

Problem Solving

How to Design Algorithms and Solve Exam Problems?



SoftUni Team
Technical Trainers



SoftUni



Software University

<https://softuni.bg>

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#fund-common

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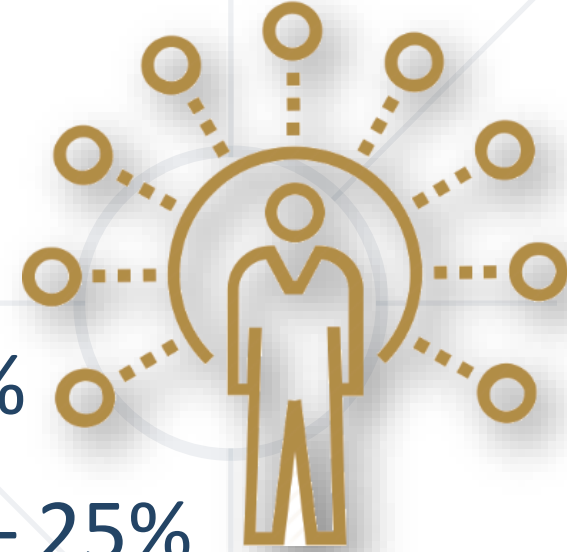
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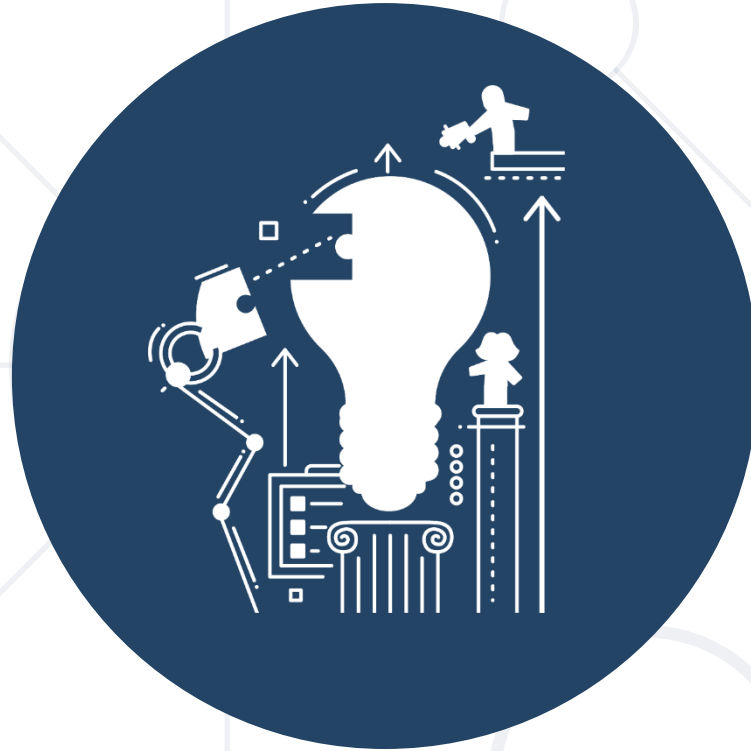
Fundamental Skills of Software Engineers

- 4 main **groups of tech skills**
 - **Coding** skills – 20%
 - Algorithmic thinking and **problem solving** – 30%
 - Fundamental software development **concepts** – 25%
 - Programming languages and software **technologies** – 25%



- **Algorithmic** (engineering, mathematical) **thinking**
 - The ability to analyze problems and find solutions
 - Breaking the problem down to steps (algorithm)
- How to develop algorithmic thinking?
 - Solve 1000+ programming problems
 - It takes 6 to 12 months of coding every day
- Courses in **SoftUni**: Programming Basics, Fundamentals and Advanced Modules
- The programming language doesn't matter!





Tech Problems: Definition and Problem Solving

What is a Tech Problem?



- **Definition** – an **assignment** to design and implement a program, app or software system
 - **Input** data + state, **output** data + state, behavior
- **Goals** – functionality you wish to **implement**
 - Calculate the **output** / implement the behavior
- **Technical difficulties** – barriers, obstacles and limitations to implement the app
 - Technical knowledge, skills and experience

Solving a Problem

- Requires a logical thinking (**algorithmic thinking**)
 - **Define** the problem (software requirements)
 - **Analyse** and understand the problem
 - **Identify** potential solutions (ideas)
 - **Evaluate** and choose a solution (try and test)
 - **Plan** actions (algorithm design)
 - **Implement** the algorithm (coding)
 - **Review** the results (testing)



Tech Problem-Solving Skills

- Software developers have strong **problem-solving skills**
 - The ability to **think logically** and solve tech problems
 - Math thinking / engineering thinking
 - The ability **analyze** problems and propose **solutions**
 - To design **algorithms** and to implement them
 - **Algorithm** == steps to achieve something
- **Problem-solving** is essential for programming!
 - Solving math / physics problems at school requires similar problem-solving skills





Solving Exam Problems

Tips and Best Practices

Read and Analyze the Problems

- You are at your "Programming Fundamentals" practical exam
 - You have **3 problems** to solve in **4 hours**
- First **read all the problems** carefully and try to estimate how difficult each one of them is (from your perspective)
 - Read the **requirements**, don't invent them!
- Start solving the **easiest / fastest** to solve problem **first!**
 - Leave the most **difficult / slowest** to solve problem **last!**
 - Approach the next problem when the previous is well tested

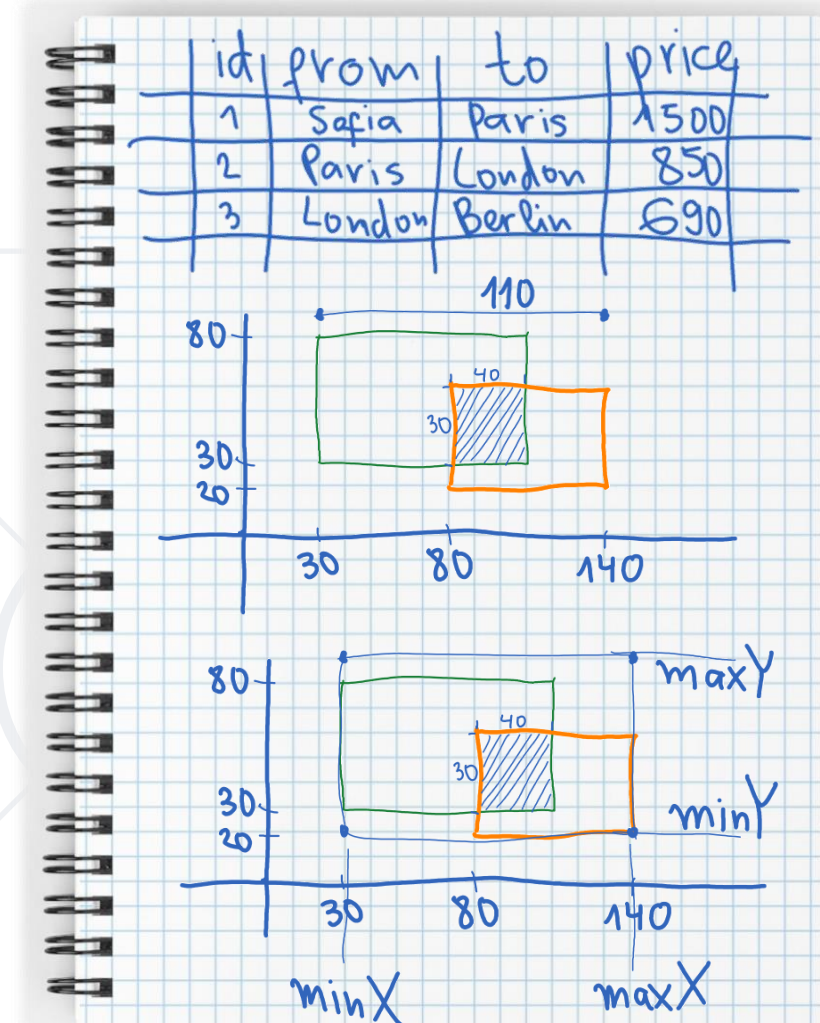
Use a Sheet of Paper and a Pen

- Never start solving a problem without a **sheet of paper + a pen**
 - You need to **sketch your ideas**
 - Paper and pen is the best **visualization tool**
 - Allows your brain to **think visually**
 - **Paper works faster** than keyboard / screen
 - Other visualization tools could also work well



Prefer Squared Paper

- Squared paper works **best for algorithmic problems**
 - Easy to draw a table
 - Easy to draw a coordinate system with objects in it
 - Easy to calculate distances
 - Easy to sketch a problem and solution ideas
- Use pens of different colors



- At the exam you have **limited time**!
 - Start with the problem, which will take you the **least time**
 - Then, again the problem, which will take you the **least time**
- When you achieve a result of 80/100 or 90/100
 - Think carefully for the **edge cases** → try to handle them
 - After you spend **10-15 minutes** on the last few tests, stop!
- **Don't spend hours** for the last 10% of the tests!
 - Achieving a score of 80-90% of 3 problems is better than 100% of just 1 problem

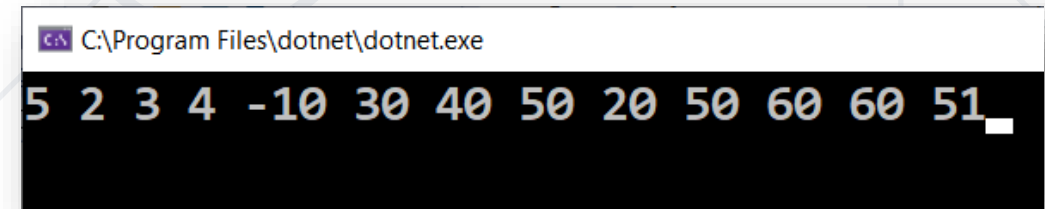
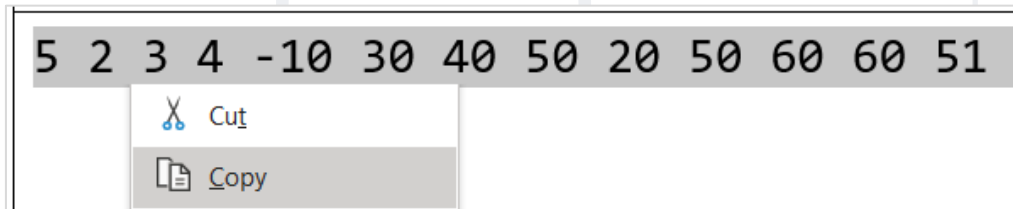
- **Wrong approach #1:** start coding at the first 5 minutes
 - These students have not read the problems (and will fail)
 - They don't start with the easiest problem, but with the first one
- **Wrong approach #2:** don't use pen + paper
 - These students try to invent solutions in their minds
 - Instead of visualizing their ideas on a sheet of paper
- **Wrong approach #3:** debugging in your mind
 - Trying to find the bugs by reading the code
 - This is wrong: you have a debugger in your IDE!

- **Wrong approach #4:** spend all the time at the first problem
 - Some students spend 4 hours at the first problem
 - This is wrong: when you spend 1 hour at certain problem, without a significant progress → go to the next problem!
 - You can go back to the first problem, after you solve the others
- **Wrong approach #5:** spend hours trying to fix a bug
 - Some students spend hours to move from 90% to 100% for the first problem and never start the next problem
 - Move on the next problem shortly after you reach 70%-90% of the score!

- **Wrong approach #6:** don't take a break, when you block
 - Everyone can block, get nervous, or become distracted
 - Take a short break, go outside, breathe, calm down
- **Wrong approach #7:** come to the exam unprepared
 - Prepare yourself, study hard, practice a lot, solve sample exams
 - You are ready, when you can solve any previous exam for 1-2 hours
- **Wrong approach #8:** trying to cheat
 - Many students try to cheat (e.g. use help from friends)
 - Cheating is bad for you! Who will do your future job?

Typical Mistakes at the Exam

- **Wrong approach #9:** working without a mouse
 - Use the mouse, not a touchpad!
 - Mouse works more precisely
 - Mouse saves time and effort
- **Wrong approach #10:** typing the sample input examples by hand
 - Use copy/paste for the input examples!





Sample Exam Problems

Following the Best Practices

Tech Problem: Longest Palindrome Sub-List

- We are given a **list of letters**
 - We want to find the longest sub-list, which is a **palindrome** (reads the same backward as forward)

■ Examples:

a	b	b	a	b	b	x	b	a
---	---	---	---	---	---	---	---	---

 → 5

a	b	b	a
---	---	---	---

 → 4

a	b	c	c	d
---	---	---	---	---

 → 2

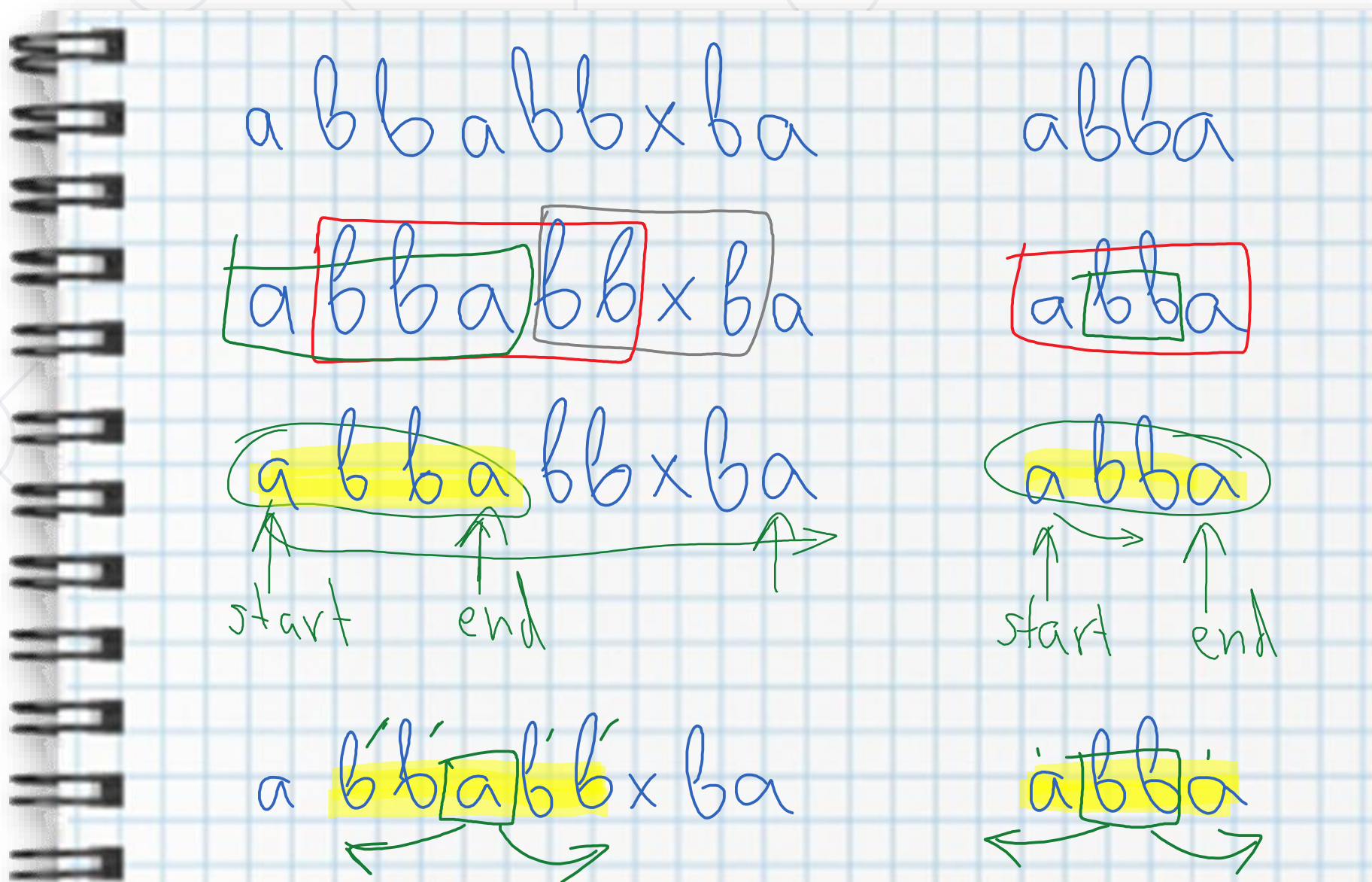
a	h	c	h	x	x	u
---	---	---	---	---	---	---

 → 3

a	h	c	h	x	x	h
---	---	---	---	---	---	---

 → 4

Take a Pen and Paper and Visualize Ideas



Longest Palindrome Sub-List: Analysis

- Problem analysis: 2 types of palindromes

- **Odd-length** (single letter at the center)



- **Even-length** (two letters at the center)



Largest Palindrome Sub-List: Solutions

- **Potential solutions:**

a	b	c	c	d
---	---	---	---	---

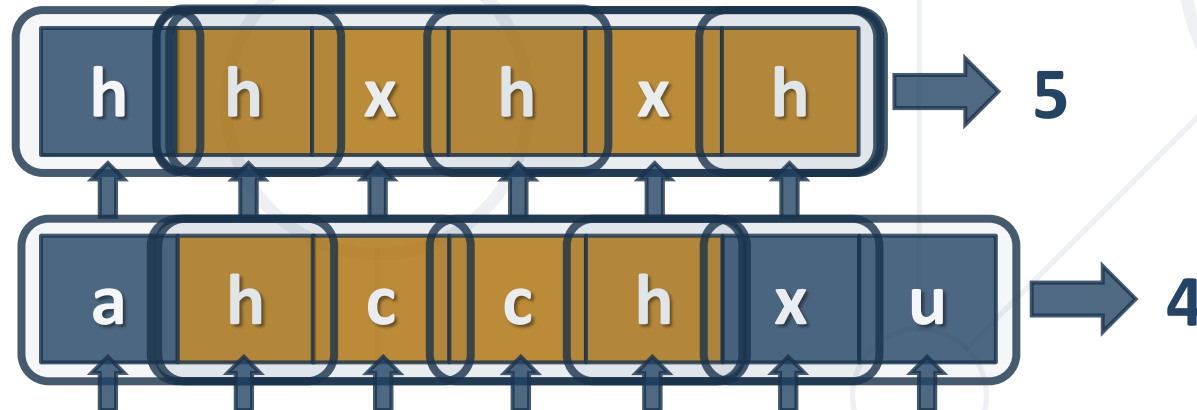
 $\rightarrow 2$

b	c	d	c
---	---	---	---

 $\rightarrow 3$
 1. Find **all possible start + end positions** and check for palindrome
 2. Find **all possible single central points** and **double central points** and check for palindrome around them
 3. Find all sub-lists of size **n** (the length of the input list), then of size **n-1, n-2, ..., 1** and check for palindrome each sub-list
- Can we find the length of the longest palindrome without checking all palindromes in the list? \rightarrow Yes, solution #3
- Which is the **most efficient solution**? \rightarrow solution #2

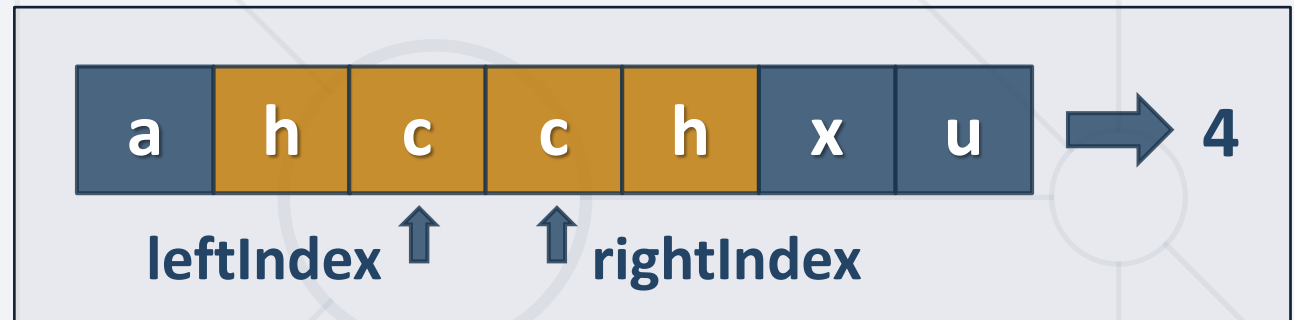
Largest Palindrome Sub-List: Algorithm

- **Algorithm** (sequence of steps) for solution #2:
 - Choose **each letter as central point** and count how many letters around it form a palindrome
 - Choose **each two consecutive equal letters as central point** and count how many letters around them form a palindrome
 - Choose **the longest** among all palindromes found



Largest Palindrome Sub-List: Implementation

```
int PalindromeLen(int leftIndex, int rightIndex)
{
    while (leftIndex > 0 && rightIndex < letters.Length
        && letters[leftIndex] == letters[rightIndex])
    {
        leftIndex--;
        rightIndex++;
    }
    return rightIndex - leftIndex - 1;
}
```



Largest Palindrome Sub-List: Implementation

```
string letters = Console.ReadLine();
int maxLen = 0;

// Check all single letter central points
for (var c = 1; c < letters.Length; c++)
    maxLen = Math.Max(maxLen, PalindromeLen(c, c));

// Check all double letter central points
for (var c = 1; c < letters.Length-1; c++)
    maxLen = Math.Max(maxLen, PalindromeLen(c, c+1));

Console.WriteLine(maxLen);
```

Submit to Judge

← → ↺

judge.softuni.bg/Contests/Practice/Index/2694#0

```
20     while (leftIndex > 0 && rightIndex < letters.Length
21           && letters[leftIndex] == letters[rightIndex])
22     {
23         leftIndex--;
24         rightIndex++;
25     }
26     return rightIndex - leftIndex - 1;
27 }
28
29 }
```

Allowed working time: 0.100 sec.
Allowed memory: 16.00 MB
Size limit: 16.00 KB
Checker: Numbers Checker ?

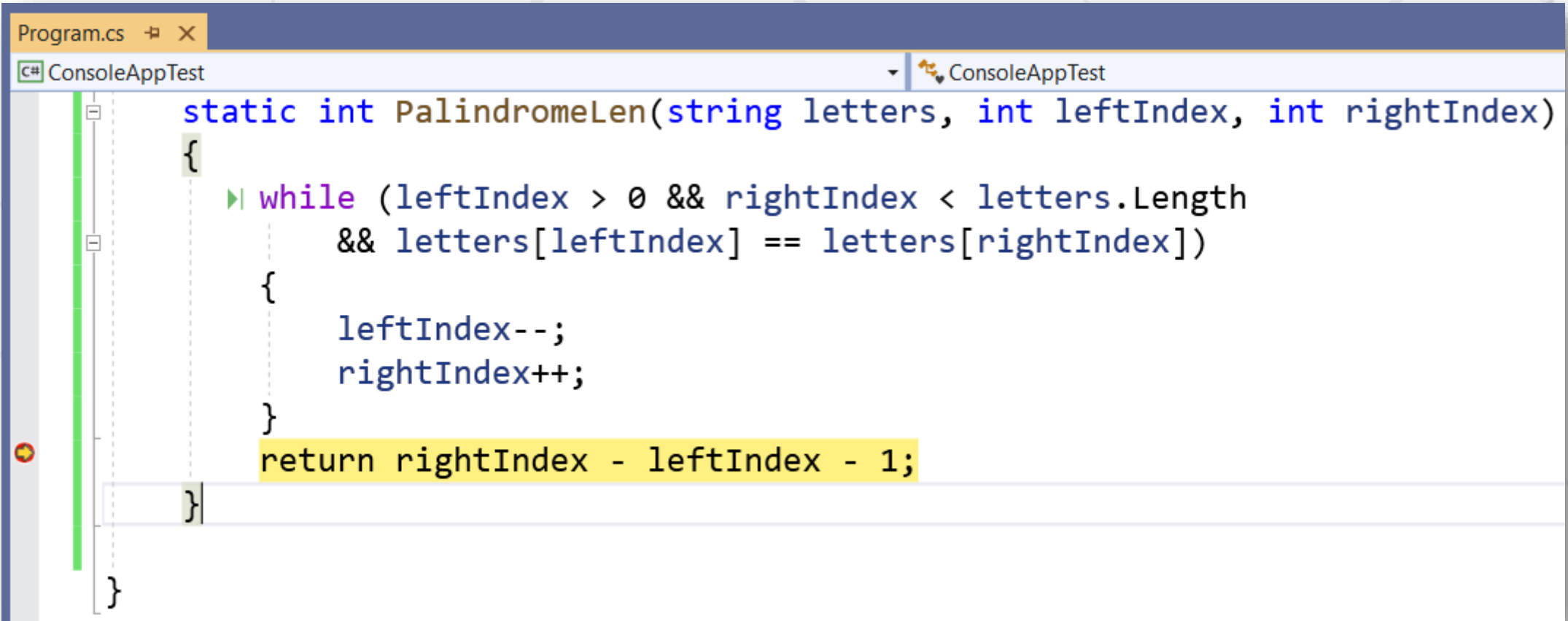
C# code Submit

Submissions		
<div>⏮ ⏪ 1 ⏩ ⏭</div>		
Points	Time and memory used	Submission date
✓✗✓✓✓✓✗✗✗ 60 / 100	Memory: 7.49 MB Time: 0.031 s	14:18:57 16.11.2020
<div>⏮ ⏪ 1 ⏩ ⏭</div>		

Details

Use the Debugger

- Use the debugger, with good input



The screenshot shows a C# code editor window titled "Program.cs" with a sub-window "ConsoleAppTest". The code defines a static method `PalindromeLen` that takes a string `letters` and two integers `leftIndex` and `rightIndex`. The method uses a `while` loop to compare characters from both ends of the string towards the center. A debugger breakpoint is set on the `return` statement, which is highlighted in yellow. The code is as follows:

```
static int PalindromeLen(string letters, int leftIndex, int rightIndex)
{
    while (leftIndex > 0 && rightIndex < letters.Length
        && letters[leftIndex] == letters[rightIndex])
    {
        leftIndex--;
        rightIndex++;
    }
    return rightIndex - leftIndex - 1;
}
```

```
int PalindromeLen(int leftIndex, int rightIndex)
{
    while (leftIndex >= 0 && rightIndex < letters.Length
           && letters[leftIndex] == letters[rightIndex])
    {
        leftIndex--;
        rightIndex++;
    }
    return rightIndex - leftIndex - 1;
}
```

90/100 → Go Ahead or Debug More?

← → ↻ judge.softuni.bg/Contests/Practice/Index/2694#0

```
20 while (leftIndex >= 0 && rightIndex < letters.Length
21     && letters[leftIndex] == letters[rightIndex])
22 {
23     leftIndex--;
24     rightIndex++;
25 }
26 return rightIndex - leftIndex - 1;
27 }
28
29 }
```

Allowed working time: 0.100 sec.
Allowed memory: 16.00 MB
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Checker: Numbers Checker ?

C# code Submit

Submissions			
◀ ◁ 1 ▷ ▶ ▶▶			
Points	Time and memory used	Submission date	
✓✓✓✓✓✓✓✓✓✓✗✓ 90 / 100	Memory: 7.49 MB Time: 0.031 s	14:21:29 16.11.2020	Details
✓✗✓✓✓✓✓✗✓✗✗ 60 / 100	Memory: 7.49 MB Time: 0.031 s	14:18:57 16.11.2020	Details

◀ ◁ 1 ▷ ▶ ▶▶

Another Bug Fix

```
string letters = Console.ReadLine();
int maxLen = 0;

// Check all single letter central points
for (var c = 0; c < letters.Length; c++)
    maxLen = Math.Max(maxLen, PalindromeLen(c, c));

// Check all double letter central points
for (var c = 0; c < letters.Length-1; c++)
    maxLen = Math.Max(maxLen, PalindromeLen(c, c+1));

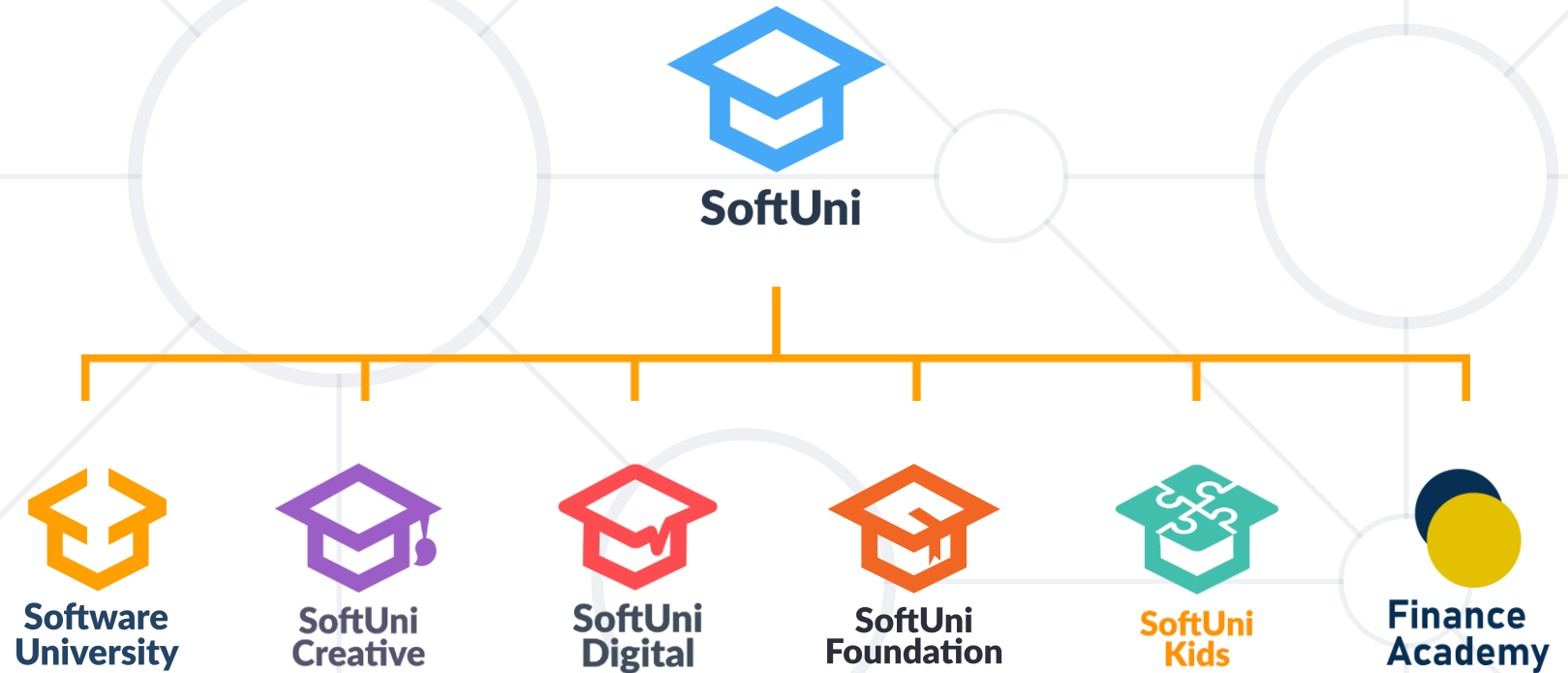
Console.WriteLine(maxLen);
```


- Review the results
 - Does this solution work well for all cases? Any edge cases?
- Tests, covering the edge cases:
 - abc, abcd, ab, a \rightarrow 1
 - aa, aa0, 0aa, 0aa1, xxaazz, 01aa234 \rightarrow 2
 - aaa, aaa0, 0aaa, 0aaa1, 012aaa34 \rightarrow 3
 - aaaa, abba, 0abba, xxxx0, 0abba1 \rightarrow 4
- Can we solve this problem better?

- The stages of **problem solving**
 - **Define** the problem (requirements)
 - **Analyze** the problem (deep understand)
 - Identify **potential solutions** (ideas)
 - Evaluate and choose the **best solution**
 - **Algorithm design** (action plan)
 - **Implement** and **review** results



Questions?



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