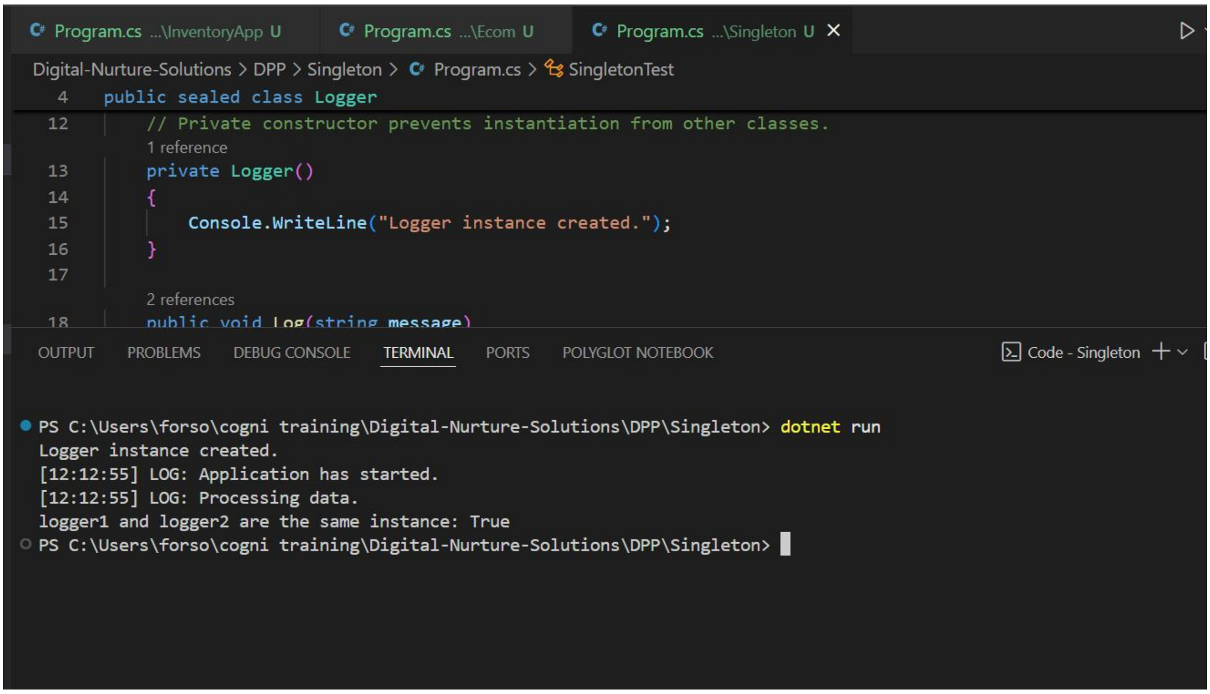
Exercise 1: Implementing the Singleton Pattern

Scenario:

You need to ensure that a logging utility class in your application has only one instance throughout the application lifecycle to ensure consistent logging.

OUTPUT:



CODE:

```
using System;

public sealed class Logger
{

    private static readonly Lazy<Logger> lazyInstance = new Lazy<Logger>(() =>
new Logger());

    public static Logger Instance => lazyInstance.Value;

    private Logger()
    {
        Console.WriteLine("Logger instance created.");
    }
```

```
    public void Log(string message)
    {
        Console.WriteLine($"[{DateTime.Now:HH:mm:ss}] LOG: {message}");
    }
}

public class SingletonTest
{
    public static void Main(string[] args)
    {
        Logger logger1 = Logger.Instance;
        logger1.Log("Application has started.");

        Logger logger2 = Logger.Instance;
        logger2.Log("Processing data.");

        Console.WriteLine($"logger1 and logger2 are the same instance: 
{object.ReferenceEquals(logger1, logger2)}");
    }
}
```

Exercise 2: Implementing the Factory Method Pattern

Scenario:

You are developing a document management system that needs to create different types of documents (e.g., Word, PDF, Excel). Use the Factory Method Pattern to achieve this.

OUTPUT:

```
OUTPUT    PROBLEMS    DEBUG CONSOLE    TERMINAL    PORTS    ...        powershell - Factory

PS C:\Users\forso\cogni training\week1-DPP-HOL\DPP\Factory> dotnet run
Document Management System using Factory Method Pattern
Choose document type:
1. Word Document
2. PDF Document
3. Excel Document
2
Opening PDF Document
Saving PDF Document
Printing PDF Document
Closing PDF Document
PS C:\Users\forso\cogni training\week1-DPP-HOL\DPP\Factory>
```

CODE:

```
// Exercise 2: Implementing the Factory Method Pattern
// Document Management System

using System;

// Step 2: Define Document Interfaces
public interface IDocument
{
    void Open();
    void Close();
    void Save();
    void Print();
}

// Step 3: Create Concrete Document Classes
public class WordDocument : IDocument
{
    public void Open()
    {
        Console.WriteLine("Opening Word Document");
    }

    public void Close()
    {
        Console.WriteLine("Closing Word Document");
    }

    public void Save()
    {
```

```
        Console.WriteLine("Saving Word Document");
    }

    public void Print()
    {
        Console.WriteLine("Printing Word Document");
    }
}

public class PdfDocument : IDocument
{
    public void Open()
    {
        Console.WriteLine("Opening PDF Document");
    }

    public void Close()
    {
        Console.WriteLine("Closing PDF Document");
    }

    public void Save()
    {
        Console.WriteLine("Saving PDF Document");
    }

    public void Print()
    {
        Console.WriteLine("Printing PDF Document");
    }
}

public class ExcelDocument : IDocument
{
    public void Open()
    {
        Console.WriteLine("Opening Excel Document");
    }

    public void Close()
    {
        Console.WriteLine("Closing Excel Document");
    }

    public void Save()
    {
        Console.WriteLine("Saving Excel Document");
    }
```

```
    public void Print()
    {
        Console.WriteLine("Printing Excel Document");
    }
}

// Step 4: Implement the Factory Method
public abstract class DocumentFactory
{
    public abstract IDocument CreateDocument();
}

public class WordDocumentFactory : DocumentFactory
{
    public override IDocument CreateDocument()
    {
        return new WordDocument();
    }
}

public class PdfDocumentFactory : DocumentFactory
{
    public override IDocument CreateDocument()
    {
        return new PdfDocument();
    }
}

public class ExcelDocumentFactory : DocumentFactory
{
    public override IDocument CreateDocument()
    {
        return new ExcelDocument();
    }
}

// Step 5: Test the Factory Method Implementation
public class FactoryMethodPatternExample
{
    static void Main(string[] args)
    {
        Console.WriteLine("Document Management System using Factory Method
Pattern");
        Console.WriteLine("Choose document type:");
        Console.WriteLine("1. Word Document");
        Console.WriteLine("2. PDF Document");
        Console.WriteLine("3. Excel Document");
```

```
        int choice = int.Parse(Console.ReadLine());
        DocumentFactory factory = null;

        switch (choice)
        {
            case 1:
                factory = new WordDocumentFactory();
                break;
            case 2:
                factory = new PdfDocumentFactory();
                break;
            case 3:
                factory = new ExcelDocumentFactory();
                break;
            default:
                Console.WriteLine("Invalid choice!");
                return;
        }

        IDocument document = factory.CreateDocument();
        document.Open();
        document.Save();
        document.Print();
        document.Close();

        Console.ReadKey();
    }
}
```

Exercise 2: E-commerce Platform Search Function

Scenario:

You are working on the search functionality of an e-commerce platform. The search needs to be optimized for fast performance.

OUTPUT:

```
OUTPUT   PROBLEMS   DEBUG CONSOLE   TERMINAL   PORTS   POLYGLOT NOTEBOOK          dotnet - Ecom

PS C:\Users\forso\cogni training\week1-DPP-HOL\DSA\Ecom> dotnet run
C:\Users\forso\cogni training\week1-DPP-HOL\DSA\Ecom\Program.cs(117,38): warning CS8604: Possible null reference argument for parameter 's' in 'int int.Parse(string s)'.
E-commerce Platform Search Function
Understanding Asymptotic Notation and Search Algorithms

Product List:
ID: 1, Name: Laptop, Category: Electronics, Price: $999.99
ID: 2, Name: Smartphone, Category: Electronics, Price: $699.99
ID: 3, Name: Headphones, Category: Electronics, Price: $149.99
ID: 4, Name: T-shirt, Category: Clothing, Price: $19.99
ID: 5, Name: Jeans, Category: Clothing, Price: $49.99
ID: 6, Name: Sneakers, Category: Footwear, Price: $89.99
ID: 7, Name: Watch, Category: Accessories, Price: $199.99
ID: 8, Name: Backpack, Category: Accessories, Price: $59.99
ID: 9, Name: Book, Category: Books, Price: $12.99
ID: 10, Name: Tablet, Category: Electronics, Price: $349.99

=== Linear Search Demo ===
Enter a product ID to search: 7
Product found at index 6: ID: 7, Name: Watch, Category: Accessories, Price: $199.99
Linear search took 3451 ticks

=== Binary Search Demo ===
Product not found.
Binary search took 3937 ticks

=== Time Complexity Analysis ===
Linear Search: O(n) - Must check each element in the worst case
Binary Search: O(log n) - Divides search space in half each time

Binary search is more efficient for large datasets, but requires sorted data.
Linear search works on unsorted data and is simpler to implement.
For small datasets, the difference in performance is negligible.
For our e-commerce platform with potentially millions of products,
binary search would be more suitable for ID-based searches on indexed fields.
```

CODE:

```csharp
// Exercise 3: E-commerce Platform Search Function
// Search Algorithms Implementation

using System;
using System.Collections.Generic;
using System.Diagnostics;

namespace EcommerceSearchFunction
{
    // Product class with attributes for searching
    public class Product
    {
        public int ProductId { get; set; }
        public string ProductName { get; set; }
        public string Category { get; set; }
        public decimal Price { get; set; }
```

```
        public Product(int id, string name, string category, decimal price)
        {
            ProductId = id;
            ProductName = name;
            Category = category;
            Price = price;
        }

        public override string ToString()
        {
            return $"ID: {ProductId}, Name: {ProductName}, Category: 
{Category}, Price: ${Price}";
        }
    }

    public class SearchAlgorithms
    {
        // Linear search implementation
        public static int LinearSearch<T>(T[] array, Predicate<T> match)
        {
            for (int i = 0; i < array.Length; i++)
            {
                if (match(array[i]))
                {
                    return i;
                }
            }
            return -1; // Not found
        }

        // Binary search implementation (requires sorted array)
        public static int BinarySearch<T>(T[] sortedArray, Predicate<T> match, 
Func<T, T, int> compare)
        {
            int left = 0;
            int right = sortedArray.Length - 1;

            while (left <= right)
            {
                int mid = (left + right) / 2;

                if (match(sortedArray[mid]))
                {
                    return mid;
                }

                // Assuming sortedArray[0] is the smallest value
                T midValue = sortedArray[mid];
```

```
                if (compare(midValue, sortedArray[0]) < 0)
                {
                    right = mid - 1;
                }
                else
                {
                    left = mid + 1;
                }
            }

            return -1; // Not found
        }
    }

    public class Program
    {
        static void Main(string[] args)
        {
            Console.WriteLine("E-commerce Platform Search Function");
            Console.WriteLine("Understanding Asymptotic Notation and Search
Algorithms");

            // Create a list of products
            List<Product> products = new List<Product>
            {
                new Product(1, "Laptop", "Electronics", 999.99m),
                new Product(2, "Smartphone", "Electronics", 699.99m),
                new Product(3, "Headphones", "Electronics", 149.99m),
                new Product(4, "T-shirt", "Clothing", 19.99m),
                new Product(5, "Jeans", "Clothing", 49.99m),
                new Product(6, "Sneakers", "Footwear", 89.99m),
                new Product(7, "Watch", "Accessories", 199.99m),
                new Product(8, "Backpack", "Accessories", 59.99m),
                new Product(9, "Book", "Books", 12.99m),
                new Product(10, "Tablet", "Electronics", 349.99m)
            };

            // Convert to array for search algorithms
            Product[] productArray = products.ToArray();

            // Sorted array by ProductId for binary search
            Product[] sortedByIdArray = new Product[productArray.Length];
            Array.Copy(productArray, sortedByIdArray, productArray.Length);
            Array.Sort(sortedByIdArray, (p1, p2) =>
p1.ProductId.CompareTo(p2.ProductId));

            Console.WriteLine("\nProduct List:");
            foreach (var product in productArray)
```

```
            {
                Console.WriteLine(product);
            }

            // Demo: Linear Search
            Console.WriteLine("\n=== Linear Search Demo ===");
            Console.Write("Enter a product ID to search: ");
            int searchId = int.Parse(Console.ReadLine());

            Stopwatch stopwatch = new Stopwatch();
            stopwatch.Start();
            int linearResult = SearchAlgorithms.LinearSearch(productArray, p
=> ((Product)p).ProductId == searchId);
            stopwatch.Stop();

            if (linearResult != -1)
            {
                Console.WriteLine($"Product found at index {linearResult}:
{productArray[linearResult]}");
            }
            else
            {
                Console.WriteLine("Product not found.");
            }
            Console.WriteLine($"Linear search took {stopwatch.ElapsedTicks}
ticks");

            // Demo: Binary Search
            Console.WriteLine("\n=== Binary Search Demo ===");
            stopwatch.Restart();
            int binaryResult = SearchAlgorithms.BinarySearch(
                sortedByIdArray,
                p => ((Product)p).ProductId == searchId,
                (p1, p2) =>
((Product)p1).ProductId.CompareTo(((Product)p2).ProductId)
            );
            stopwatch.Stop();

            if (binaryResult != -1)
            {
                Console.WriteLine($"Product found at index {binaryResult}:
{sortedByIdArray[binaryResult]}");
            }
            else
            {
                Console.WriteLine("Product not found.");
            }
```

```
            Console.WriteLine($"Binary search took {stopwatch.ElapsedTicks}
ticks");

            // Analysis
            Console.WriteLine("\n=== Time Complexity Analysis ===");
            Console.WriteLine("Linear Search: O(n) - Must check each element
in the worst case");
            Console.WriteLine("Binary Search: O(log n) - Divides search space
in half each time");
            Console.WriteLine("\nBinary search is more efficient for large
datasets, but requires sorted data.");
            Console.WriteLine("Linear search works on unsorted data and is
simpler to implement.");
            Console.WriteLine("For small datasets, the difference in
performance is negligible.");
            Console.WriteLine("For our e-commerce platform with potentially
millions of products,");
            Console.WriteLine("binary search would be more suitable for ID-
based searches on indexed fields.");

            Console.ReadKey();
        }
    }
}
```

Exercise 7: Financial Forecasting

Scenario:

You are developing a financial forecasting tool that predicts future values based on past data.

OUTPUT:

```
OUTPUT    PROBLEMS    DEBUG CONSOLE    TERMINAL    PORTS    POLYGLOT NOTEBOOK

PS C:\Users\forso\cogni training\week1-DPP-HOL\DSA\FinForecast> dotnet run
Financial Forecasting Tool
==========================

Initial Investment: $10000.00
Annual Growth Rate: 5.00%
Forecast Period: 10 years

Calculating future values using different methods...

Simple Recursive Method:
Future Value after 10 years: $16,288.95
Calculation time: 9491 ticks

Optimized Recursive Method (with memoization):
Future Value after 10 years: $16,288.95
Calculation time: 74011 ticks

Iterative Method:
Future Value after 10 years: $16,288.95
Calculation time: 3801 ticks

Variable Growth Rate Method:
Future Value with variable growth rates: $15,976.51

Method with Monthly Investments ($100.00/month):

Optimized Recursive Method (with memoization):
Future Value after 10 years: $16,288.95
Calculation time: 74011 ticks

Iterative Method:
Future Value after 10 years: $16,288.95
Calculation time: 3801 ticks

Variable Growth Rate Method:
Future Value with variable growth rates: $15,976.51
```

```
Method with Monthly Investments ($100.00/month):
Future Value with variable growth rates: $15,976.51

Method with Monthly Investments ($100.00/month):
Method with Monthly Investments ($100.00/month):
Future Value after 10 years: $31,998.32

=== Time Complexity Analysis ===
Simple Recursive Method: O(n) - Linear time complexity
  - Each call depends on the result of the previous call
  - Creates a call stack of depth n (periods)
  - Risk of stack overflow for large n

Memoized Recursive Method: O(n) - Linear time complexity with space optimization
  - Avoids redundant calculations by storing results
  - Uses additional O(n) memory for memoization table
  - Still creates a call stack but avoids recalculation

Iterative Method: O(n) - Linear time complexity
  - Same computational complexity as recursive methods
  - Constant space complexity (no call stack or memo table)
  - Generally more efficient in practice

Recommendation for optimizing recursive solutions:
1. Use memoization to avoid redundant calculations
2. Consider tail recursion when applicable
3. For simple growth formulas, iterative solutions may be more efficient
4. For complex models with variable inputs, recursion offers more flexibility
2
PS C:\Users\forso\cogni training\week1-DPP-HOL\DSA\FinForecast>
```

CODE:

```
// Exercise 7: Financial Forecasting
// Recursive algorithm to predict future values

using System;
using System.Collections.Generic;
using System.Diagnostics;

namespace FinancialForecasting
{
    public class FinancialForecast
    {
        // Simple recursive method to calculate future value with constant
growth rate
        public static decimal CalculateFutureValueRecursive(decimal
presentValue, decimal growthRate, int periods)
        {
            // Base case: when no periods left, return the present value
```

```
            if (periods == 0)
            {
                return presentValue;
            }

            // Recursive case: calculate future value based on previous period
            return CalculateFutureValueRecursive(presentValue, growthRate,
periods - 1) * (1 + growthRate);
        }

        // Optimized recursive method using memoization to avoid redundant
calculations
        public static decimal CalculateFutureValueMemoized(decimal
presentValue, decimal growthRate, int periods, Dictionary<int, decimal> memo =
null)
        {
            // Initialize memoization dictionary if not provided
            if (memo == null)
            {
                memo = new Dictionary<int, decimal>();
            }

            // If result is already calculated, return from memo
            if (memo.ContainsKey(periods))
            {
                return memo[periods];
            }

            // Base case: when no periods left, return the present value
            if (periods == 0)
            {
                return presentValue;
            }

            // Recursive case: calculate future value based on previous period
            decimal result = CalculateFutureValueMemoized(presentValue,
growthRate, periods - 1, memo) * (1 + growthRate);

            // Store result in memo for future use
            memo[periods] = result;

            return result;
        }

        // Iterative method for comparison
        public static decimal CalculateFutureValueIterative(decimal
presentValue, decimal growthRate, int periods)
        {
```

```
            decimal result = presentValue;
            for (int i = 0; i < periods; i++)
            {
                result *= (1 + growthRate);
            }
            return result;
        }

        // Advanced recursive forecasting with variable growth rates
        public static decimal CalculateFutureValueWithVariableGrowth(decimal
presentValue, decimal[] growthRates, int currentPeriod = 0)
        {
            // Base case: when we've applied all growth rates, return the
current value
            if (currentPeriod >= growthRates.Length)
            {
                return presentValue;
            }

            // Calculate value for current period
            decimal newValue = presentValue * (1 + growthRates[currentPeriod]);

            // Recurse for next period
            return CalculateFutureValueWithVariableGrowth(newValue,
growthRates, currentPeriod + 1);
        }

        // Recursive forecasting with additional investments
        public static decimal CalculateFutureValueWithInvestments(decimal
currentValue, decimal periodicInvestment, decimal growthRate, int
periodsRemaining)
        {
            // Base case: no more periods
            if (periodsRemaining == 0)
            {
                return currentValue;
            }

            // Calculate new value after growth and add investment
            decimal newValue = currentValue * (1 + growthRate) +
periodicInvestment;

            // Recurse for next period
            return CalculateFutureValueWithInvestments(newValue,
periodicInvestment, growthRate, periodsRemaining - 1);
        }
    }
```

```
    public class Program
    {
        static void Main(string[] args)
        {
            Console.WriteLine("Financial Forecasting Tool");
            Console.WriteLine("==========================\n");

            // Example initial values
            decimal initialValue = 10000.00m;
            decimal annualGrowthRate = 0.05m; // 5%
            int forecastYears = 10;

            Console.WriteLine($"Initial Investment: ${initialValue}");
            Console.WriteLine($"Annual Growth Rate: {annualGrowthRate *
100}%");
            Console.WriteLine($"Forecast Period: {forecastYears} years\n");

            // Measure performance of different methods
            Console.WriteLine("Calculating future values using different
methods...\n");

            Stopwatch stopwatch = new Stopwatch();

            // Test simple recursive method
            stopwatch.Start();
            decimal futureValueRecursive =
FinancialForecast.CalculateFutureValueRecursive(initialValue, annualGrowthRate,
forecastYears);
            stopwatch.Stop();
            Console.WriteLine($"Simple Recursive Method:");
            Console.WriteLine($"Future Value after {forecastYears} years:
${futureValueRecursive:N2}");
            Console.WriteLine($"Calculation time: {stopwatch.ElapsedTicks}
ticks");

            // Test memoized recursive method
            stopwatch.Restart();
            decimal futureValueMemoized =
FinancialForecast.CalculateFutureValueMemoized(initialValue, annualGrowthRate,
forecastYears);
            stopwatch.Stop();
            Console.WriteLine($"\nOptimized Recursive Method (with
memoization):");
            Console.WriteLine($"Future Value after {forecastYears} years:
${futureValueMemoized:N2}");
            Console.WriteLine($"Calculation time: {stopwatch.ElapsedTicks}
ticks");
```

```
            // Test iterative method
            stopwatch.Restart();
            decimal futureValueIterative =
FinancialForecast.CalculateFutureValueIterative(initialValue, annualGrowthRate,
forecastYears);
            stopwatch.Stop();
            Console.WriteLine($"\nIterative Method:");
            Console.WriteLine($"Future Value after {forecastYears} years:
${futureValueIterative:N2}");
            Console.WriteLine($"Calculation time: {stopwatch.ElapsedTicks}
ticks");

            // Example with variable growth rates
            decimal[] variableGrowthRates = { 0.03m, 0.04m, 0.05m, 0.045m,
0.05m, 0.055m, 0.06m, 0.055m, 0.05m, 0.045m };
            decimal futureValueVariableGrowth =
FinancialForecast.CalculateFutureValueWithVariableGrowth(initialValue,
variableGrowthRates);
            Console.WriteLine($"\nVariable Growth Rate Method:");
            Console.WriteLine($"Future Value with variable growth rates:
${futureValueVariableGrowth:N2}");

            // Example with additional investments
            decimal monthlyInvestment = 100.00m;
            decimal monthlyGrowthRate = annualGrowthRate / 12;
            int forecastMonths = forecastYears * 12;
            decimal futureValueWithInvestments =
FinancialForecast.CalculateFutureValueWithInvestments(initialValue,
monthlyInvestment, monthlyGrowthRate, forecastMonths);
            Console.WriteLine($"\nMethod with Monthly Investments
(${monthlyInvestment}/month):");
            Console.WriteLine($"Future Value after {forecastYears} years:
${futureValueWithInvestments:N2}");

            // Analysis
            Console.WriteLine("\n=== Time Complexity Analysis ===");
            Console.WriteLine("Simple Recursive Method: O(n) - Linear time
complexity");
            Console.WriteLine("  - Each call depends on the result of the
previous call");
            Console.WriteLine("  - Creates a call stack of depth n (periods)");
            Console.WriteLine("  - Risk of stack overflow for large n");
            Console.WriteLine("\nMemoized Recursive Method: O(n) - Linear time
complexity with space optimization");
            Console.WriteLine("  - Avoids redundant calculations by storing
results");
            Console.WriteLine("  - Uses additional O(n) memory for memoization
table");
```

```
            Console.WriteLine("  - Still creates a call stack but avoids 
recalculation");
            Console.WriteLine("\nIterative Method: O(n) - Linear time 
complexity");
            Console.WriteLine("  - Same computational complexity as recursive 
methods");
            Console.WriteLine("  - Constant space complexity (no call stack or 
memo table)");
            Console.WriteLine("  - Generally more efficient in practice");
            Console.WriteLine("\nRecommendation for optimizing recursive 
solutions:");
            Console.WriteLine("1. Use memoization to avoid redundant 
calculations");
            Console.WriteLine("2. Consider tail recursion when applicable");
            Console.WriteLine("3. For simple growth formulas, iterative 
solutions may be more efficient");
            Console.WriteLine("4. For complex models with variable inputs, 
recursion offers more flexibility");

            Console.ReadKey();
        }
    }
}
```