] == 1) &&
                       (studentGrades.GradeProfile[2] == 1) &&
                       (studentGrades.GradeProfile[3] == 1) &&
                       (studentGrades.GradeProfile[4] == 4));

    // Assert
    Assert.IsTrue(expectedProfile);
}
```

No code exists so the test fails

CalculateGradeProfile()

```
public void CalculateGradeProfile()
{
    for(int i = 0; i < GradeProfile.Length; i++)
    {
        GradeProfile[i] = 0;
    }

    foreach(int mark in Marks)
    {
        Grade grade = ConvertToGrade(mark);
        GradeProfile[(int)grade]++;
    }

    OutputGradeProfile();
}
```



The enumeration Grade is stored internally as an integer but still needs to be cast as an int

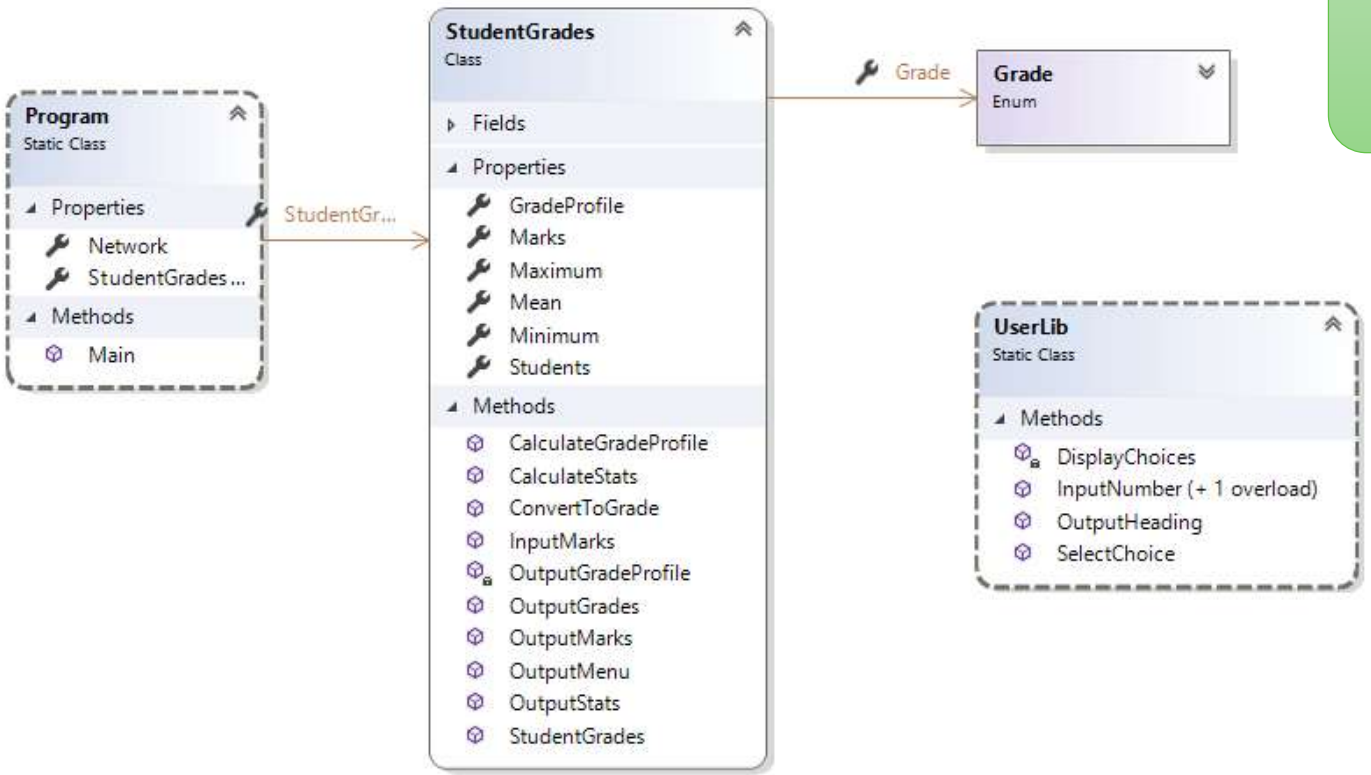
OutputGradeProfile()

```
private void OutputGradeProfile()
{
    Grade grade = Grade.X;
    Console.WriteLine();

    foreach(int count in GradeProfile)
    {
        int percentage = count * 100 / Marks.Length;
        Console.WriteLine($"Grade {grade} {percentage}% Count {count}");
        grade++;
    }

    Console.WriteLine();
}
```

Remaining methods involve user input and output that cannot be Unit Tested

Automated Testing records user input, but the tools are not available with community edition of Visual Studio

UML Class Diagram



Final Design

Independent Study

App01 Distance Converter

Finalized and Documented

App02 BMI Calculator

Finalized and Documented

App03 Student Grades

Complete the application methods to process student marks into grades and all unit tests