Lab 11 Report: Analyzing C# Console Games for Bugs

Course: CS202 Software Tools and Techniques for CSE
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1. Introduction, Setup, and Tools

Objective: Learn to use the Visual Studio debugger to understand control flow and locate/fix runtime bugs in C# console games.

Environment:

- **OS:** Windows 11
- **IDE:** Visual Studio 2022 Community Edition with .NET 6.0 SDK
- **Repository:** `dotnet-console-games` (cloned from GitHub) GitHub.
- **Language:** C# with top-level statements (no explicit `Main()` needed)

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2. Methodology and Execution

2.1 Cloning and Opening the Solution

```
git clone https://github.com/dotnet/dotnet-console-games.git
cd dotnet-console-games
```

- Open `dotnet-console-games.sln` in Visual Studio and allow NuGet package restore.

2.2 Selecting the "Gravity" Game Project

- In **Solution Explorer**, expand **Projects** → **Gravity**.
- Entry point is in `Program.cs` via **top-level statements** (compiler generates `Main()` automatically).

2.3 Debugger Basics

1. **Set a breakpoint** at the first game-loop statement in `Program.cs` by clicking the left margin.
2. **Start Debugging** (F5) to pause at your breakpoint.

3. Use **Step Into (F11)** to enter methods, **Step Over (F10)** to execute without entering, and **Step Out (Shift+F11)** to finish the current method and return.
4. Observe variable values by hovering over them or inspecting in the **Autos**/ **Locals** windows.

Note: All the Screenshots are attached to the end of the report in order.

2.4 Mutation Testing: Injecting Five Bugs

Above the main loop, we applied five separate mutations, each illustrating a distinct bug. For each, record:

- **What?** Behavior observed
- **When?** Execution point
- **Why?** Root cause
- **Where?** File and line number

Bug 1: Incorrect Starting Position

```
415 -   return (j + 2, i + 1);
415 +   return (j + 0, i + 0);
```

- **What?** Player spawns at the wrong coordinates.
- **When?** Game start, before rendering level.
- **Why?** Offset parameters changed from `(j+2, i+1)` to `(j, i)`.
- **Where?** `GetStartingPlayerPositionFromLevel()`, Program.cs, line 415.

Bug 2: Treating Spikes as Victory

```
638 - case 'X': gameState |= GameState.Died; break;
638 + case 'X': gameState |= GameState.Won; break;
```

- **What?** Colliding with spikes instantly wins the game.
- **When?** Collision detection loop.
- **Why?** `GameState.Won` used instead of `GameState.Died`.
- **Where?** Collision check in `Program.cs`, line 638.

Bug 3: Level Skipping on Win

```
669 -   level++;
669 +   level = level + 2;
```

- **What?** Pressing Enter after victory jumps two levels ahead.
- **When?** After `GameState.Won` branch, on level completion.
- **Why?** `level` increment mutated to add 2 instead of 1.
- **Where?** Win-handling block in `Program.cs`, line 669.

Bug 4: Rendering Out-of-Bounds Index

```
 if (c is not 'X' and not '●' &&
-     PlayerPosition.X - 2 <= j &&
-     PlayerPosition.X + 2 >= j &&
-     PlayerPosition.Y - 1 <= i &&
-     PlayerPosition.Y + 1 >= i)


 if (c is not 'X' and not '●' &&
+     PlayerPosition.X - 3 <= j &&
+     PlayerPosition.X + 3 >= j &&
+     PlayerPosition.Y - 2 <= i &&
+     PlayerPosition.Y + 2 >= i)
```

- **What?** `IndexOutOfRangeException` during render.
- **When?** In `Render()` when building `render` string.
- **Why?** Logical mutation removed Y-bounds check, causing invalid array access.
- **Where?** Rendering loop in `Program.cs`, line 717-720.

Bug 5: Overlapping Bit-flags for GameState

```
-   Died    = 1 << 0,
851 +   Died    = 1 << 1
-   Won     = 1 << 1
851 +   Won     = 1 << 1
```

- **What?** Died and Won share the same flag bit, making state ambiguous.
- **When?** Anywhere `gameState.HasFlag(..)` is tested.
- **Why?** Both enum values shifted by one bit rather than defining unique bits.
- **Where?** `enum GameState` in `Program.cs`, line 851.

2.5 Fixing and Verifying Bugs

For each bug:

1. **Revert** the diff to original correct code.
2. **Rebuild** (Ctrl+Shift+B) and **Run** (F5).
3. **Confirm** expected behavior: correct spawn, spikes kill, single-level increment, no exception, distinct win/die states.

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3. Results and Analysis

- **Bug 1 Fix:** Player now starts at intended offset (●) .
- **Bug 2 Fix:** Spikes correctly kill player, not win.
- **Bug 3 Fix:** Each win advances exactly one level.
- **Bug 4 Fix:** Render no longer throws `IndexOutOfRangeException`.
- **Bug 5 Fix:** `GameState.Died` and `GameState.Won` use distinct bits per [enum flags guidelines].

Key insight: systematic mutation testing quickly uncovers both logic and configuration errors .

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4. Discussion and Conclusion

Challenges: Precisely locating the rendering-bounds bug required careful stepping and call-stack inspection. **Lessons Learned:**

- Visual Studio's step commands (F10/F11/Shift+F11) are essential for understanding control flow Microsoft Learn .
- Mutation testing (even manual) is a powerful technique to stress-test code behavior Stryker Mutator.
- Proper use of bit-flags enums prevents unintended state overlap Aaron Bos' Blog.

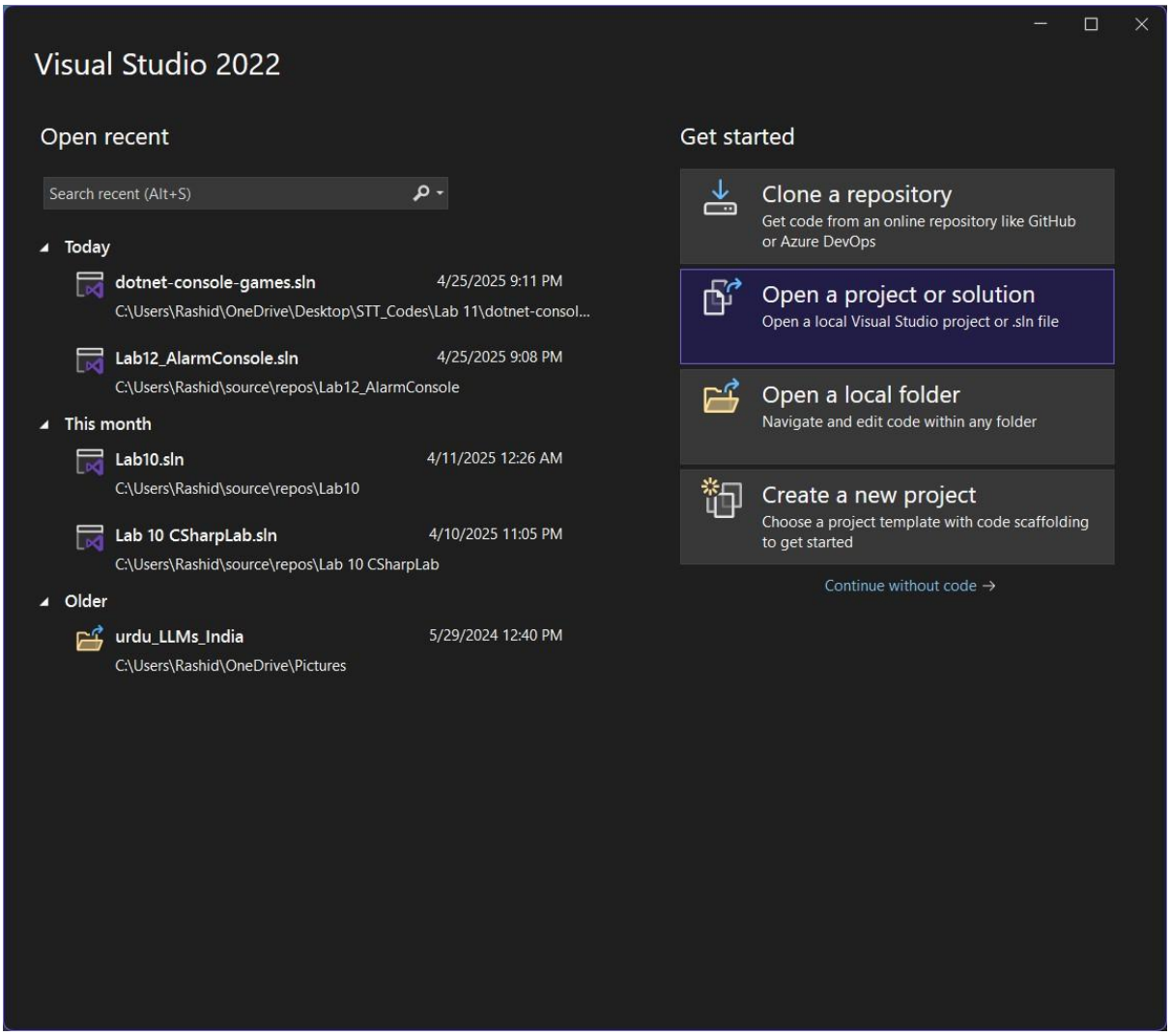
5. GitHub Repository

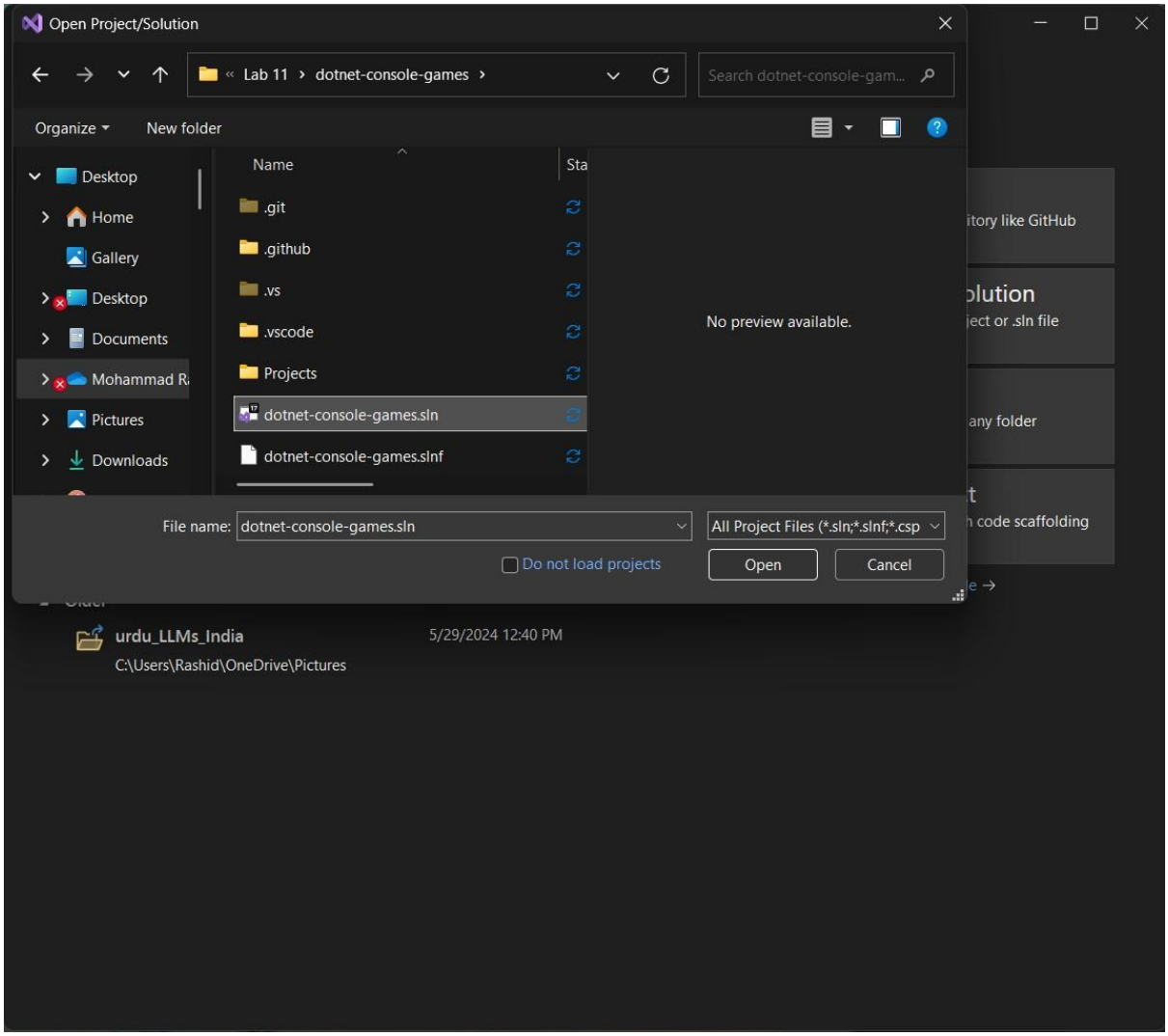
- All code files, the detailed report, and additional documentation can be found in my GitHub repository: https://github.com/Pathan-Mohammad-Rashid/STT_Labs.git
- *Onedrive Link: https://iitgnacin-my.sharepoint.com/:f:/g/personal/22110187_iitgn_ac_in/EnECtzFbUNZKkBWY6aa8QJYBp6liTXfpuYRtJNMd1TwR6A?e=nsND4y*

1. Lab 12: Environment Setup and Initialization

This section illustrates the initial setup process for Lab 12, including configuring the development environment and preparing the necessary files.

```
PS C:\Users\Rashid\OneDrive\Desktop\STT_Codes\Lab 11\lab11> git clone https://github.com/dotnet/dotnet-console-games.git
Cloning into 'dotnet-console-games'...
remote: Enumerating objects: 9991, done.
remote: Counting objects: 100% (99/99), done.
remote: Compressing objects: 100% (24/24), done.
remote: Total 9991 (delta 87), reused 75 (delta 75), pack-reused 9892 (from 2)
Receiving objects: 100% (9991/9991), 141.47 MiB | 7.77 MiB/s, done.
Resolving deltas:  65% (4384/6744)
Resolving deltas: 100% (6744/6744), done.
Updating files: 100% (661/661), done.
PS C:\Users\Rashid\OneDrive\Desktop\STT_Codes\Lab 11\lab11>
```




Open Project/Solution
Lab 11 › dotnet-console-games ›
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New folder
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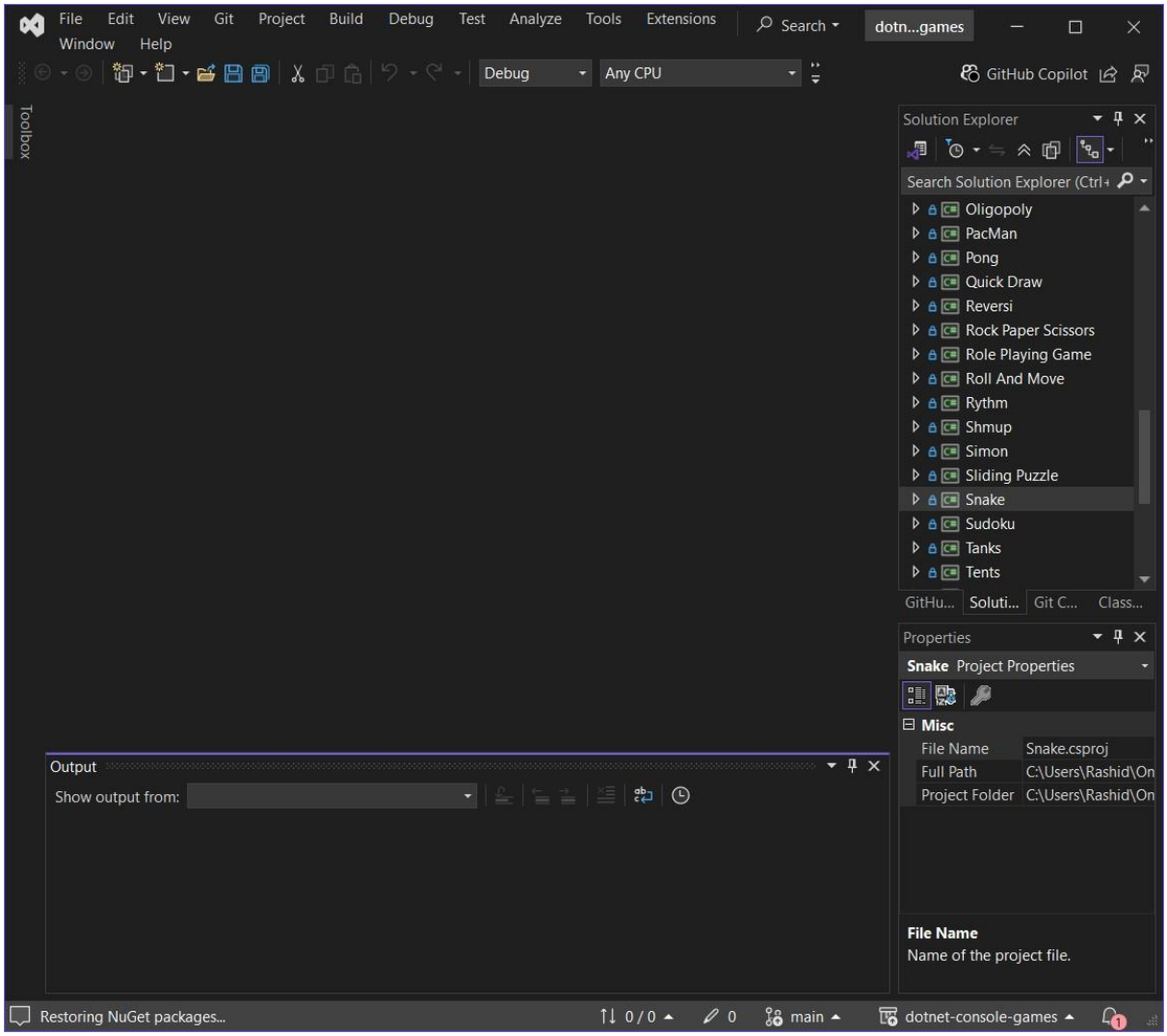
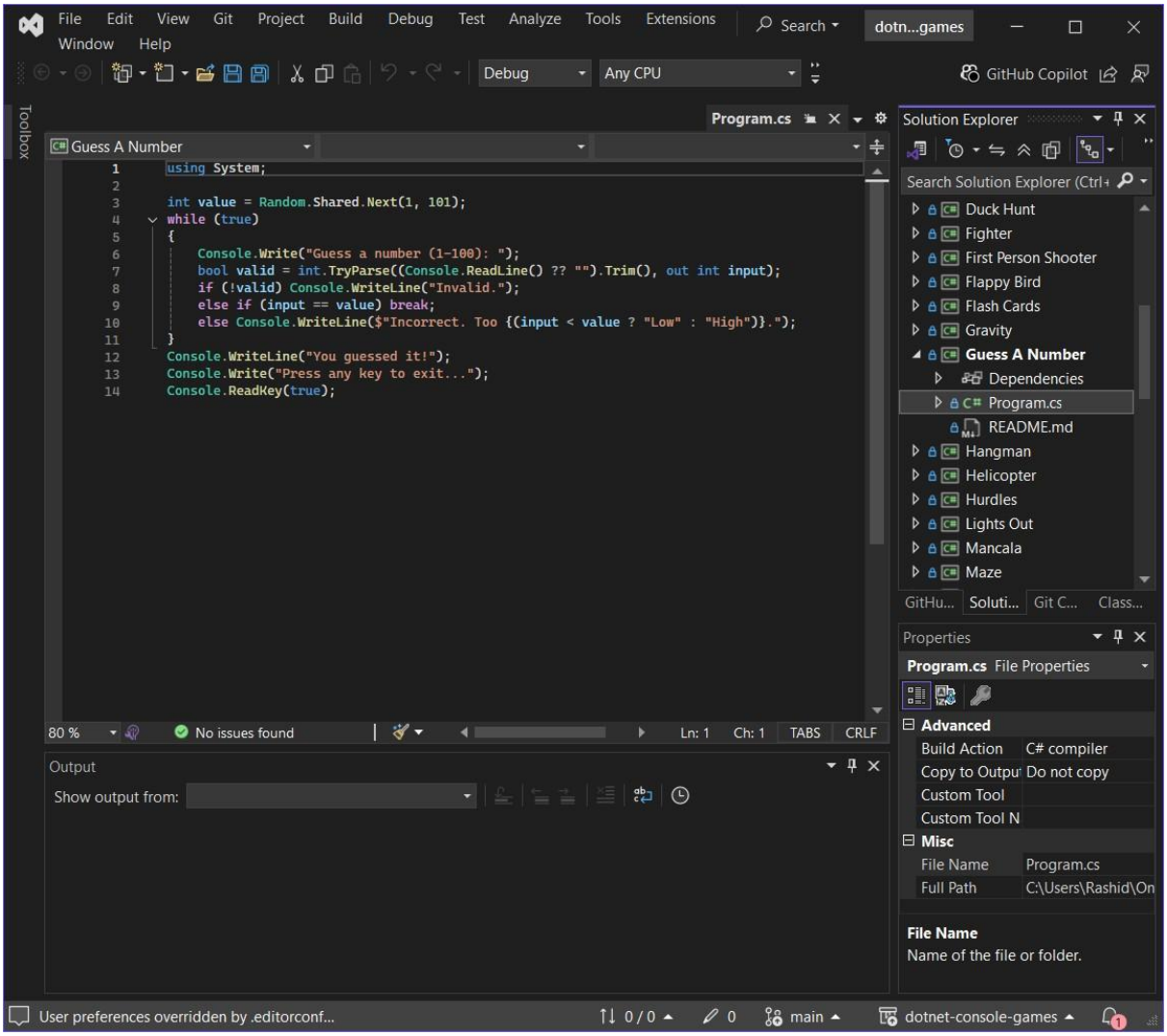


2. Game 1: Guess a Number
a. Standard Execution Demonstrates the normal flow of the game without debugging intervention.
b. Debugging with Breakpoints and Step Controls Showcases the use of breakpoints and debugging tools such as step into, step over, and step out for detailed code execution analysis.


File Edit View Git Project Build Debug Test Analyze Tools Extensions
Window Help
Search
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Program.cs
Guess A Number
using System;
int value = Random.Shared.Next(1, 101);
while (true)
{
Console.Write("Guess a number (1-100): ");
bool valid = int.TryParse((Console.ReadLine() ?? "").Trim(), out int input);
if (!valid) Console.WriteLine("Invalid.");
else if (input == value) break;
else Console.WriteLine($"Incorrect. Too {(input < value ? "Low" : "High")}.");
}
Console.WriteLine("You guessed it!");
Console.Write("Press any key to exit...");
Console.ReadKey(true);
80 %
No issues found
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Fighter
First Person Shooter
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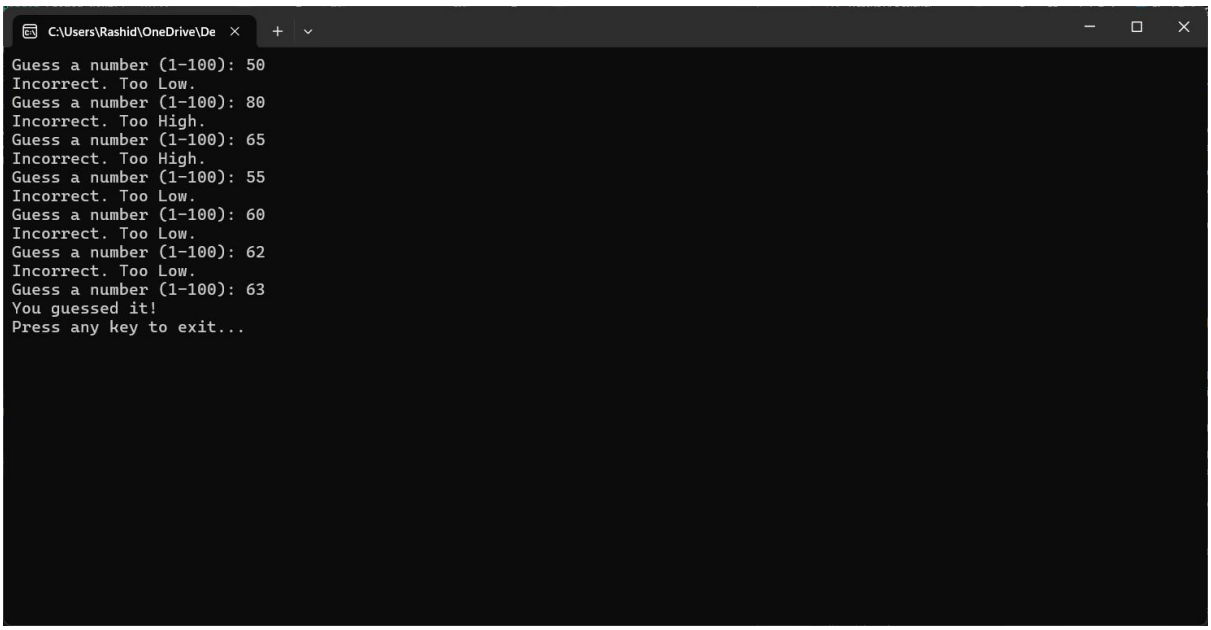
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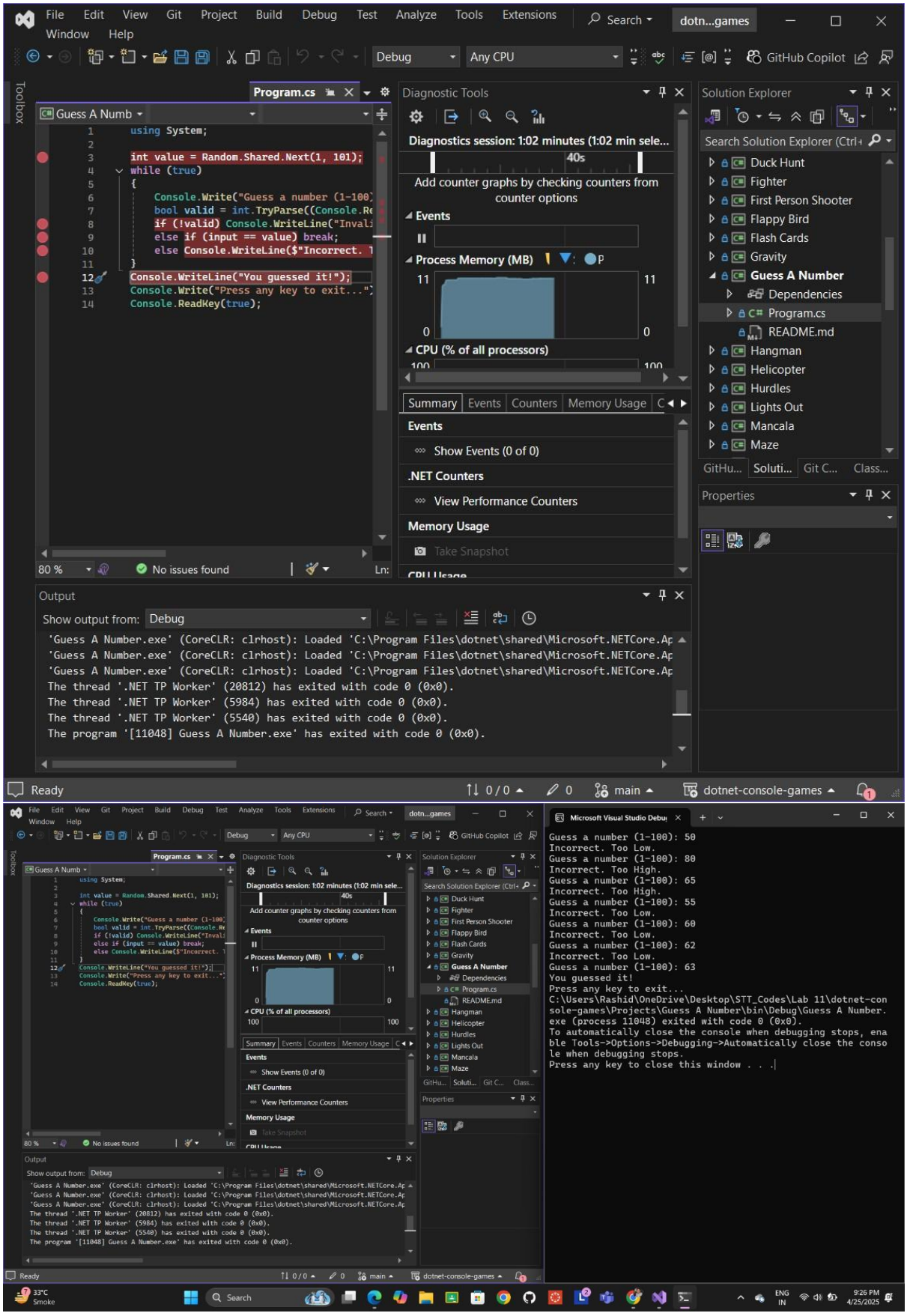
Guess a number (1-100): 50
Incorrect. Too Low.
Guess a number (1-100): 80
Incorrect. Too High.
Guess a number (1-100): 65
Incorrect. Too High.
Guess a number (1-100): 55
Incorrect. Too Low.
Guess a number (1-100): 60
Incorrect. Too Low.
Guess a number (1-100): 62
Incorrect. Too Low.
Guess a number (1-100): 63
You guessed it!
Press any key to exit...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using System;
int value = Random.Shared.Next(1, 101);
while (true)
{
Console.Write("Guess a number (1-100)
bool valid = int.TryParse((Console.Re
if (!valid) Console.WriteLine("Invali
else if (input == value) break;
else Console.WriteLine($"Incorrect.
}
Console.WriteLine("You guessed it!");
Console.Write("Press any key to exit...")
Console.ReadKey(true);
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Hangman
Helicopter
Hurdles
Lights Out
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Maze
Properties
Output
Show output from: Debug
'Guess A Number.exe' (CoreCLR: clrhost): Loaded 'C:\Program Files\dotnet\shared\Microsoft.NETCore.Ap
'Guess A Number.exe' (CoreCLR: clrhost): Loaded 'C:\Program Files\dotnet\shared\Microsoft.NETCore.Ap
'Guess A Number.exe' (CoreCLR: clrhost): Loaded 'C:\Program Files\dotnet\shared\Microsoft.NETCore.Ap
The thread '.NET TP Worker' (20812) has exited with code 0 (0x0).
The thread '.NET TP Worker' (5984) has exited with code 0 (0x0).
The thread '.NET TP Worker' (5540) has exited with code 0 (0x0).
The program '[11048] Guess A Number.exe' has exited with code 0 (0x0).
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Guess a number (1-100): 50
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Guess a number (1-100): 80
Incorrect. Too High.
Guess a number (1-100): 65
Incorrect. Too High.
Guess a number (1-100): 55
Incorrect. Too Low.
Guess a number (1-100): 60
Incorrect. Too Low.
Guess a number (1-100): 62
Incorrect. Too Low.
Guess a number (1-100): 63
You guessed it!
Press any key to exit...
C:\Users\Rashid\OneDrive\Desktop\STT_Codes\Lab 11\dotnet-console-games\Projects\Guess A Number\bin\Debug\Guess A Number.exe (process 11048) exited with code 0 (0x0).
To automatically close the console when debugging stops, enable Tools->Options->Debugging->Automatically close the console when debugging stops.
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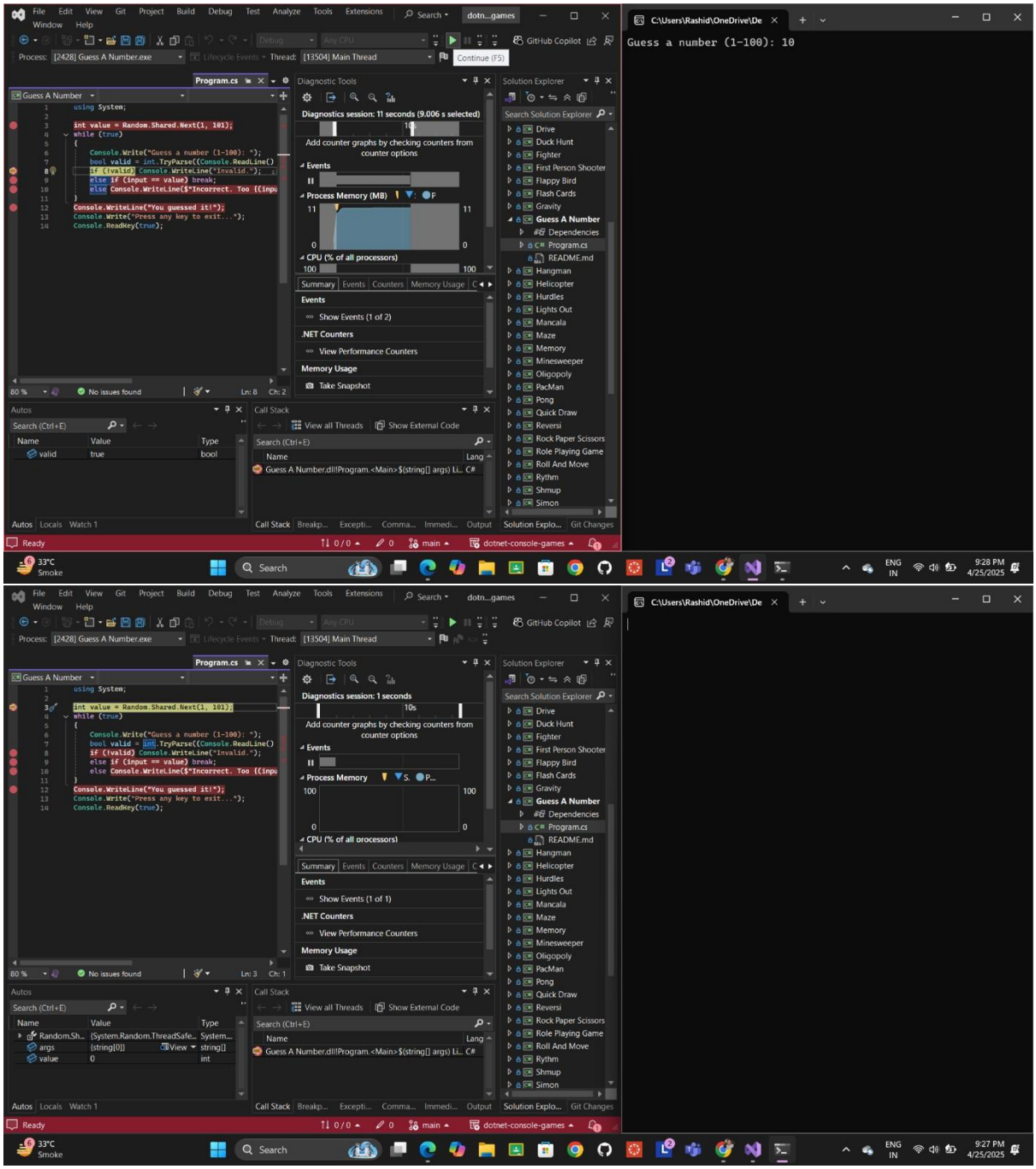
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Process: [2428] Guess A Number.exe
Thread: [13504] Main Thread
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Program.cs
Guess A Number
using System;
int value = Random.Shared.Next(1, 101);
while (true)
{
Console.Write("Guess a number (1-100): ");
bool valid = int.TryParse(Console.ReadLine()
if (!valid) Console.WriteLine("Invalid.");
else if (input == value) break;
else Console.WriteLine($"Incorrect. Too {(inpu
}
Console.WriteLine("You guessed it!");
Console.Write("Press any key to exit...");
Console.ReadKey(true);
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Flappy Bird
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Process: [2428] Guess A Number.exe
Thread: [13504] Main Thread
Program.cs
Guess A Number
using System;
int value = Random.Shared.Next(1, 101);
while (true)
{
Console.Write("Guess a number (1-100): ");
bool valid = int.TryParse((Console.ReadLine()
if (!valid) Console.WriteLine("Invalid.");
else if (input == value) break;
else Console.WriteLine($"Incorrect. Too {(inpu
}
Console.WriteLine("You guessed it!");
Console.Write("Press any key to exit...");
Console.ReadKey(true);
Diagnostic Tools
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Guess A Number.dll!Program.<Main>$(string[] args) Li... C#
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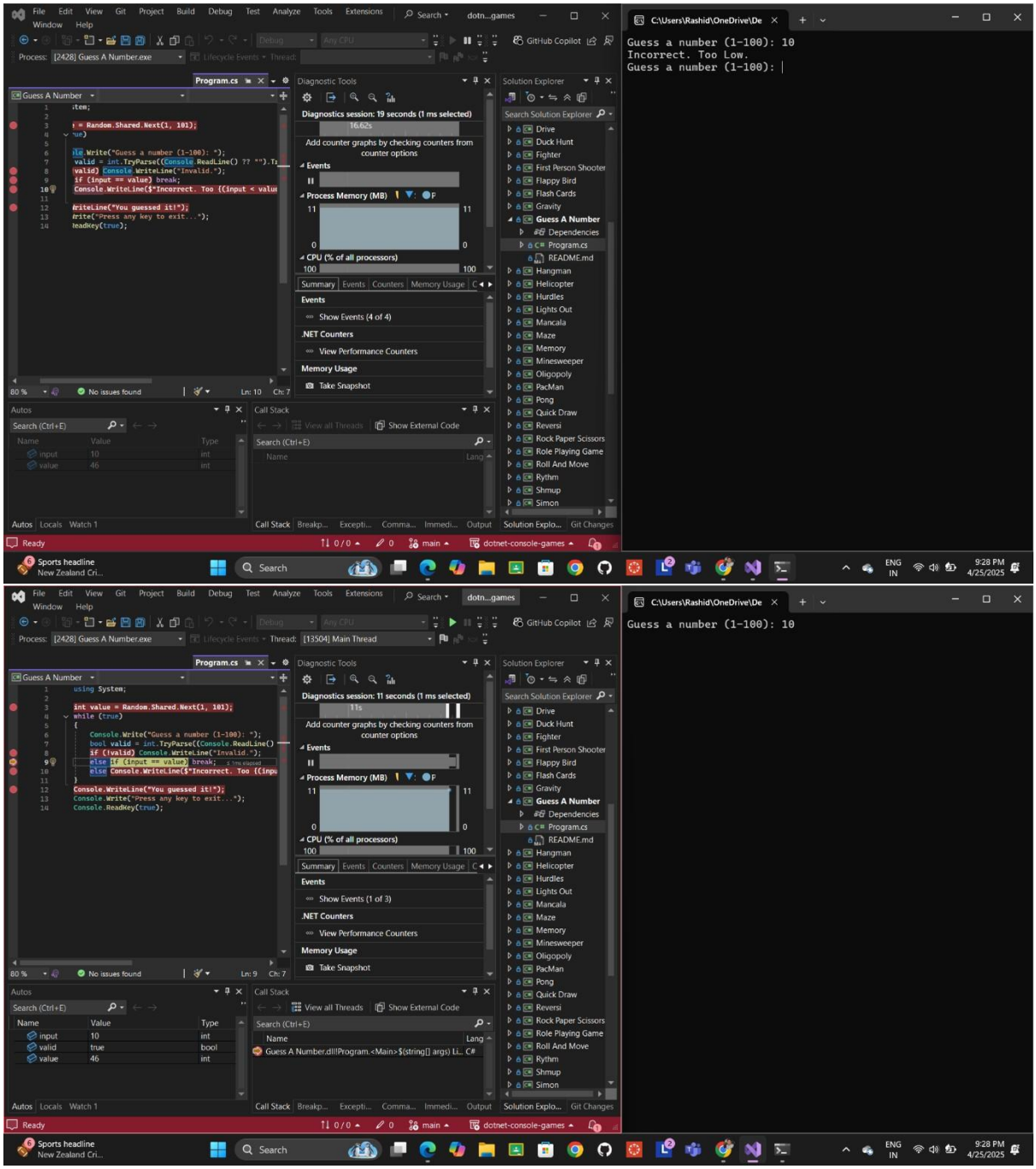
C:\Users\Rashid\OneDrive\De
Guess a number (1-100): 10
Incorrect. Too Low.
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Diagnostic Tools
Diagnostics session: 19 seconds (1 ms selected)
Add counter graphs by checking counters from counter options
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Program.cs
README.md
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Guess A Number.dll!Program.<Main>$(string[] args) Li... C#
Ready
No issues found
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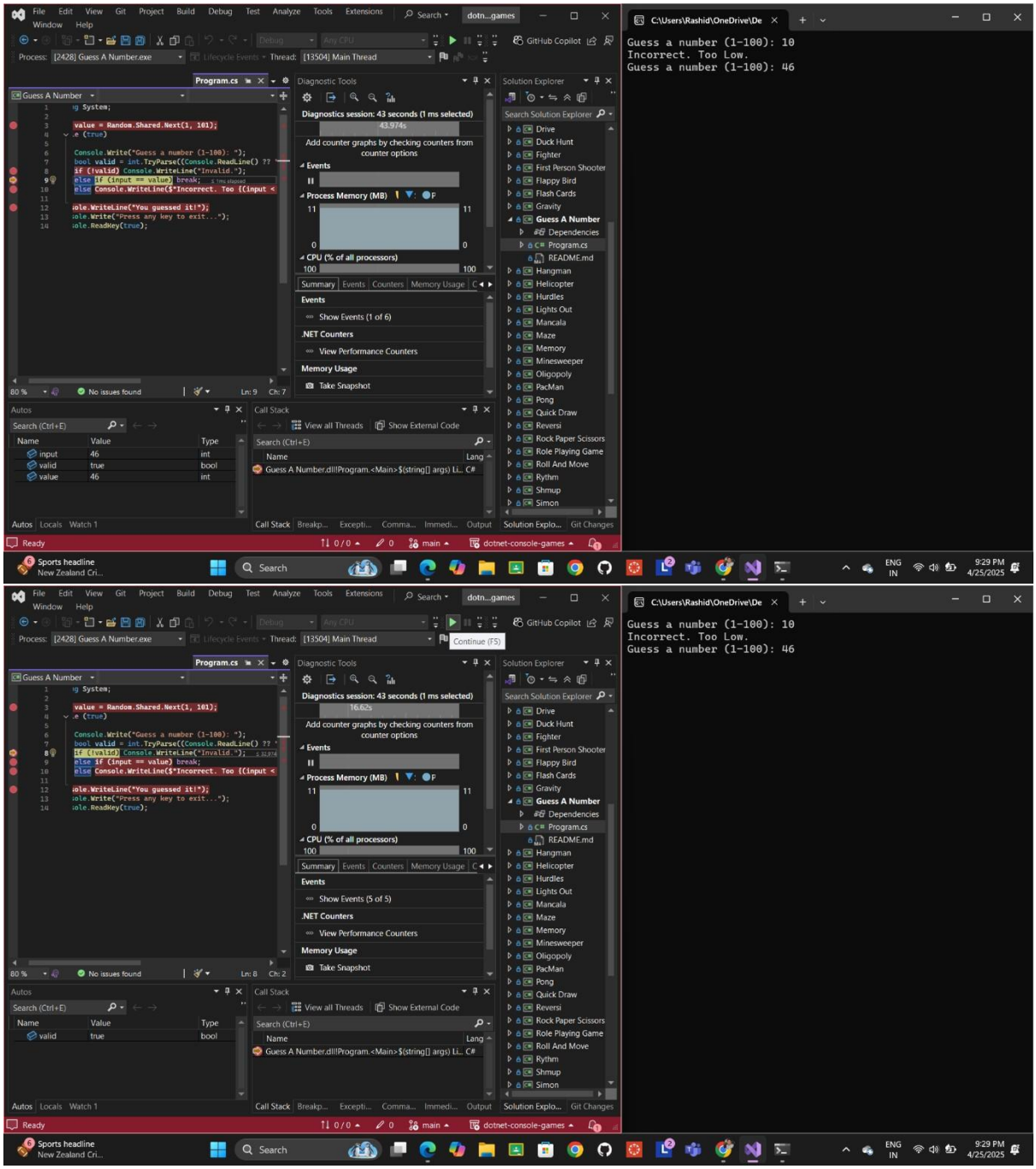
C:\Users\Rashid\OneDrive\De
Guess a number (1-100): 10
Incorrect. Too Low.
Guess a number (1-100): 46
Program.cs
Guess A Number
Diagnostic Tools
Diagnostics session: 43 seconds (1 ms selected)
Add counter graphs by checking counters from counter options
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CPU (% of all processors)
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Search Solution Explorer
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README.md
Autos
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C:\Users\Rashid\OneDrive\De
Guess a number (1-100): 10
Incorrect. Too Low.
Guess a number (1-100): 46
Continue (F5)
Program.cs
Guess A Number
Diagnostic Tools
Diagnostics session: 43 seconds (1 ms selected)
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
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Take Snapshot
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Dependencies
Program.cs
README.md
Autos
Call Stack
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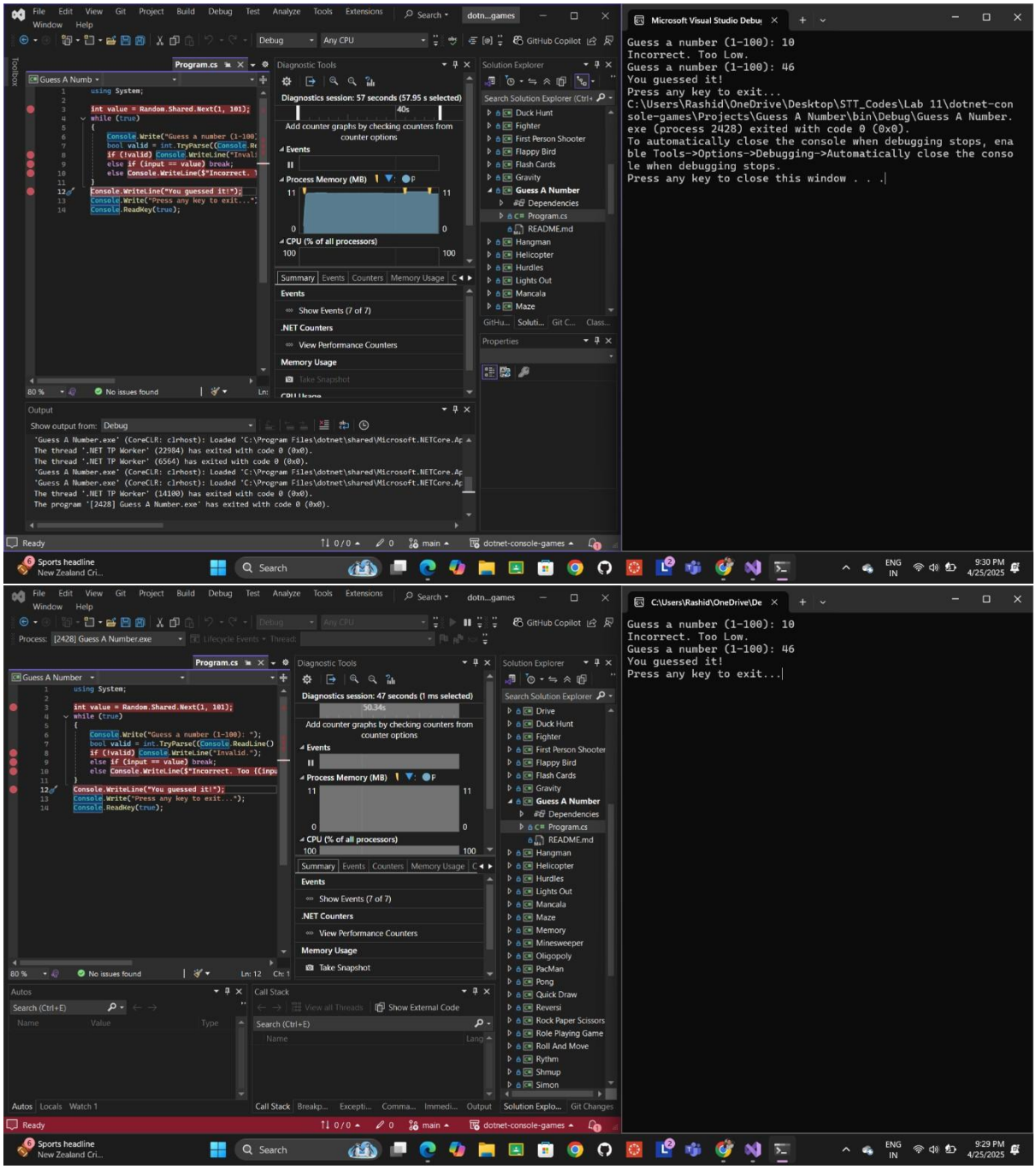

3. Game 2: *Helicopter*

a. Standard Execution

Depicts the unaltered gameplay and normal execution of the *Helicopter* game.


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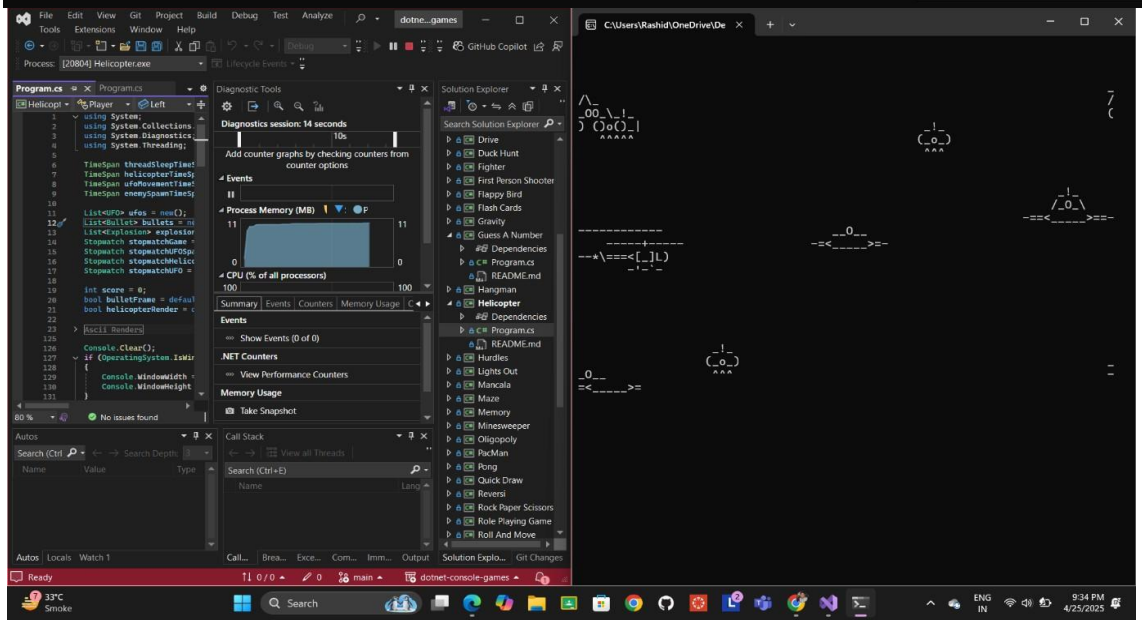
Snipping Tool
Screenshot copied to clipboard and saved
Select here to mark up and share.


File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
Program.cs
Diagnostic Tools
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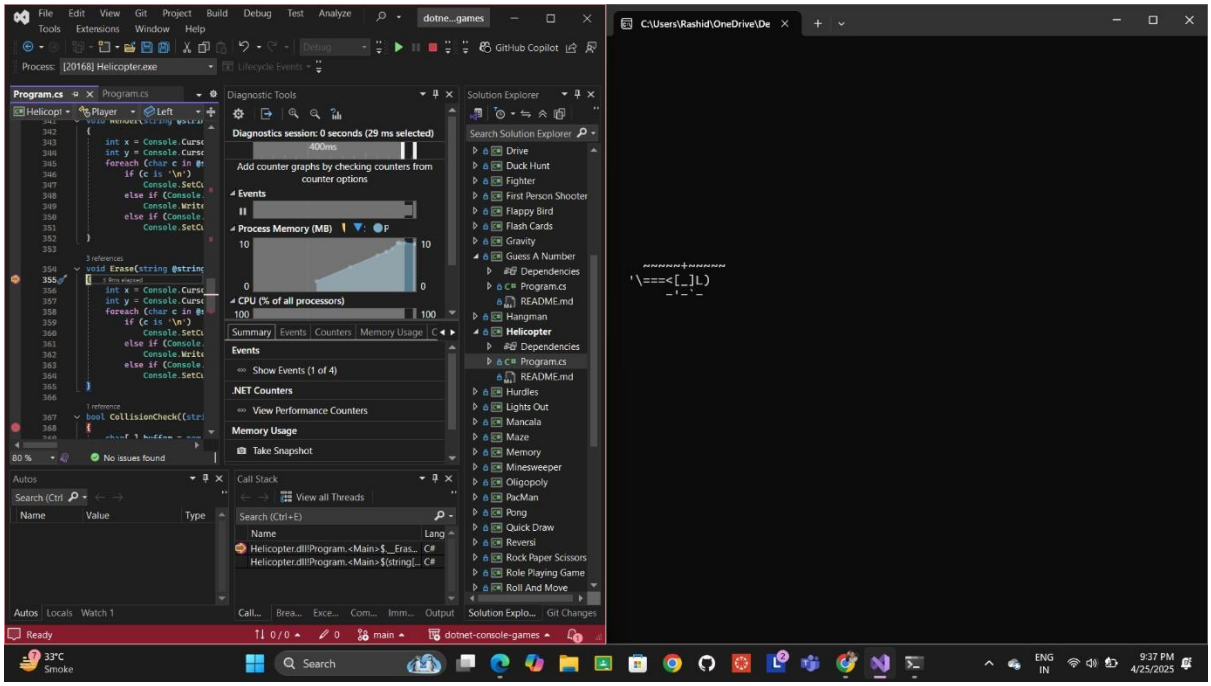
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Process: [20168] Helicopter.exe
Program.cs
Diagnostic Tools
Diagnostics session: 0 seconds (29 ms selected)
Add counter graphs by checking counters from counter options
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Show Events (1 of 4)
.NET Counters
View Performance Counters
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Lights Out
Mancala
Maze
Memory
Minesweeper
Oligopoly
PacMan
Pong
Quick Draw
Reversi
Rock Paper Scissors
Role Playing Game
Roll And Move
No issues found
Autos
Call Stack
View all Threads
Ready
main
dotnet-console-games
C:\Users\Rashid\OneDrive\De
33°C
Smoke
Search
ENG
IN
9:37 PM
4/25/2025


C:\Users\Rashid\OneDrive\De

4. Game 3: *Gravity*

a. Standard Execution

Illustrates the default execution of the game without modifications.

b. Debugging with Breakpoints and Step Controls

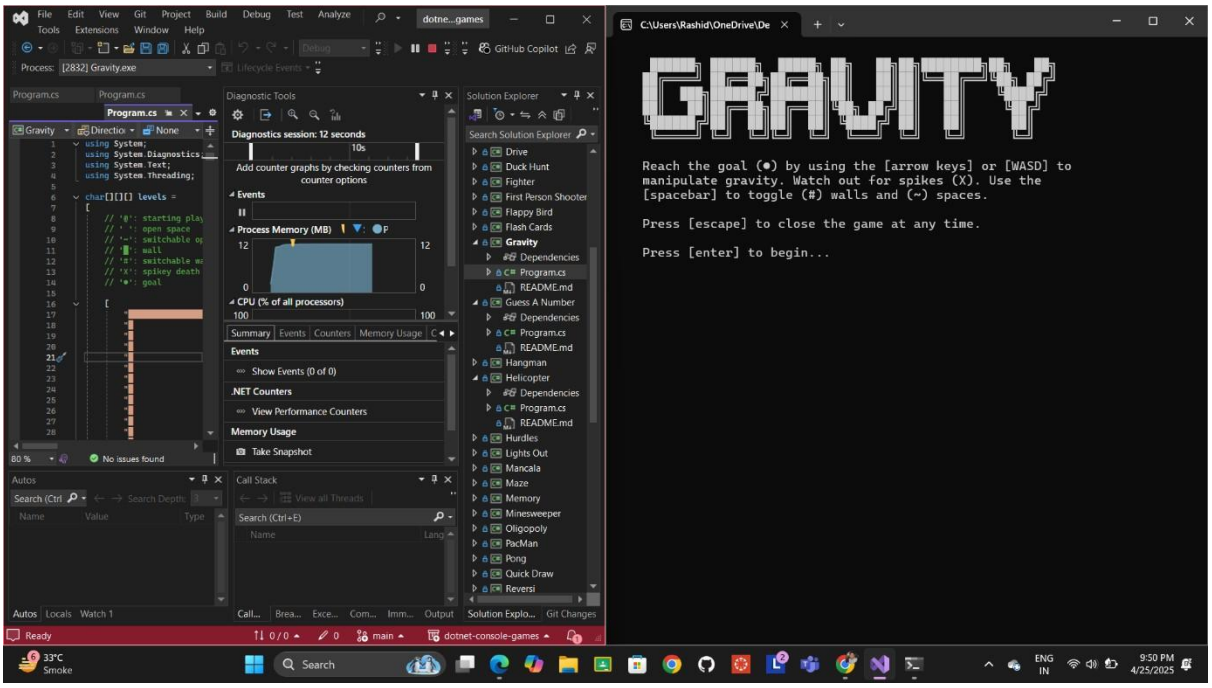
Displays debugging techniques applied to the game's logic using breakpoints and step functions.

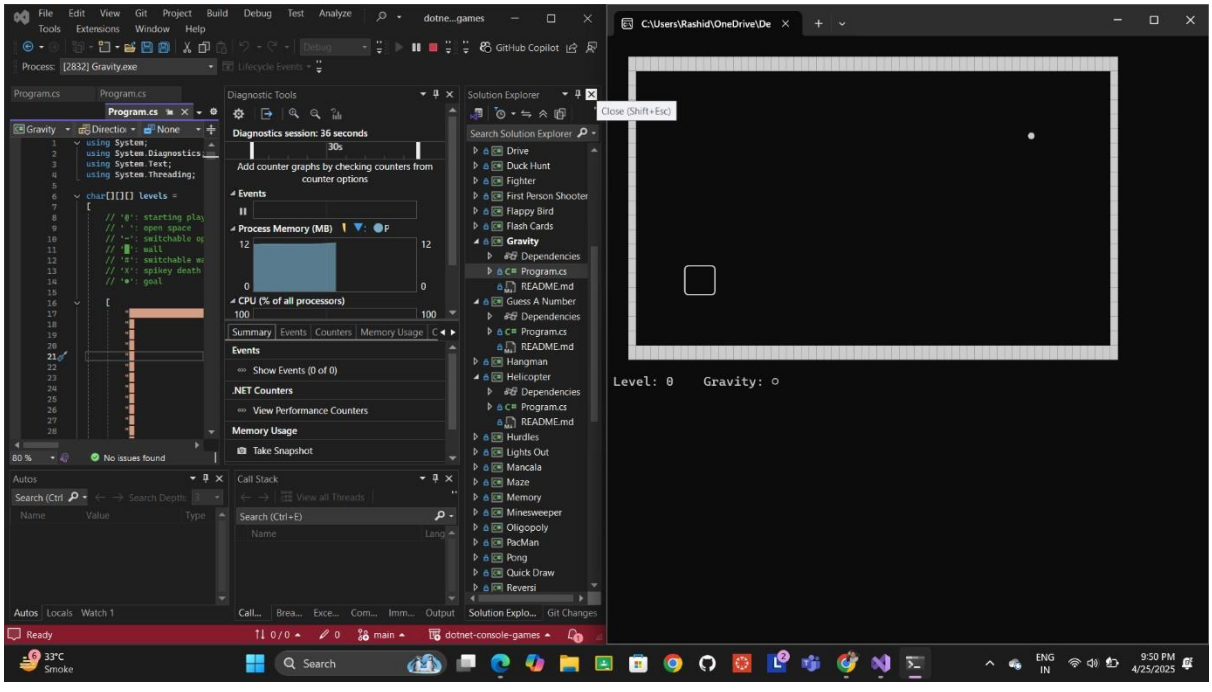
c. Bug Introduction and Execution

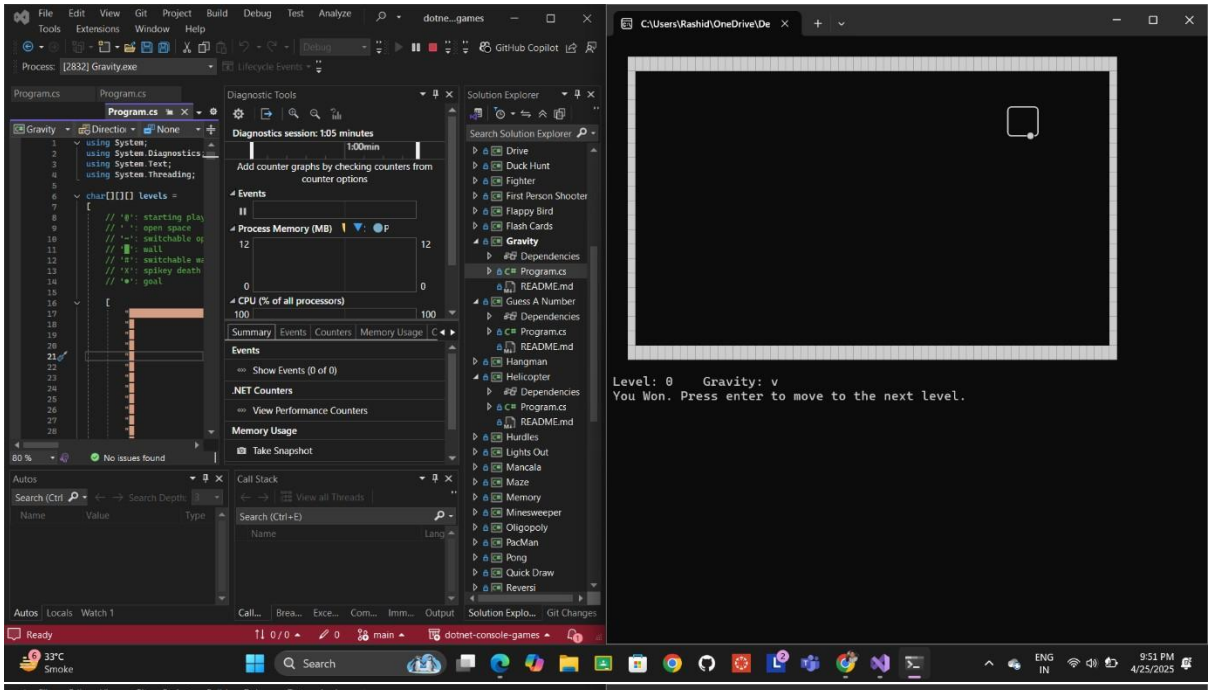
Highlights how intentionally added bugs affect the program’s behavior during execution.

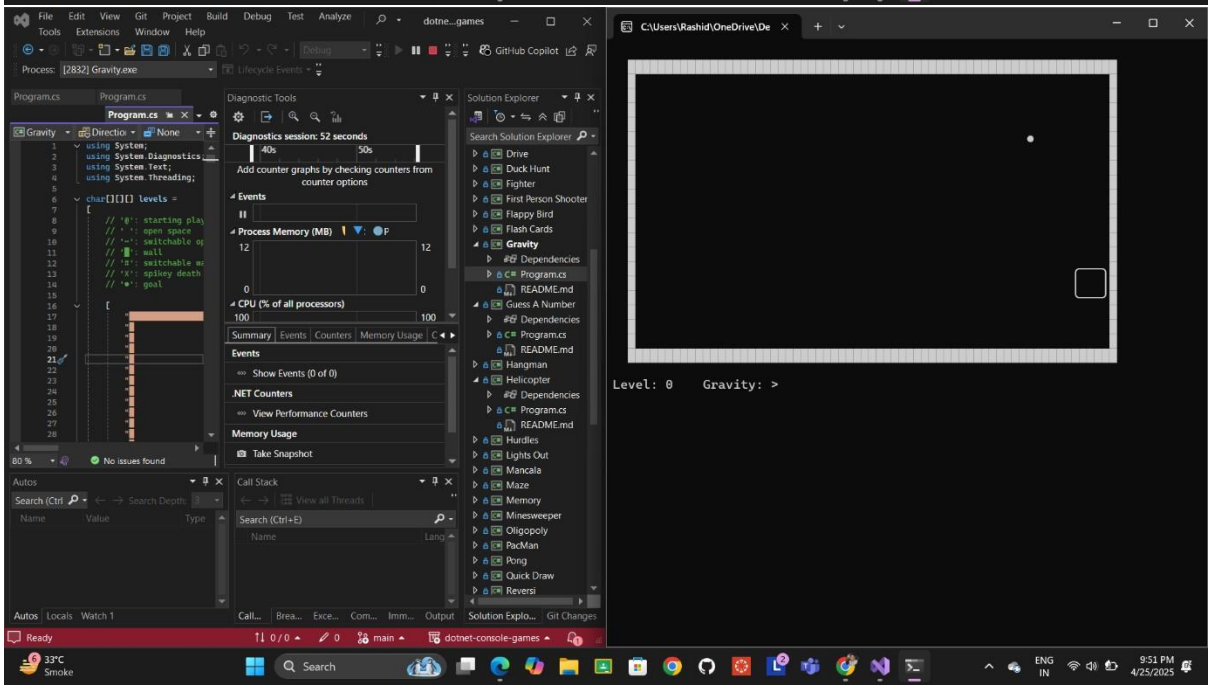
d. Bug Fixing and Re-execution

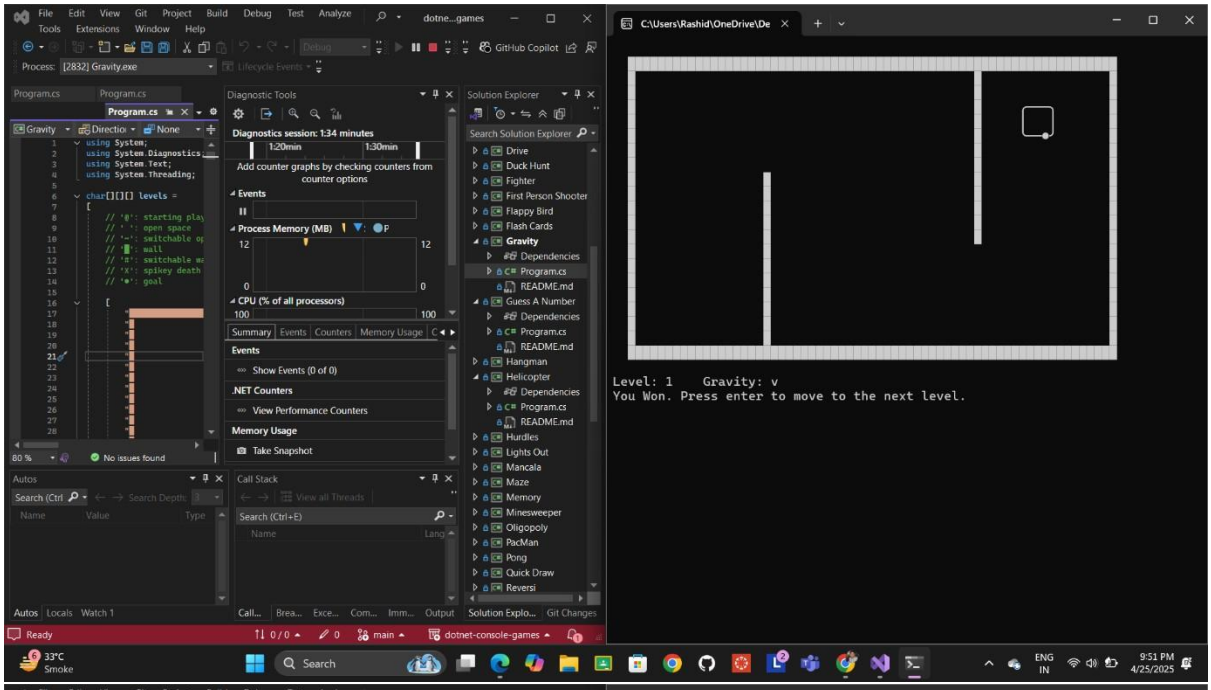
Shows the restoration of the game’s correct behavior after resolving the introduced bugs.

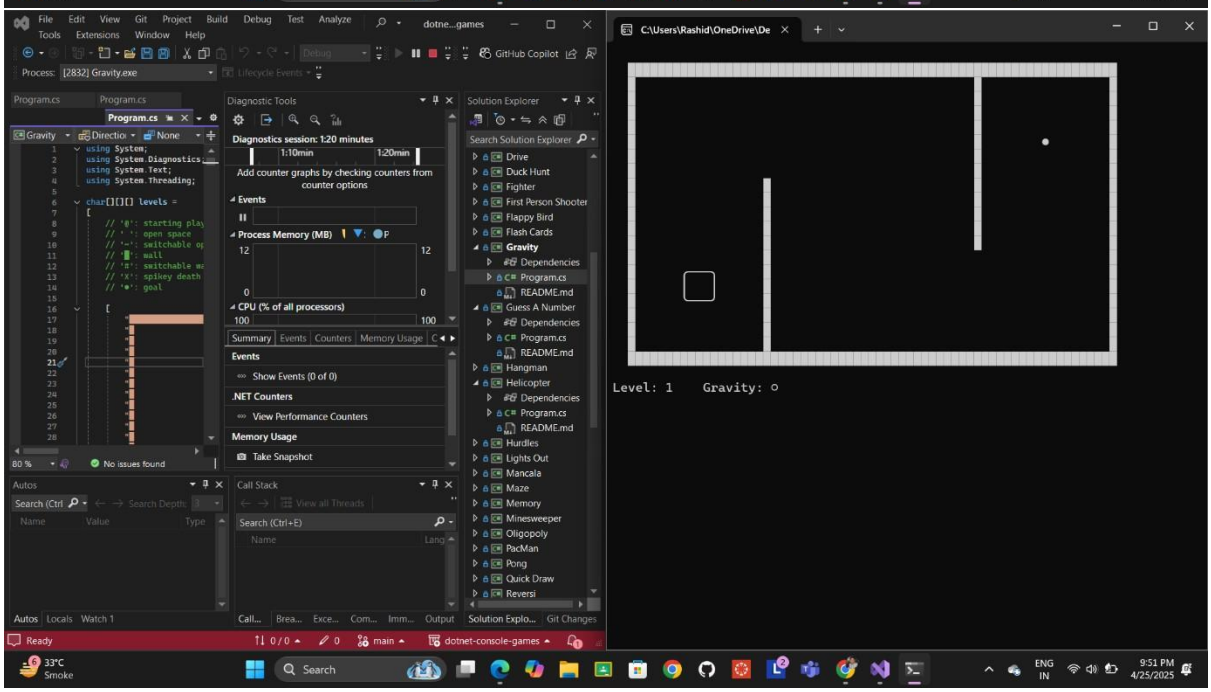


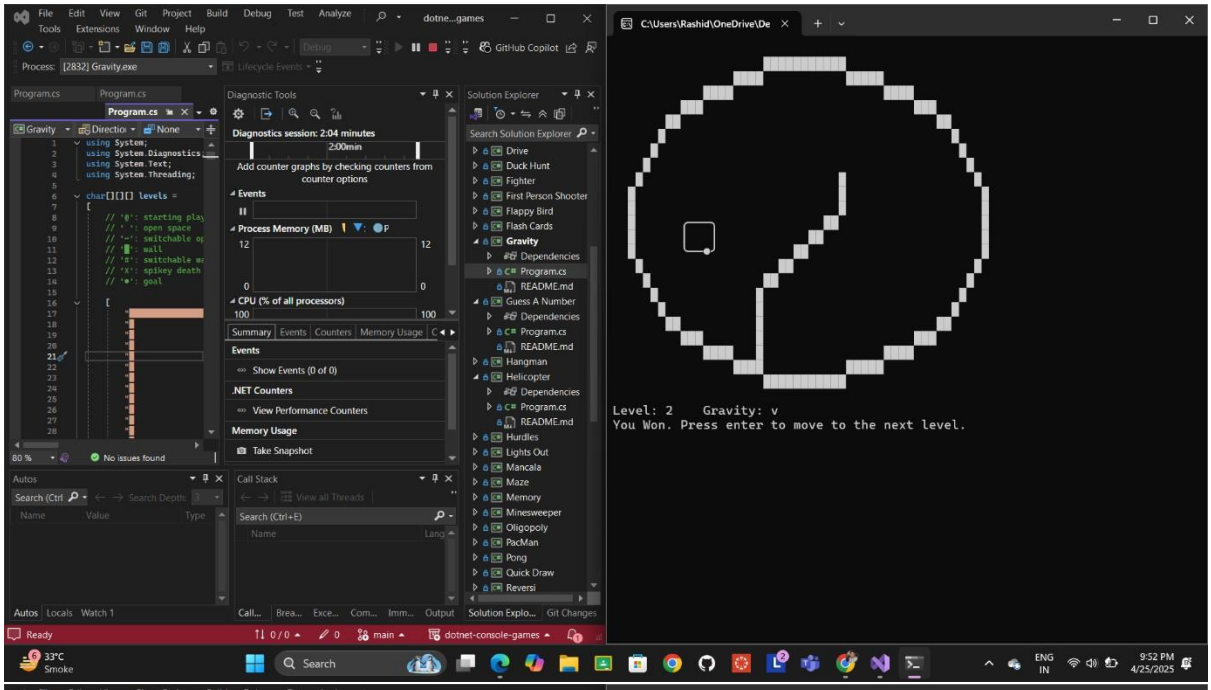


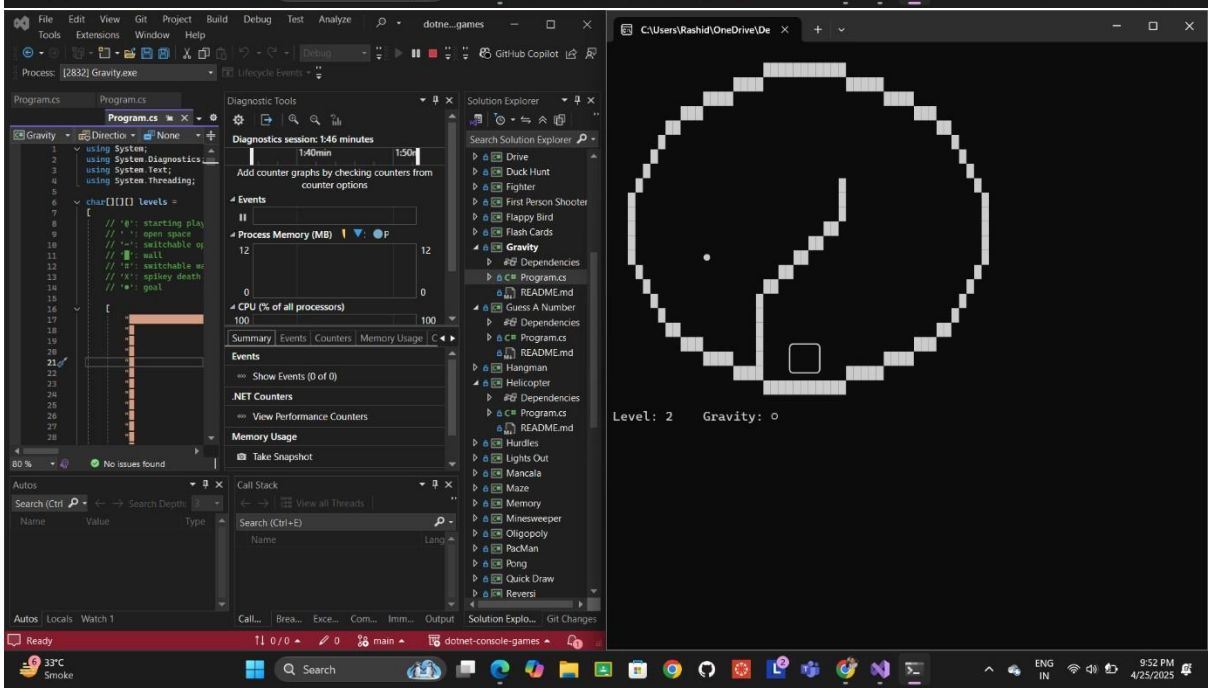

C:\Users\Rashid\OneDrive\De
Level: 0 Gravity: v
You Won. Press enter to move to the next level.

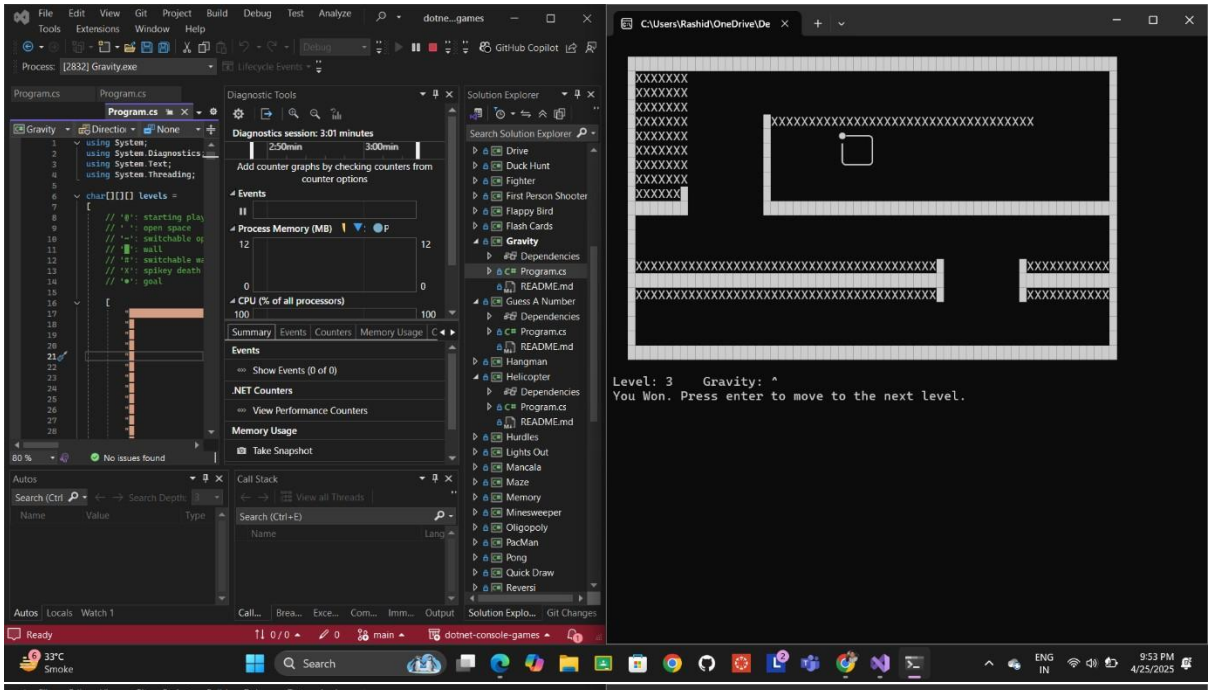

C:\Users\Rashid\OneDrive\De
Level: 0 Gravity: >

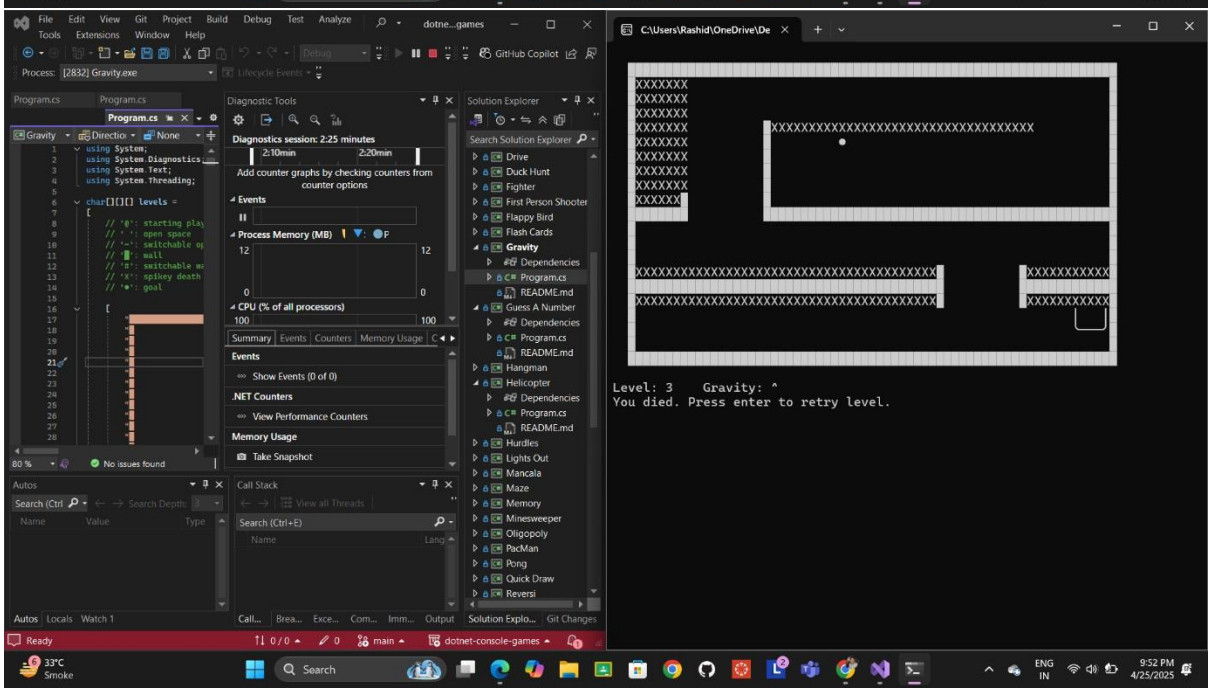

C:\Users\Rashid\OneDrive\De
Level: 1 Gravity: v
You Won. Press enter to move to the next level.

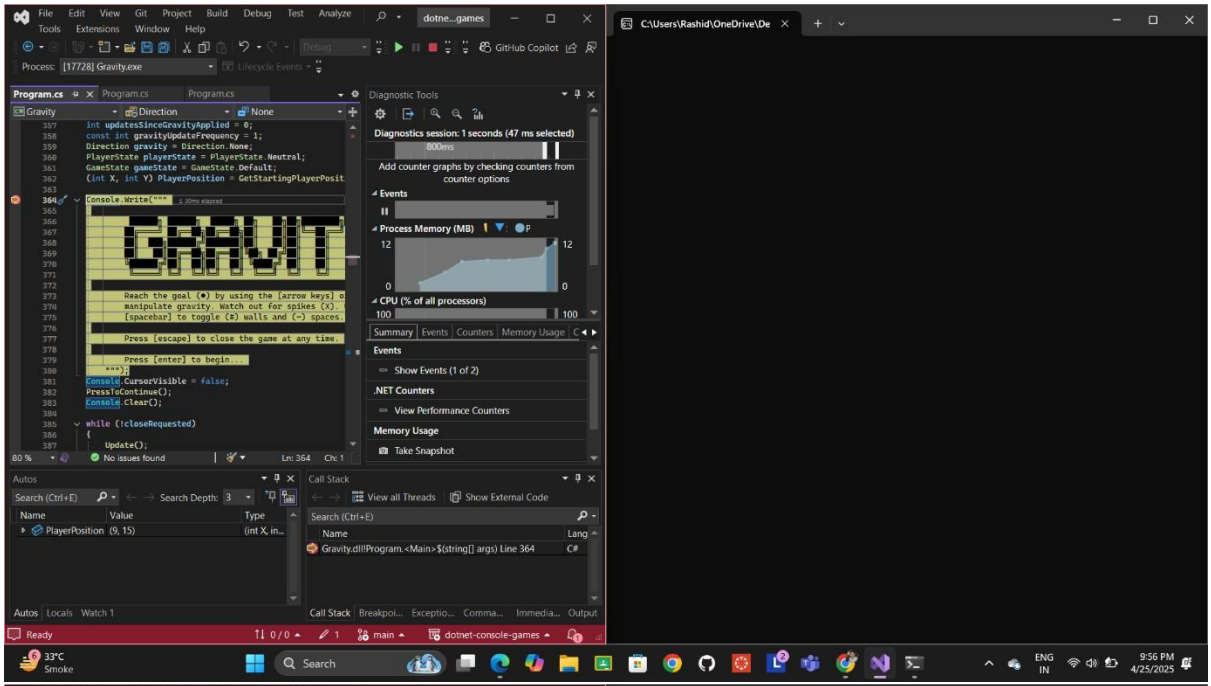

C:\Users\Rashid\OneDrive\De
Level: 1 Gravity: o

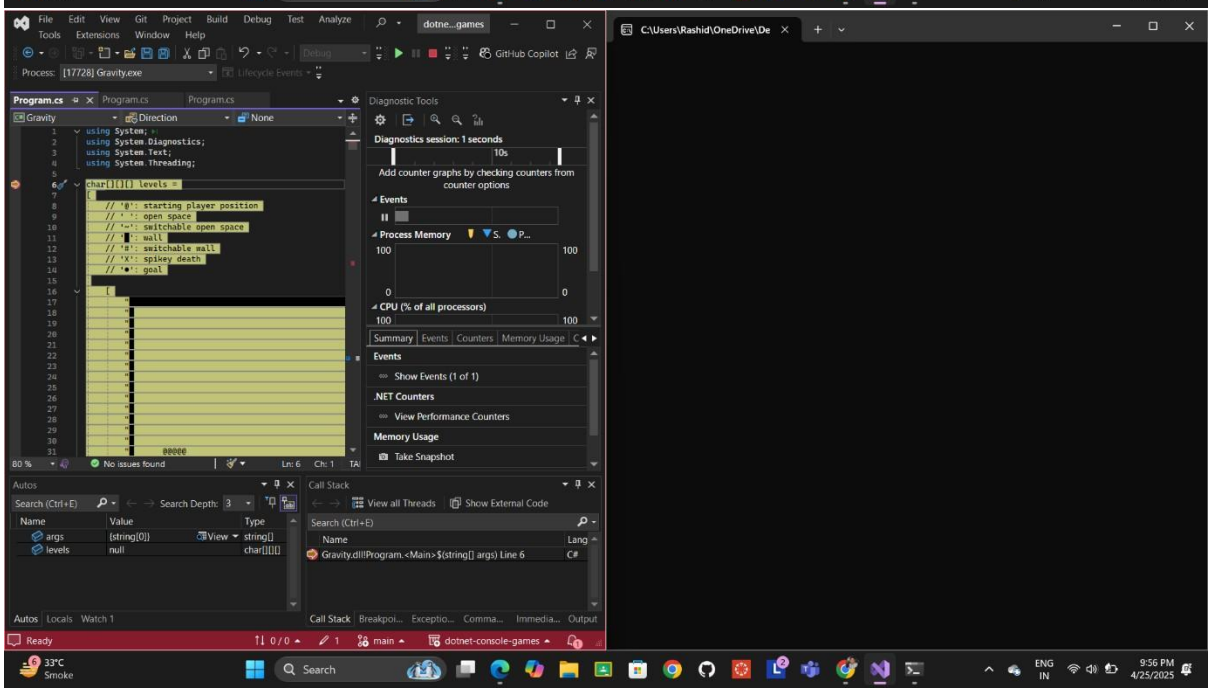

C:\Users\Rashid\OneDrive\De
Level: 2 Gravity: v
You Won. Press enter to move to the next level.

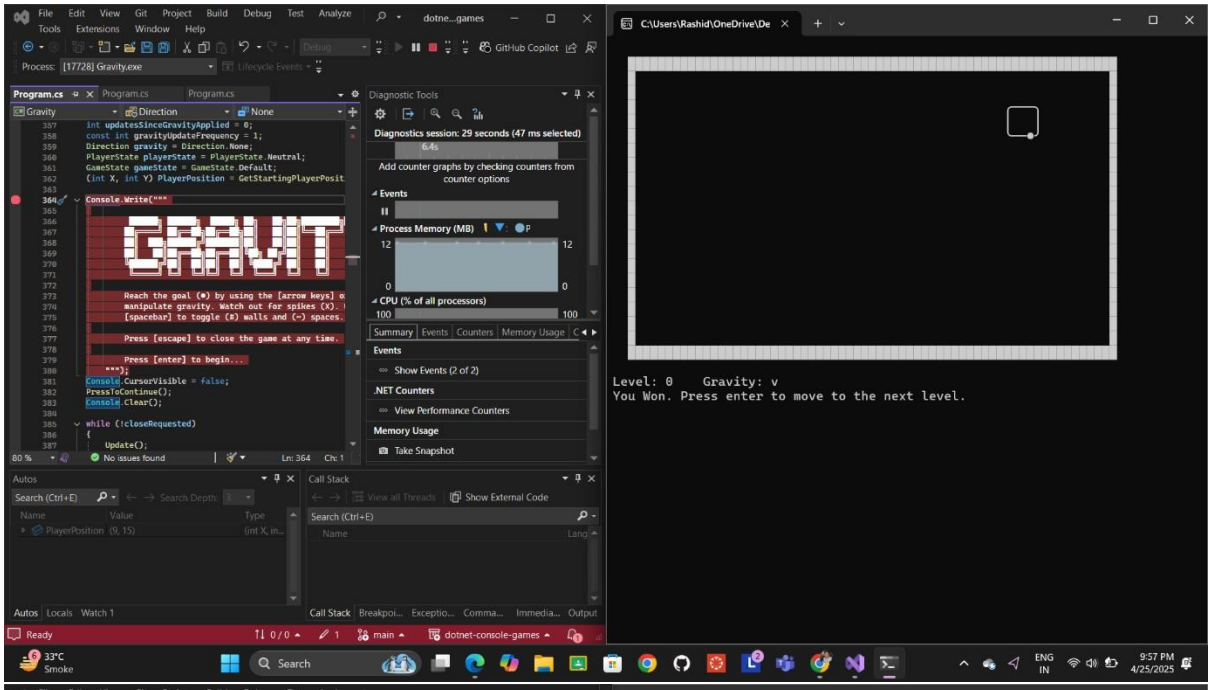

C:\Users\Rashid\OneDrive\De
Level: 2 Gravity: o

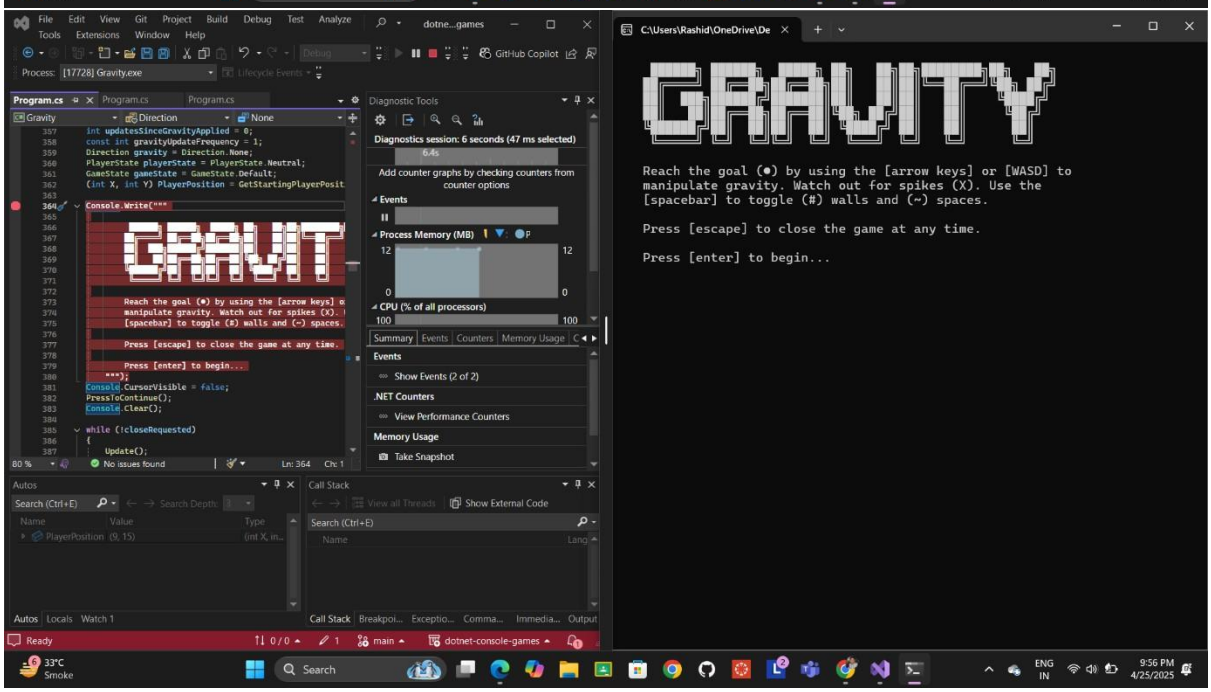

C:\Users\Rashid\OneDrive\De
Level: 3 Gravity: ^
You Won. Press enter to move to the next level.

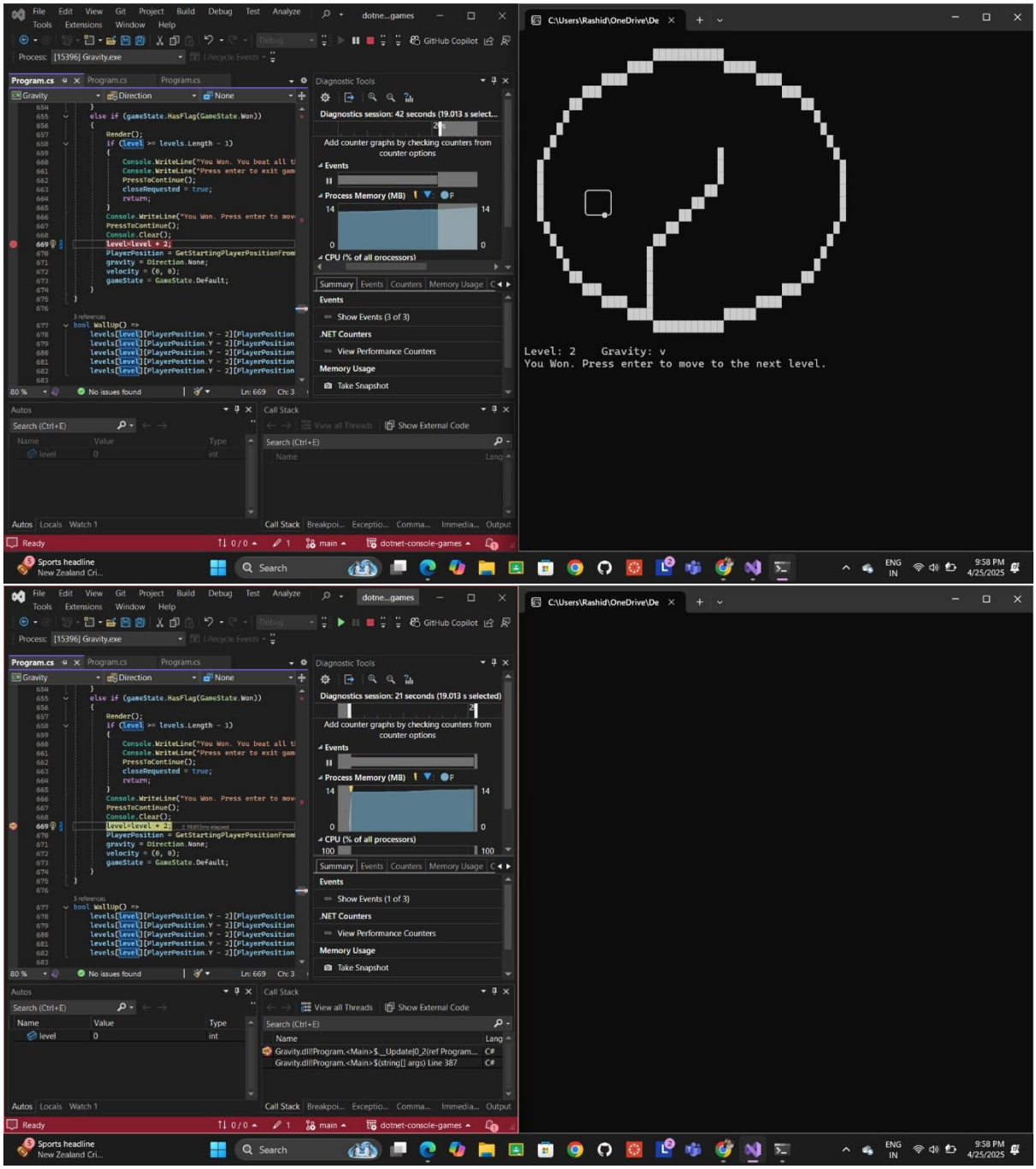

C:\Users\Rashid\OneDrive\De
Level: 3 Gravity: ^
You died. Press enter to retry level.


File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [17728] Gravity.exe
Program.cs
Gravity
Direction
None
Diagnostic Tools
Diagnostics session: 1 seconds (47 ms selected)
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Summary
Events
Counters
Memory Usage
Show Events (1 of 2)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
Autos
Search (Ctrl+E)
Search Depth: 3
Name
Value
Type
PlayerPosition (9, 15) (int X, in...
Call Stack
View all Threads
Show External Code
Gravity.dll!Program.<Main>$(string[] args) Line 364 C#
Autos
Locals
Watch 1
Call Stack
Breakpoi...
Exceptio...
Comma...
Immedia...
Output
Ready
main
dotnet-console-games
C:\Users\Rashid\OneDrive\De
33°C
Smoke
Search
ENG
IN
9:56 PM
4/25/2025

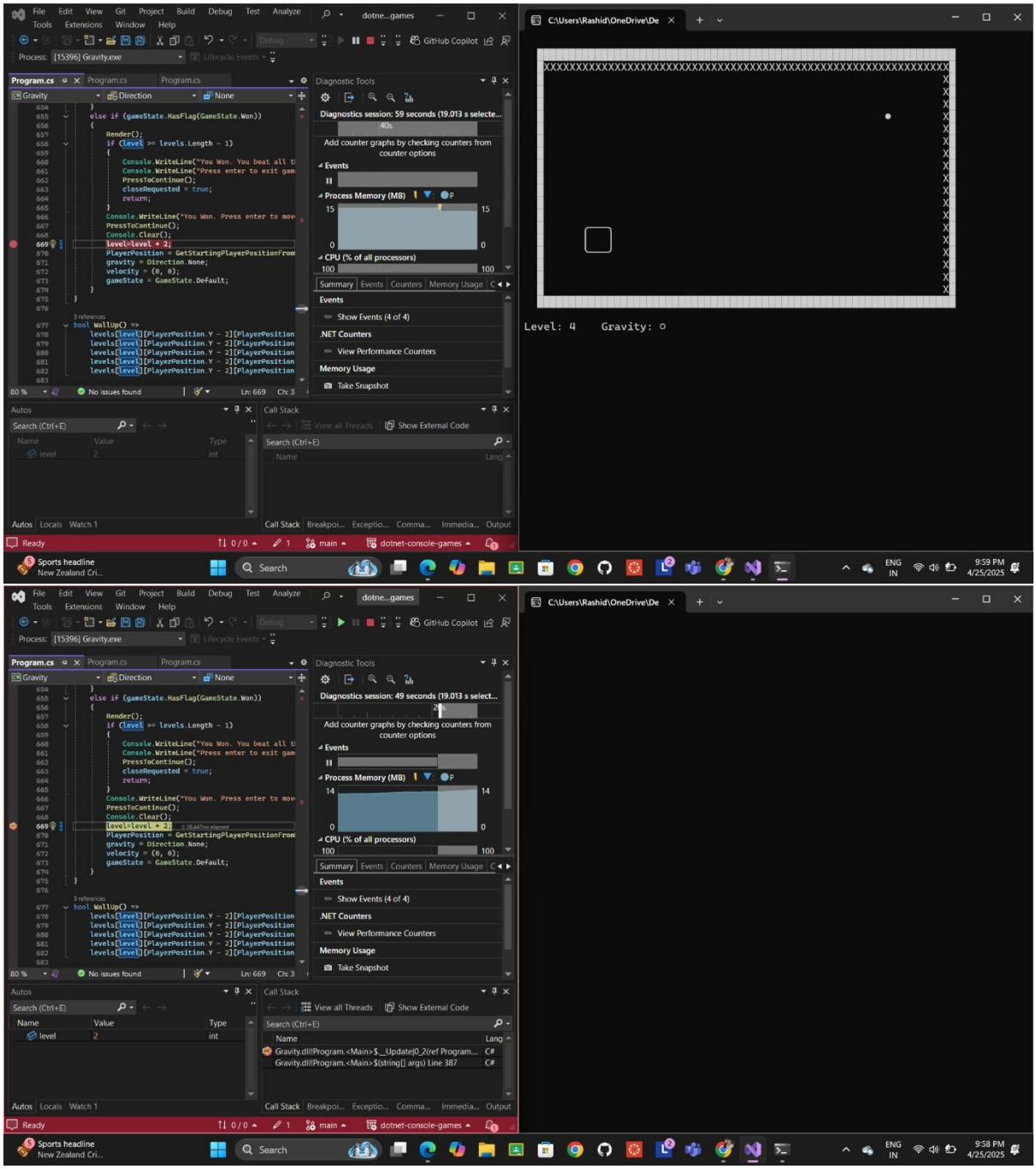

File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [17728] Gravity.exe
Program.cs
Gravity
Direction
None
Diagnostic Tools
Diagnostics session: 1 seconds
10s
Add counter graphs by checking counters from counter options
Events
Process Memory
CPU (% of all processors)
Summary
Events
Counters
Memory Usage
Show Events (1 of 1)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
Autos
Search (Ctrl+E)
Search Depth: 3
Name
Value
Type
args {string[0]} string[]
levels null char[][][]
Call Stack
View all Threads
Show External Code
Gravity.dll!Program.<Main>$(string[] args) Line 6 C#
Autos
Locals
Watch 1
Call Stack
Breakpoi...
Exceptio...
Comma...
Immedia...
Output
Ready
main
dotnet-console-games
C:\Users\Rashid\OneDrive\De
33°C
Smoke
Search
ENG
IN
9:56 PM
4/25/2025

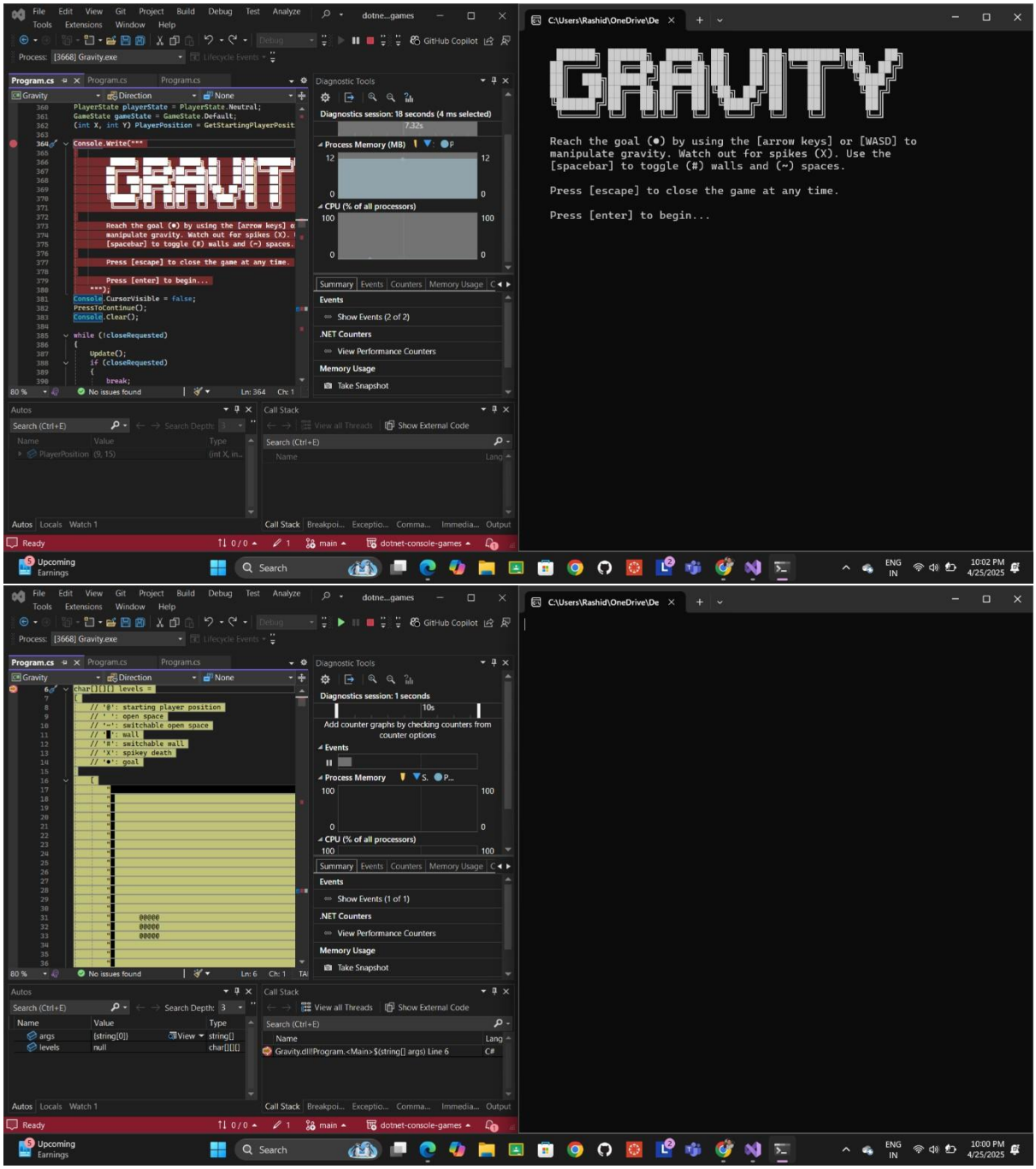

Program.cs
Diagnostic Tools
Diagnostics session: 29 seconds (47 ms selected)
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Summary
Events
Counters
Memory Usage
Show Events (2 of 2)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
Autos
Call Stack
Ready
Level: 0 Gravity: v
You Won. Press enter to move to the next level.

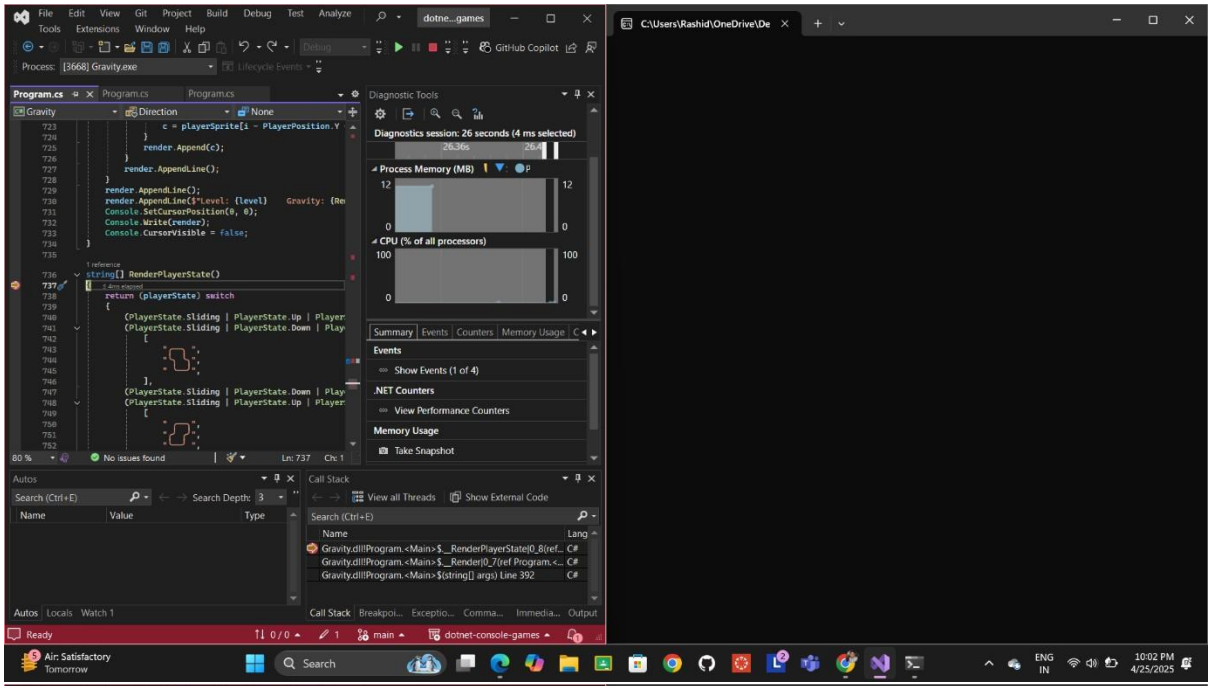

Program.cs
Diagnostic Tools
Diagnostics session: 6 seconds (47 ms selected)
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Summary
Events
Counters
Memory Usage
Show Events (2 of 2)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
Autos
Call Stack
Ready
GRAVITY
Reach the goal (●) by using the [arrow keys] or [WASD] to manipulate gravity. Watch out for spikes (X). Use the [spacebar] to toggle (#) walls and (~) spaces.
Press [escape] to close the game at any time.
Press [enter] to begin...

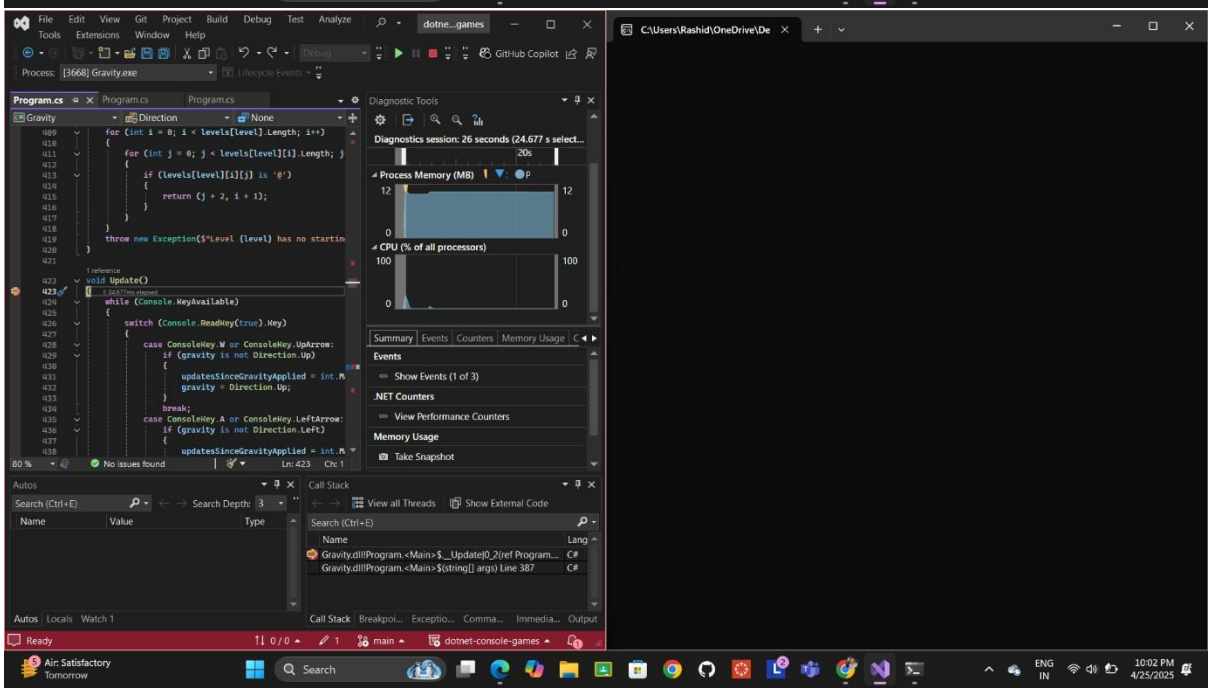

C:\Users\Rashid\OneDrive\De
Level: 2 Gravity: v
You Won. Press enter to move to the next level.
Diagnostic Tools
Diagnostics session: 42 seconds (19.013 s select...
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Summary
Events
Counters
Memory Usage
Show Events (3 of 3)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
Autos
Call Stack
Ready
Sports headline
New Zealand Cri...
Search
ENG
IN
9:58 PM
4/25/2025

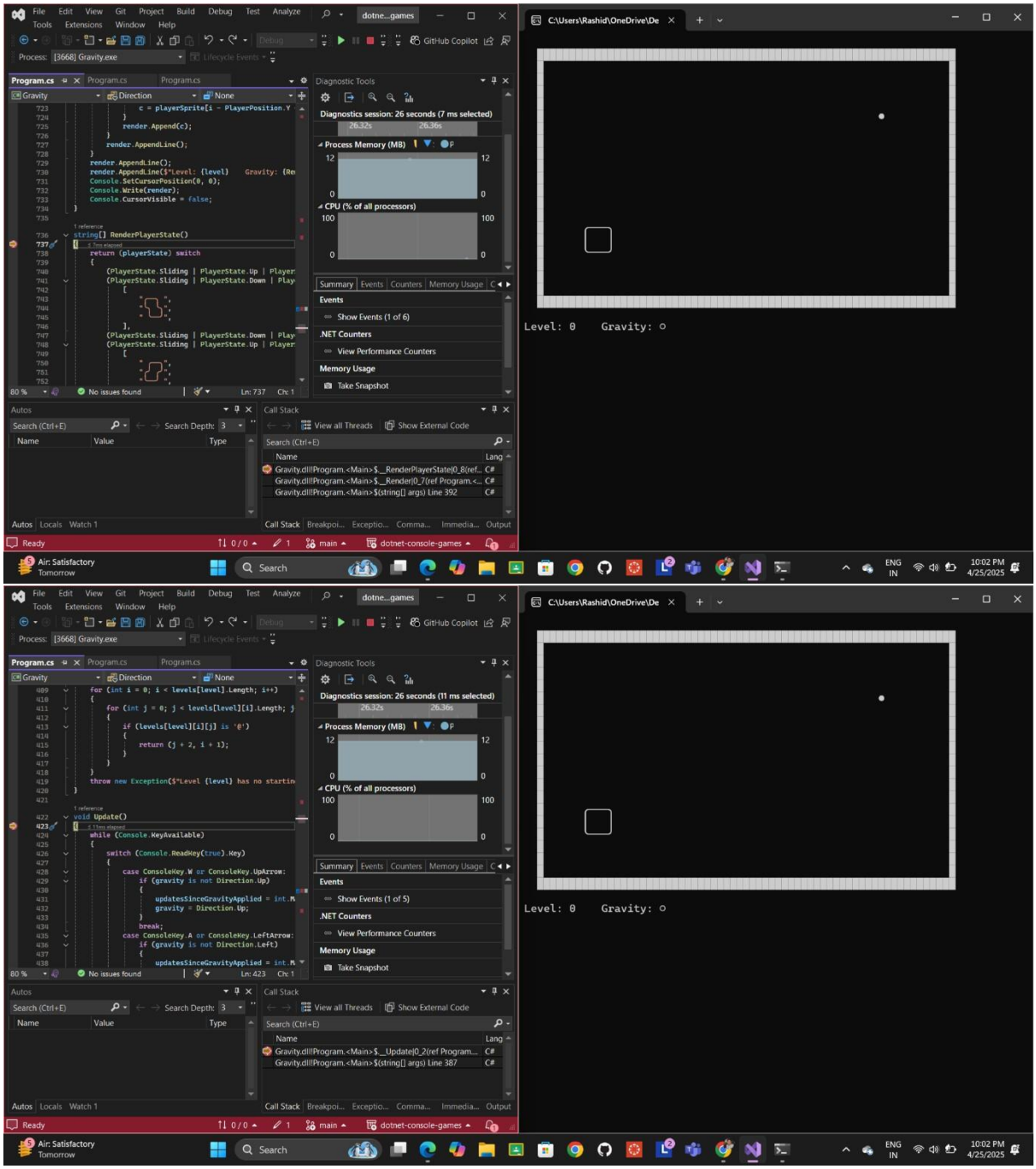
C:\Users\Rashid\OneDrive\De
Diagnostic Tools
Diagnostics session: 21 seconds (19.013 s selected)
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Summary
Events
Counters
Memory Usage
Show Events (1 of 3)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
Autos
Call Stack
Gravity.dll!Program.<Main>$__Update|0_2(ref Program...
Gravity.dll!Program.<Main>$(string[] args) Line 387
Ready
Sports headline
New Zealand Cri...
Search
ENG
IN
9:58 PM
4/25/2025


C:\Users\Rashid\OneDrive\De
Level: 4 Gravity: o
Gravity.dll!Program.<Main>$__Update|0_2(ref Program...
Gravity.dll!Program.<Main>$(string[] args) Line 387
9:59 PM
4/25/2025
9:58 PM
4/25/2025

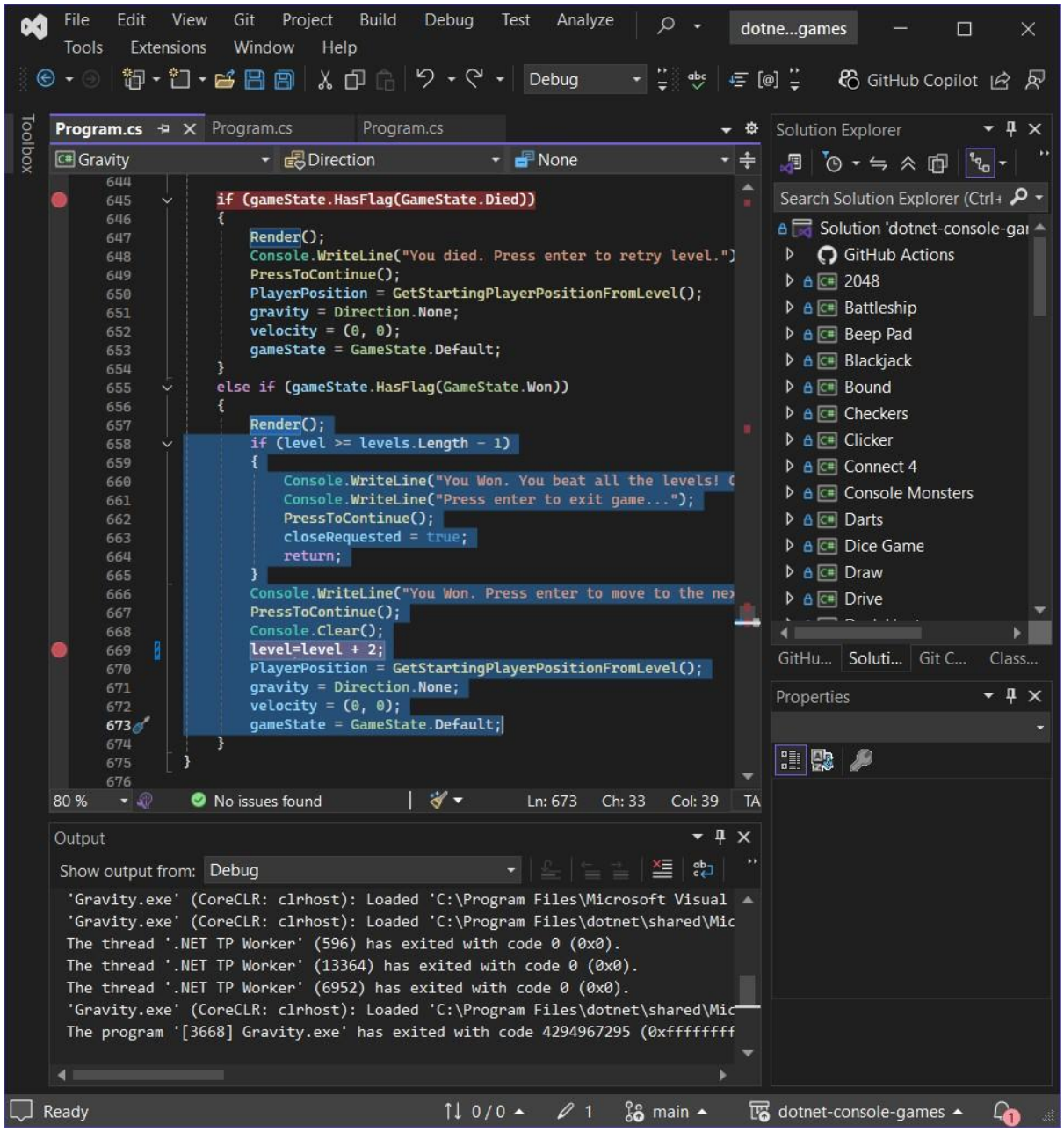

GRAVITY
Reach the goal (●) by using the [arrow keys] or [WASD] to manipulate gravity. Watch out for spikes (X). Use the [spacebar] to toggle (#) walls and (~) spaces.
Press [escape] to close the game at any time.
Press [enter] to begin...

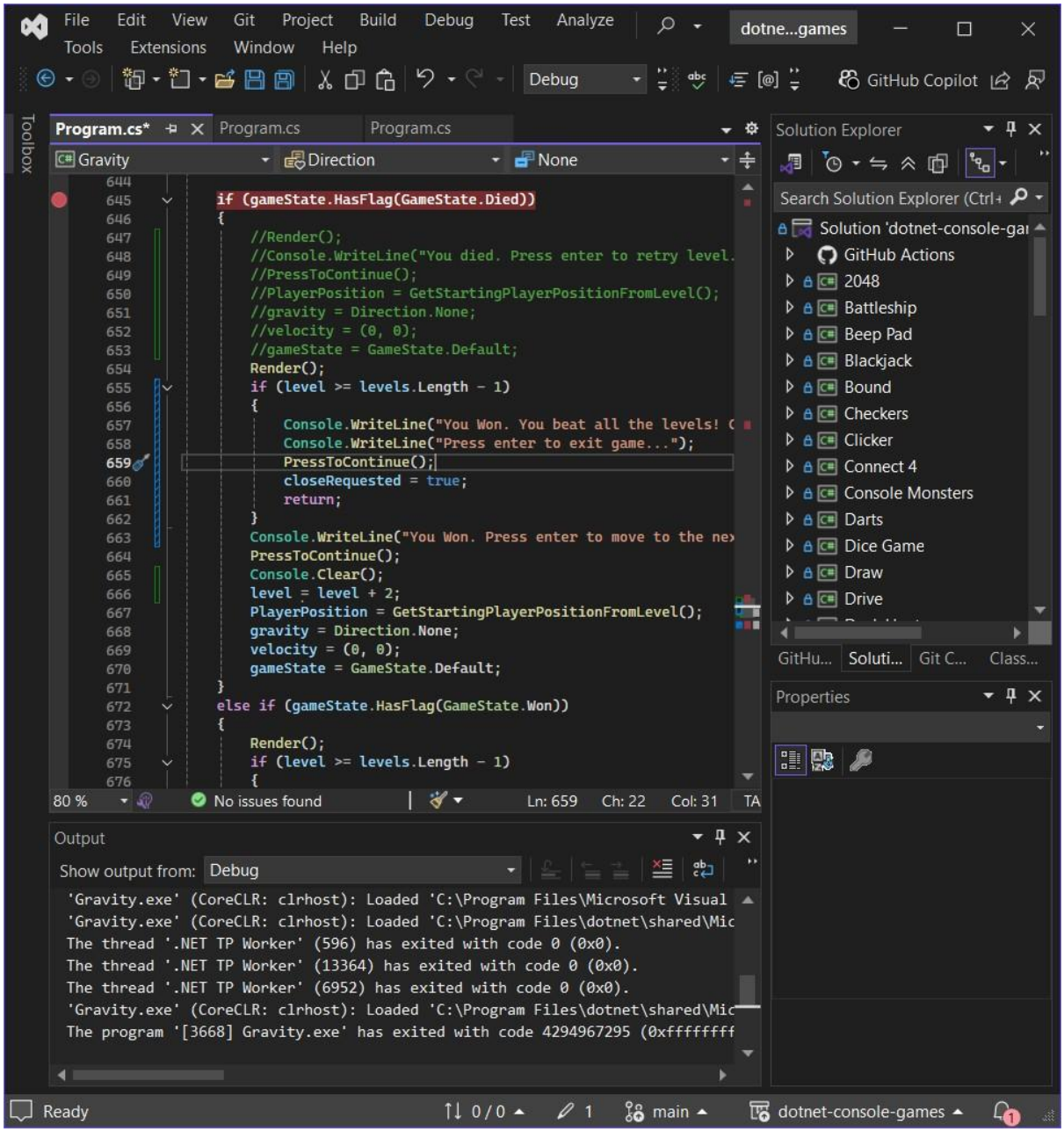

File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [3668] Gravity.exe
Program.cs
Gravity
Direction
None
Diagnostic Tools
Diagnostics session: 26 seconds (4 ms selected)
Process Memory (MB)
CPU (% of all processors)
Summary
Events
Counters
Memory Usage
Show Events (1 of 4)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
No issues found
Ln: 737 Ch: 1
Autos
Search (Ctrl+E)
Search Depth: 3
Name
Value
Type
Call Stack
View all Threads
Show External Code
Gravity.dll!Program.<Main>$__RenderPlayerState|0_8(ref...
Gravity.dll!Program.<Main>$__Render|0_7(ref Program.<...
Gravity.dll!Program.<Main>$(string[] args) Line 392
Autos
Locals
Watch 1
Call Stack
Breakpoi...
Exceptio...
Comma...
Immedia...
Output
Ready
main
dotnet-console-games
C:\Users\Rashid\OneDrive\De
Air: Satisfactory
Tomorrow
Search
ENG
IN
10:02 PM
4/25/2025

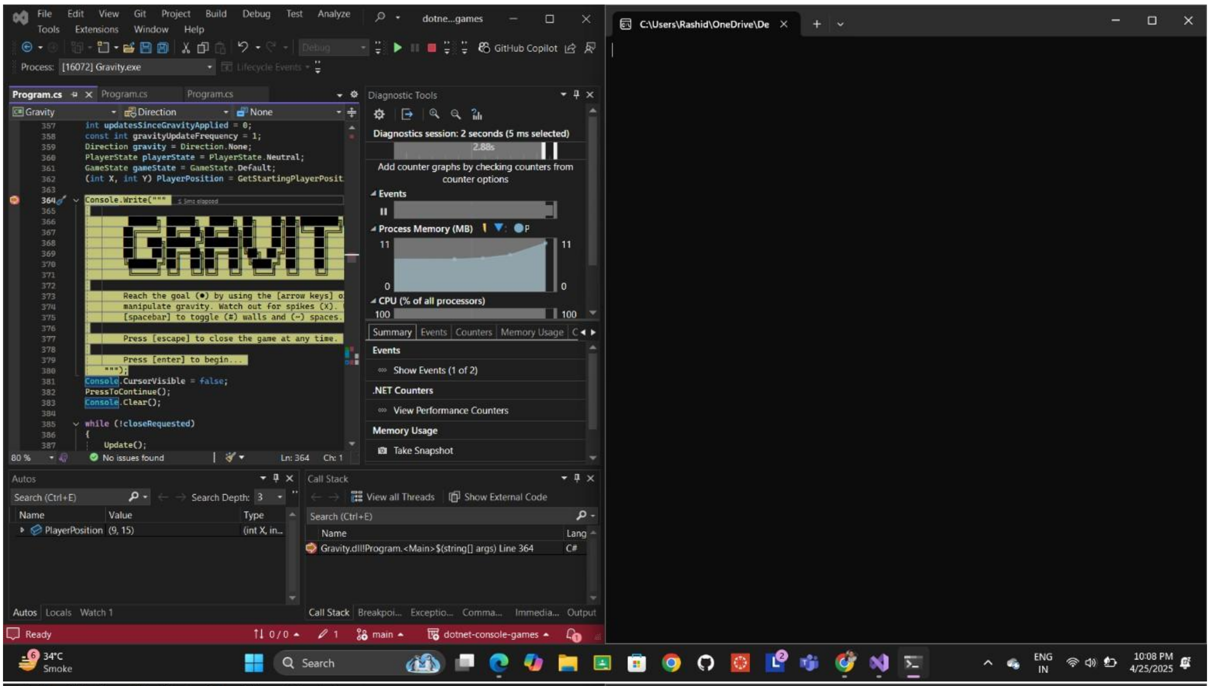

File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [3668] Gravity.exe
Program.cs
Gravity
Direction
None
Diagnostic Tools
Diagnostics session: 26 seconds (24.677 s select...
Process Memory (MB)
CPU (% of all processors)
Summary
Events
Counters
Memory Usage
Show Events (1 of 3)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
No issues found
Ln: 423 Ch: 1
Autos
Search (Ctrl+E)
Search Depth: 3
Name
Value
Type
Call Stack
View all Threads
Show External Code
Gravity.dll!Program.<Main>$__Update|0_2(ref Program....
Gravity.dll!Program.<Main>$(string[] args) Line 387
Autos
Locals
Watch 1
Call Stack
Breakpoi...
Exceptio...
Comma...
Immedia...
Output
Ready
main
dotnet-console-games
C:\Users\Rashid\OneDrive\De
Air: Satisfactory
Tomorrow
Search
ENG
IN
10:02 PM
4/25/2025

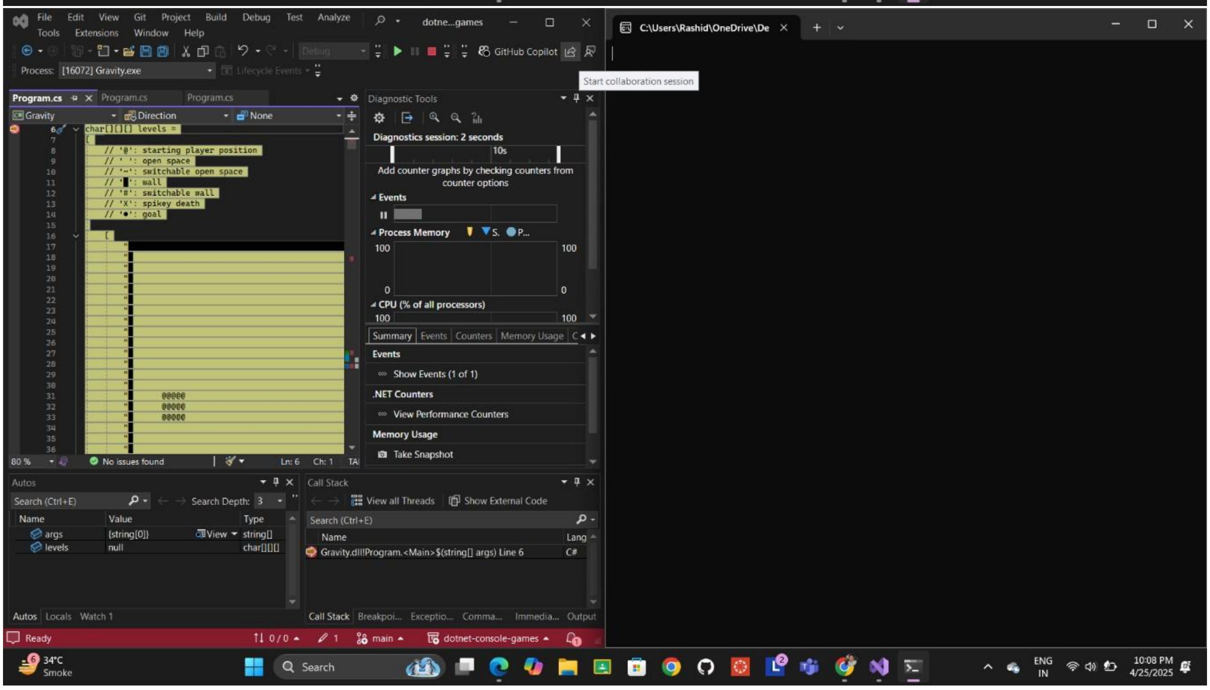

File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [3668] Gravity.exe
Program.cs
Diagnostic Tools
Diagnostics session: 26 seconds (7 ms selected)
Process Memory (MB)
CPU (% of all processors)
Summary Events Counters Memory Usage
Events
Show Events (1 of 6)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
No issues found
Autos
Call Stack
View all Threads
Show External Code
Gravity.dll!Program.<Main>$__RenderPlayerState|0_8(ref...
Gravity.dll!Program.<Main>$__Render|0_7(ref Program.<...
Gravity.dll!Program.<Main>$(string[] args) Line 392
Ready
C:\Users\Rashid\OneDrive\De
Level: 0 Gravity: ○
Air: Satisfactory
Tomorrow
Search
ENG
IN
10:02 PM
4/25/2025

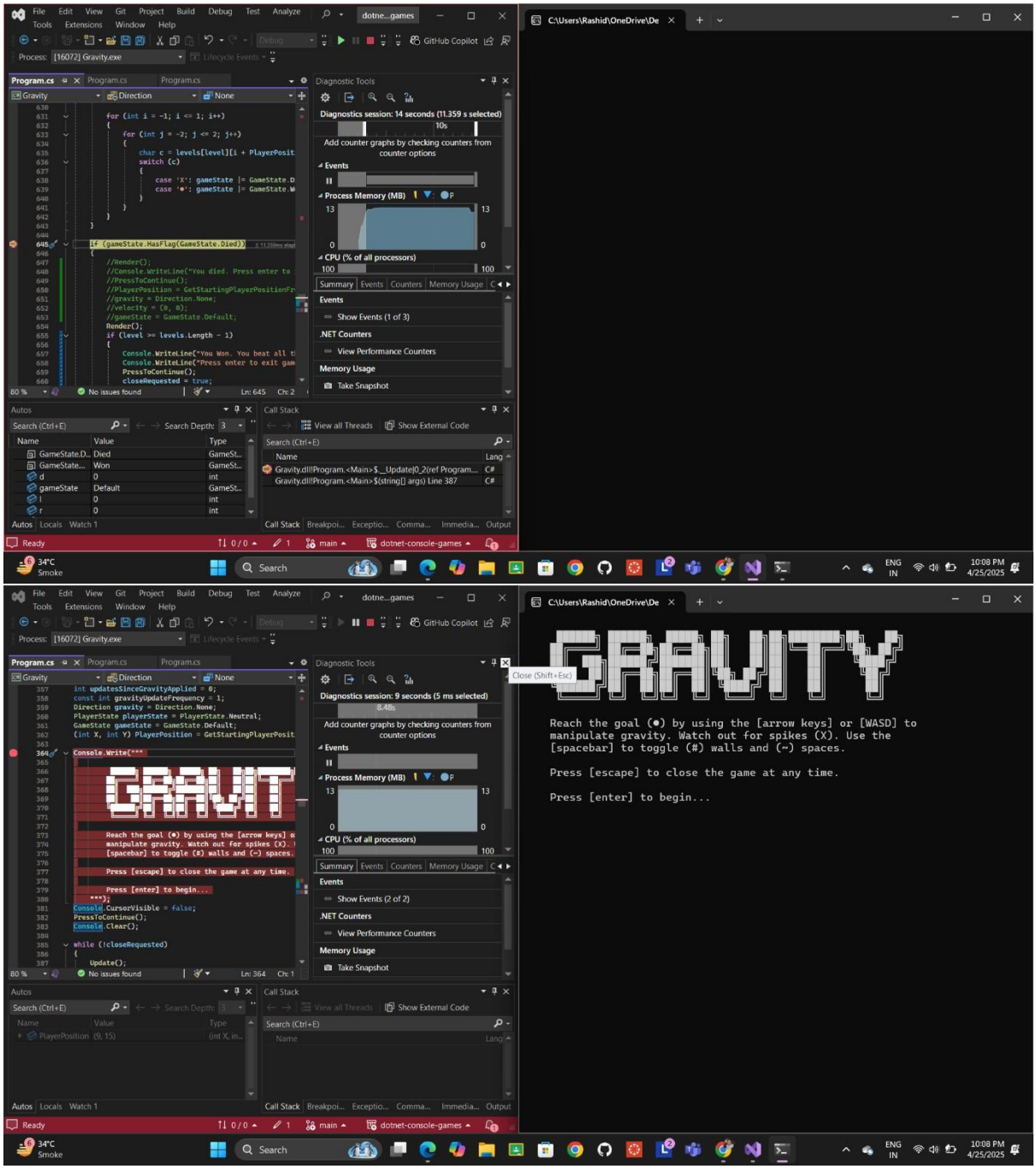
File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [3668] Gravity.exe
Program.cs
Diagnostic Tools
Diagnostics session: 26 seconds (11 ms selected)
Process Memory (MB)
CPU (% of all processors)
Summary Events Counters Memory Usage
Events
Show Events (1 of 5)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
No issues found
Autos
Call Stack
View all Threads
Show External Code
Gravity.dll!Program.<Main>$__Update|0_2(ref Program....
Gravity.dll!Program.<Main>$(string[] args) Line 387
Ready
C:\Users\Rashid\OneDrive\De
Level: 0 Gravity: ○
Air: Satisfactory
Tomorrow
Search
ENG
IN
10:02 PM
4/25/2025


File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
Debug
GitHub Copilot
Program.cs
Program.cs
Program.cs
Gravity
Direction
None
644
645 if (gameState.HasFlag(GameState.Died))
646 {
647 Render();
648 Console.WriteLine("You died. Press enter to retry level.")
649 PressToContinue();
650 PlayerPosition = GetStartingPlayerPositionFromLevel();
651 gravity = Direction.None;
652 velocity = (0, 0);
653 gameState = GameState.Default;
654 }
655 else if (gameState.HasFlag(GameState.Won))
656 {
657 Render();
658 if (level >= levels.Length - 1)
659 {
660 Console.WriteLine("You Won. You beat all the levels! (
661 Console.WriteLine("Press enter to exit game...");
662 PressToContinue();
663 closeRequested = true;
664 return;
665 }
666 Console.WriteLine("You Won. Press enter to move to the nex
667 PressToContinue();
668 Console.Clear();
669 level=level + 2;
670 PlayerPosition = GetStartingPlayerPositionFromLevel();
671 gravity = Direction.None;
672 velocity = (0, 0);
673 gameState = GameState.Default;
674 }
675 }
676
80 %
No issues found
Ln: 673 Ch: 33 Col: 39 TA
Solution Explorer
Search Solution Explorer (Ctrl+
Solution 'dotnet-console-gai
GitHub Actions
2048
Battleship
Beep Pad
Blackjack
Bound
Checkers
Clicker
Connect 4
Console Monsters
Darts
Dice Game
Draw
Drive
GitHu... Soluti... Git C... Class...
Properties
Output
Show output from: Debug
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program Files\Microsoft Visual
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program Files\dotnet\shared\Mic
The thread '.NET TP Worker' (596) has exited with code 0 (0x0).
The thread '.NET TP Worker' (13364) has exited with code 0 (0x0).
The thread '.NET TP Worker' (6952) has exited with code 0 (0x0).
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program Files\dotnet\shared\Mic
The program '[3668] Gravity.exe' has exited with code 4294967295 (0xffffffff
Ready
0 / 0
1
main
dotnet-console-games

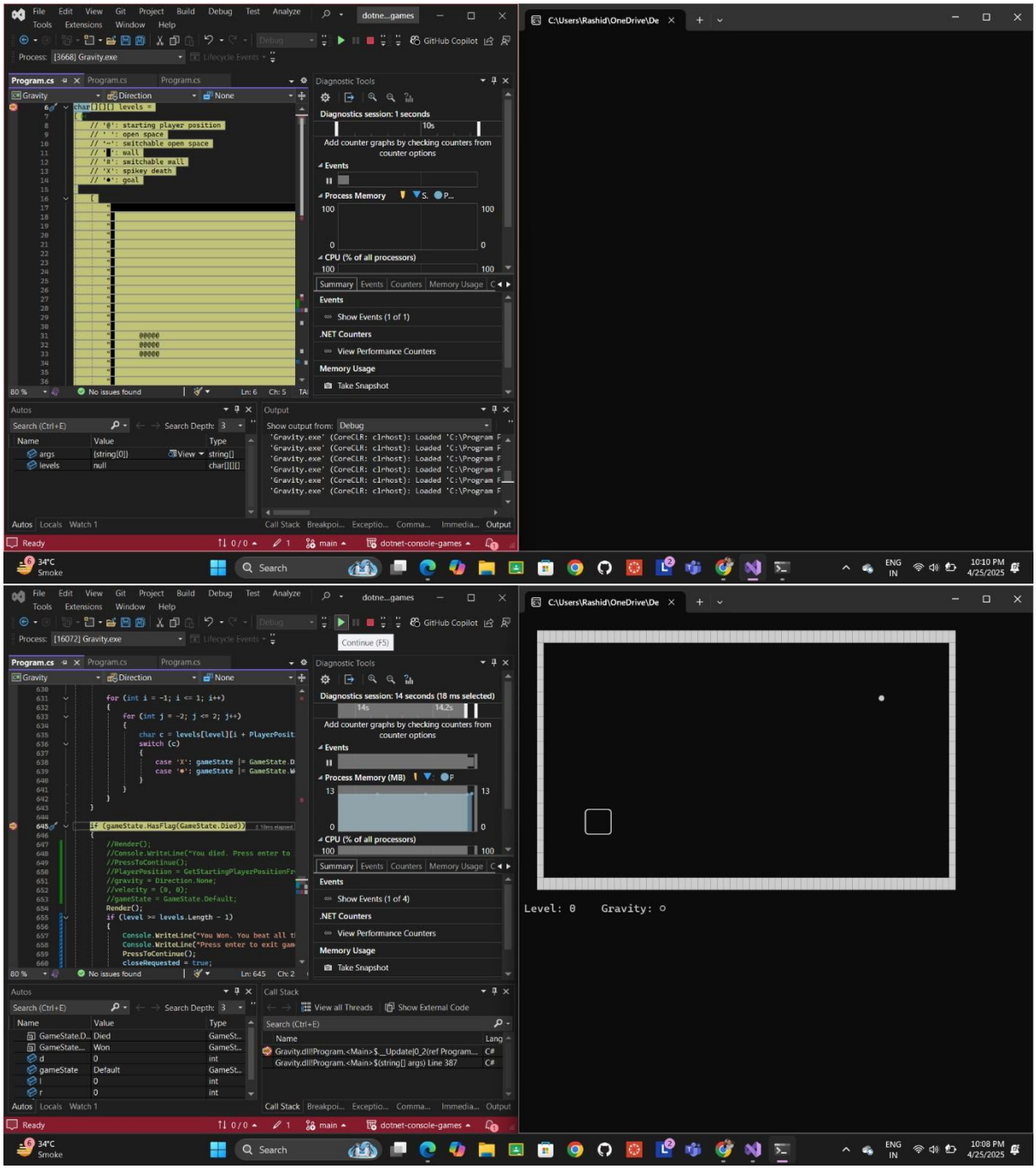

File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
Debug
GitHub Copilot
Program.cs*
Program.cs
Program.cs
Gravity
Direction
None
644
645 if (gameState.HasFlag(GameState.Died))
646 {
647 //Render();
648 //Console.WriteLine("You died. Press enter to retry level.
649 //PressToContinue();
650 //PlayerPosition = GetStartingPlayerPositionFromLevel();
651 //gravity = Direction.None;
652 //velocity = (0, 0);
653 //gameState = GameState.Default;
654 Render();
655 if (level >= levels.Length - 1)
656 {
657 Console.WriteLine("You Won. You beat all the levels! (
658 Console.WriteLine("Press enter to exit game...");
659 PressToContinue();
660 closeRequested = true;
661 return;
662 }
663 Console.WriteLine("You Won. Press enter to move to the ne
664 PressToContinue();
665 Console.Clear();
666 level = level + 2;
667 PlayerPosition = GetStartingPlayerPositionFromLevel();
668 gravity = Direction.None;
669 velocity = (0, 0);
670 gameState = GameState.Default;
671 }
672 else if (gameState.HasFlag(GameState.Won))
673 {
674 Render();
675 if (level >= levels.Length - 1)
676 {
80 %
No issues found
Ln: 659 Ch: 22 Col: 31
Solution Explorer
Search Solution Explorer (Ctrl+
Solution 'dotnet-console-gai
GitHub Actions
2048
Battleship
Beep Pad
Blackjack
Bound
Checkers
Clicker
Connect 4
Console Monsters
Darts
Dice Game
Draw
Drive
GitHu...
Soluti...
Git C...
Class...
Properties
Output
Show output from: Debug
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program Files\Microsoft Visual
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program Files\dotnet\shared\Mic
The thread '.NET TP Worker' (596) has exited with code 0 (0x0).
The thread '.NET TP Worker' (13364) has exited with code 0 (0x0).
The thread '.NET TP Worker' (6952) has exited with code 0 (0x0).
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program Files\dotnet\shared\Mic
The program '[3668] Gravity.exe' has exited with code 4294967295 (0xffffffff
Ready
0 / 0
1
main
dotnet-console-games


Process: [16072] Gravity.exe
Program.cs
Diagnostic Tools
Diagnostics session: 2 seconds (5 ms selected)
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Reach the goal (●) by using the [arrow keys] o
manipulate gravity. Watch out for spikes (X).
[spacebar] to toggle (#) walls and (~) spaces
Press [escape] to close the game at any time.
Press [enter] to begin...
Show Events (1 of 2)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
No issues found
Autos
PlayerPosition (9, 15)
Call Stack
Gravity.dll!Program.<Main>$(string[] args) Line 364
Ready
main
dotnet-console-games
C:\Users\Rashid\OneDrive\De
34°C
Smoke
10:08 PM
4/25/2025

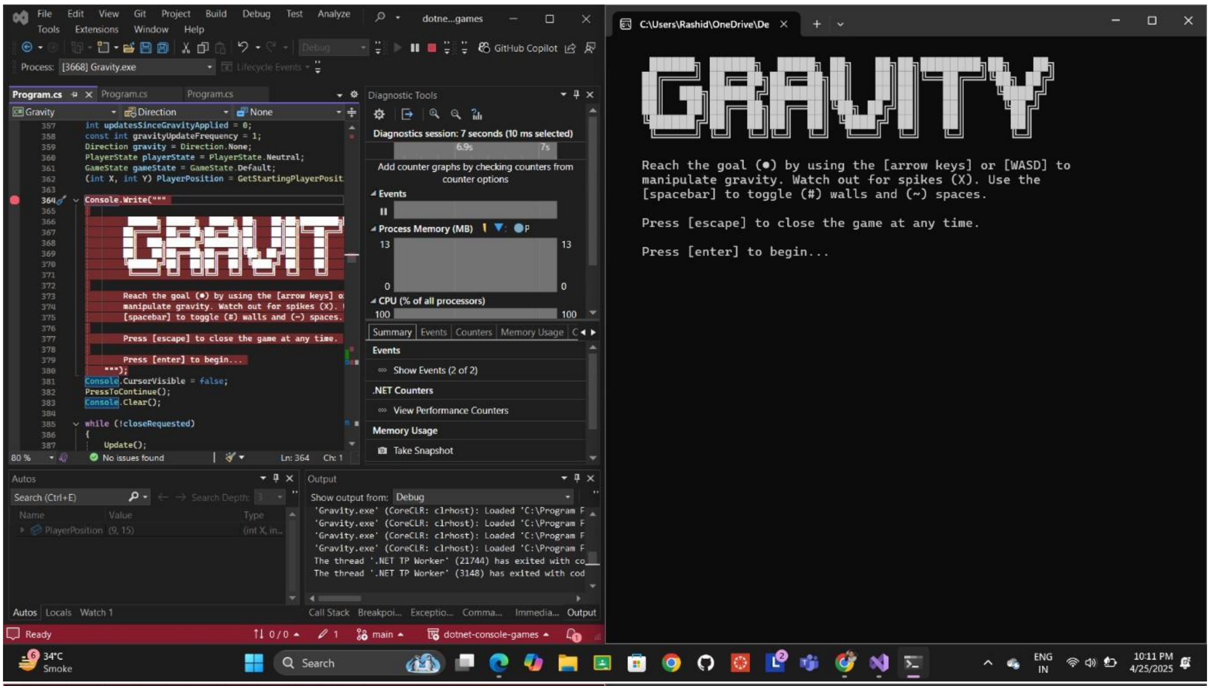

Process: [16072] Gravity.exe
Start collaboration session
Program.cs
Diagnostic Tools
Diagnostics session: 2 seconds
Add counter graphs by checking counters from counter options
char[][][] levels =
// '@': starting player position
// ' ': open space
// '~': switchable open space
// '█': wall
// '#': switchable wall
// 'X': spikey death
// '●': goal
Show Events (1 of 1)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
No issues found
Autos
args {string[0]} string[]
levels null char[][][]
Call Stack
Gravity.dll!Program.<Main>$(string[] args) Line 6
Ready
main
dotnet-console-games
C:\Users\Rashid\OneDrive\De
34°C
Smoke
10:08 PM
4/25/2025

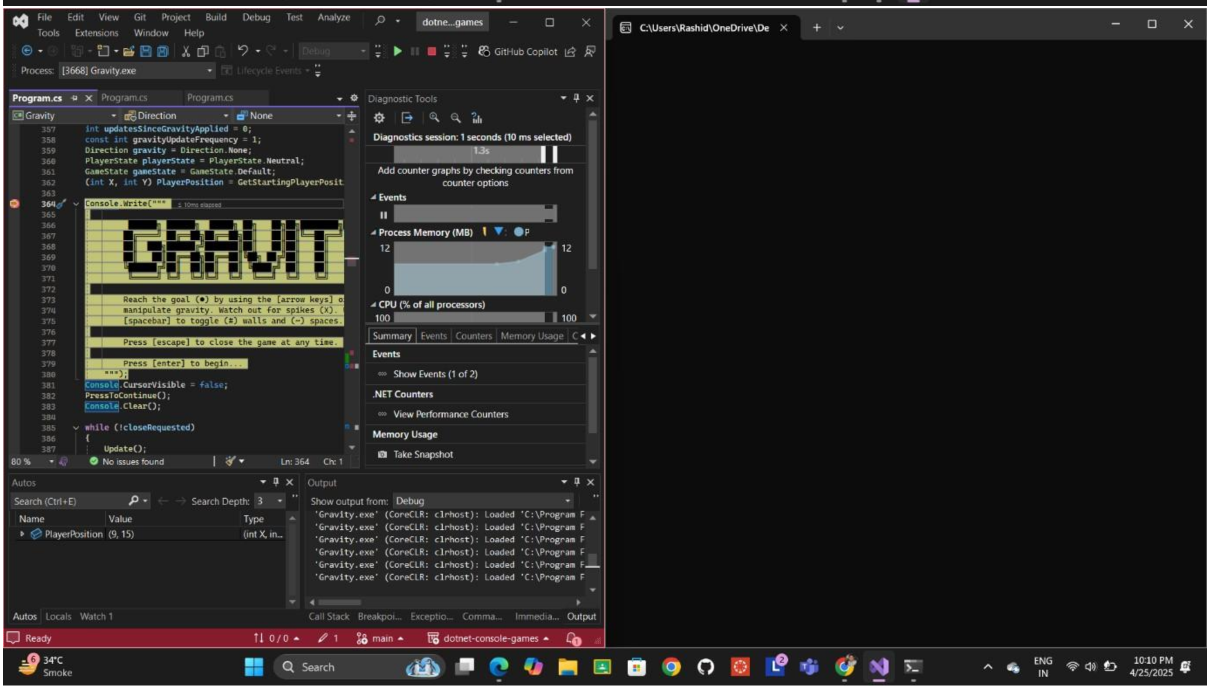

File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [16072] Gravity.exe
Program.cs
Diagnostic Tools
Diagnostics session: 14 seconds (11.359 s selected)
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Summary Events Counters Memory Usage
Show Events (1 of 3)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
Autos
Call Stack
Ready
C:\Users\Rashid\OneDrive\De
34°C Smoke
Search
ENG IN
10:08 PM 4/25/2025

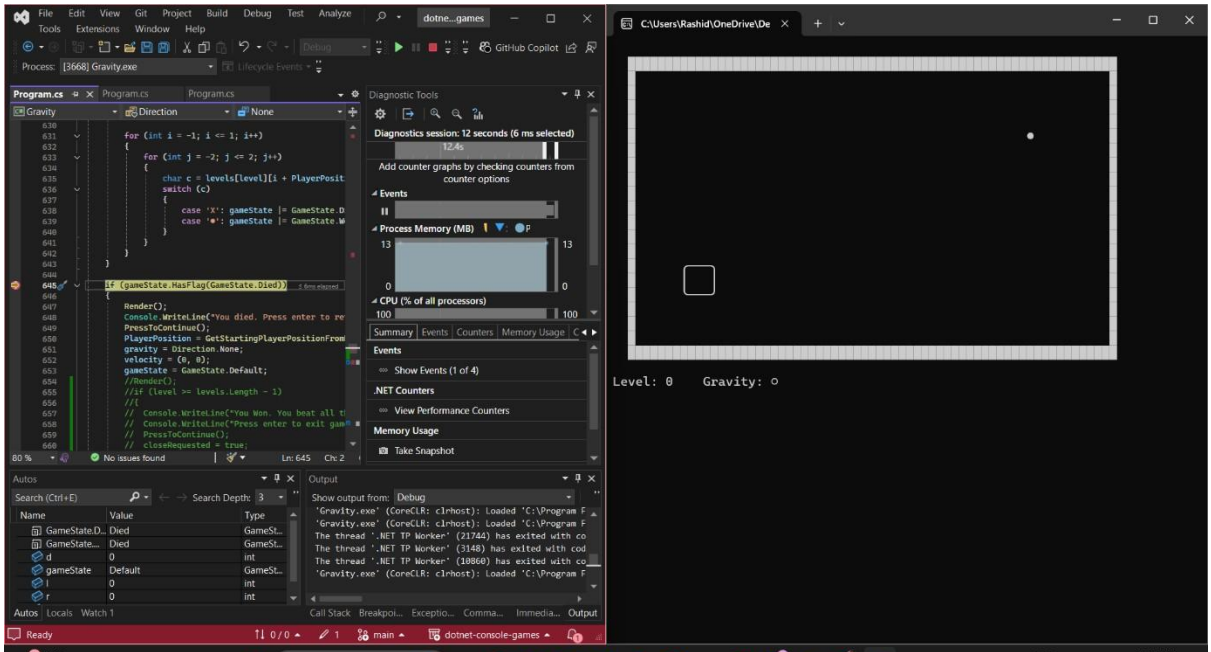
File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [16072] Gravity.exe
Program.cs
Diagnostic Tools
Diagnostics session: 9 seconds (5 ms selected)
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Summary Events Counters Memory Usage
Show Events (2 of 2)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
Autos
Call Stack
Ready
C:\Users\Rashid\OneDrive\De
Close (Shift+Esc)
GRAVITY
Reach the goal (●) by using the [arrow keys] or [WASD] to manipulate gravity. Watch out for spikes (X). Use the [spacebar] to toggle (#) walls and (~) spaces.
Press [escape] to close the game at any time.
Press [enter] to begin...
34°C Smoke
Search
ENG IN
10:08 PM 4/25/2025

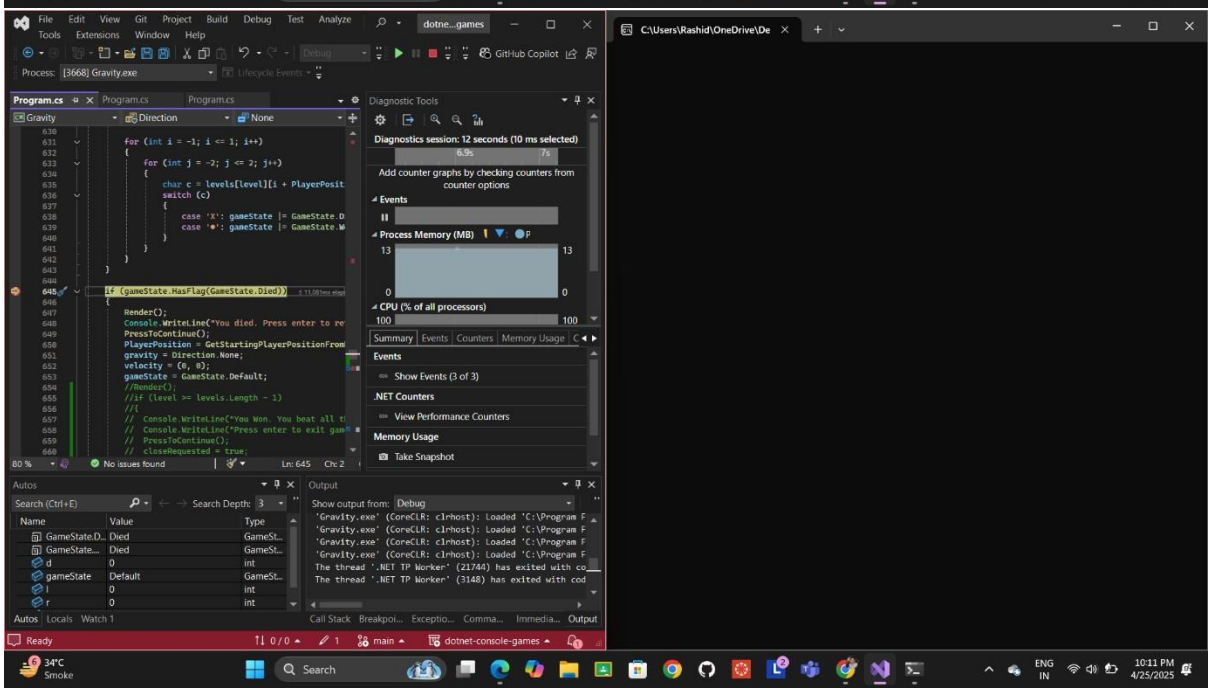

File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [3668] Gravity.exe
Program.cs
Diagnostic Tools
Diagnostics session: 1 seconds
Add counter graphs by checking counters from counter options
Events
Process Memory
CPU (% of all processors)
Summary Events Counters Memory Usage
Show Events (1 of 1)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
Autos
Search (Ctrl+E)
Search Depth: 3
Name Value Type
args {string[0]} string[]
levels null char[][][]
Output
Show output from: Debug
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program F
Autos Locals Watch 1
Call Stack Breakpoi... Exceptio... Comma... Immedia... Output
Ready
main
dotnet-console-games
C:\Users\Rashid\OneDrive\De
34°C
Smoke
Search
ENG
IN
10:10 PM
4/25/2025

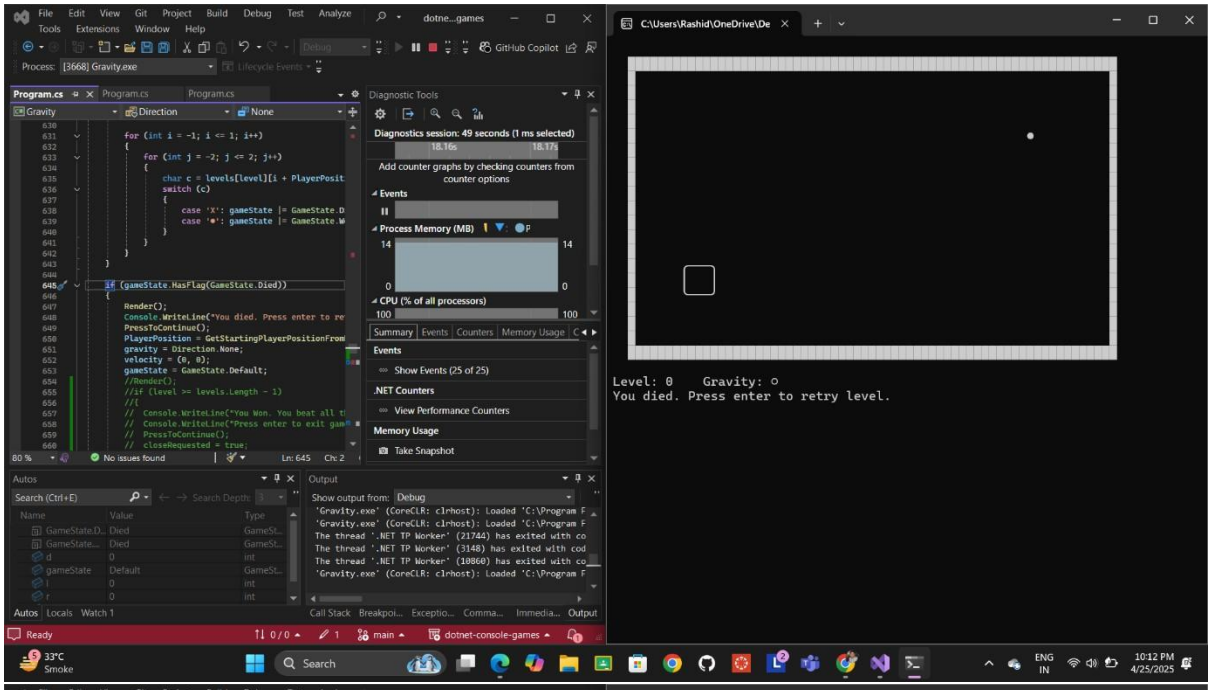
File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [16072] Gravity.exe
Continue (F5)
Program.cs
Diagnostic Tools
Diagnostics session: 14 seconds (18 ms selected)
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Summary Events Counters Memory Usage
Show Events (1 of 4)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
Autos
Search (Ctrl+E)
Search Depth: 3
Name Value Type
GameState.D... Died GameSt...
GameState.... Won GameSt...
d 0 int
gameState Default GameSt...
l 0 int
r 0 int
Call Stack
View all Threads
Show External Code
Name Lang
Gravity.dll!Program.<Main>$__Update|0_2(ref Program.... C#
Gravity.dll!Program.<Main>$(string[] args) Line 387 C#
Autos Locals Watch 1
Call Stack Breakpoi... Exceptio... Comma... Immedia... Output
Ready
main
dotnet-console-games
C:\Users\Rashid\OneDrive\De
Level: 0 Gravity: 0
34°C
Smoke
Search
ENG
IN
10:08 PM
4/25/2025

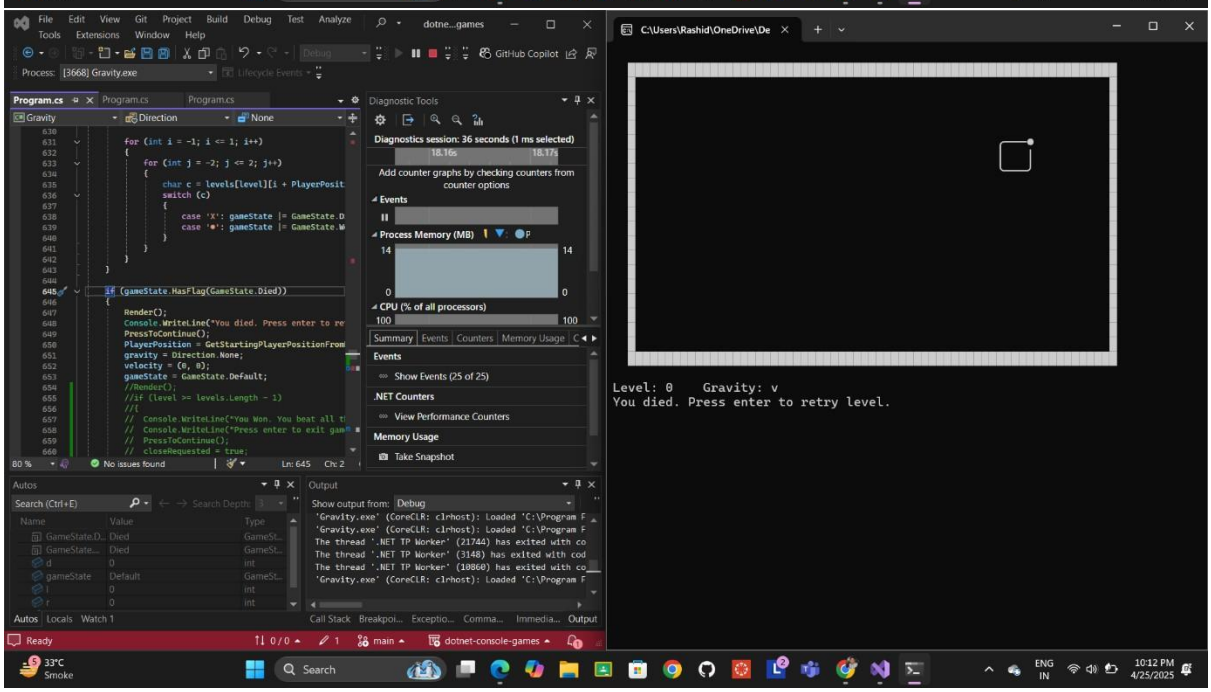

GRAVITY
Reach the goal (●) by using the [arrow keys] or [WASD] to manipulate gravity. Watch out for spikes (X). Use the [spacebar] to toggle (#) walls and (~) spaces.
Press [escape] to close the game at any time.
Press [enter] to begin...

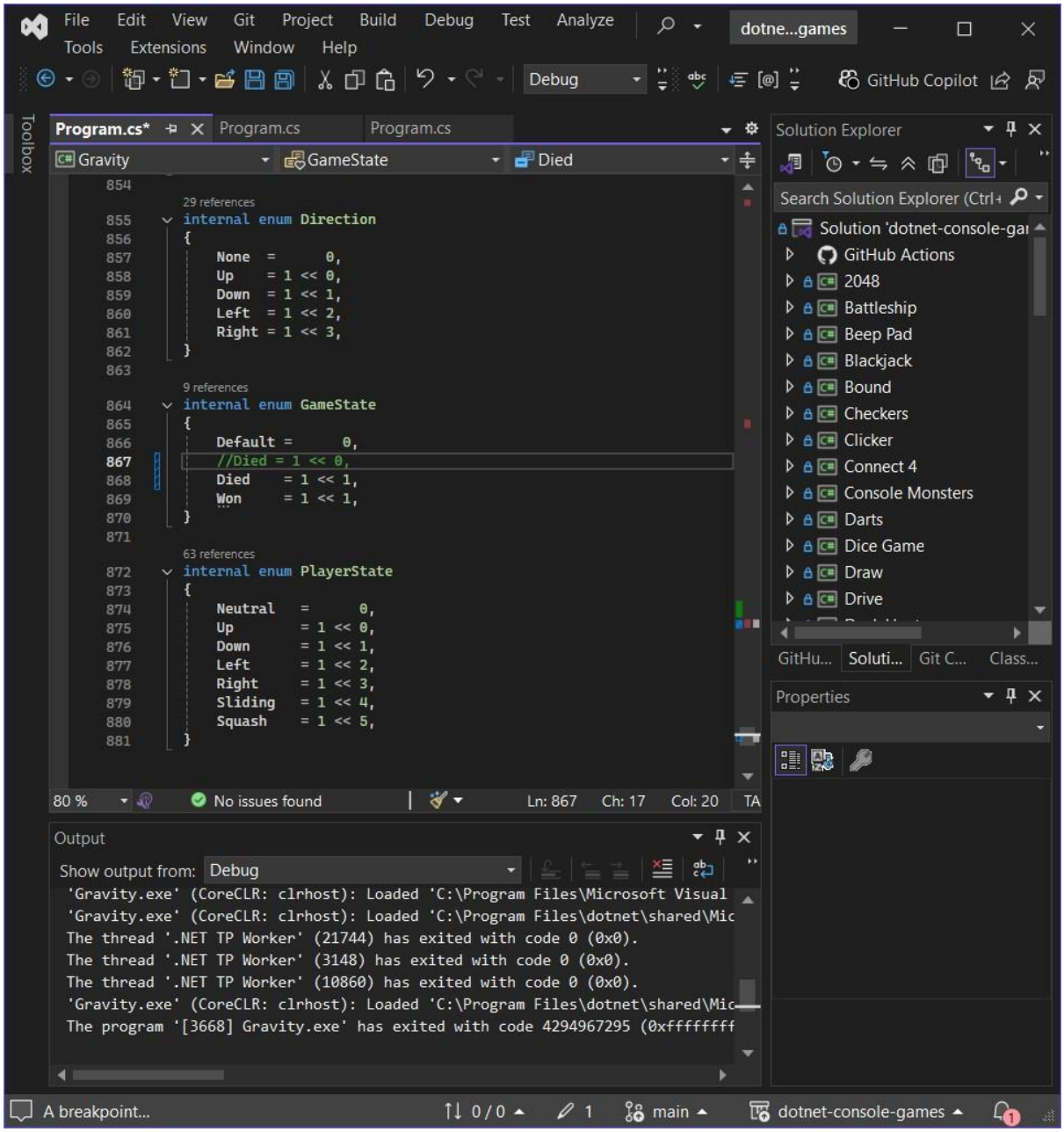


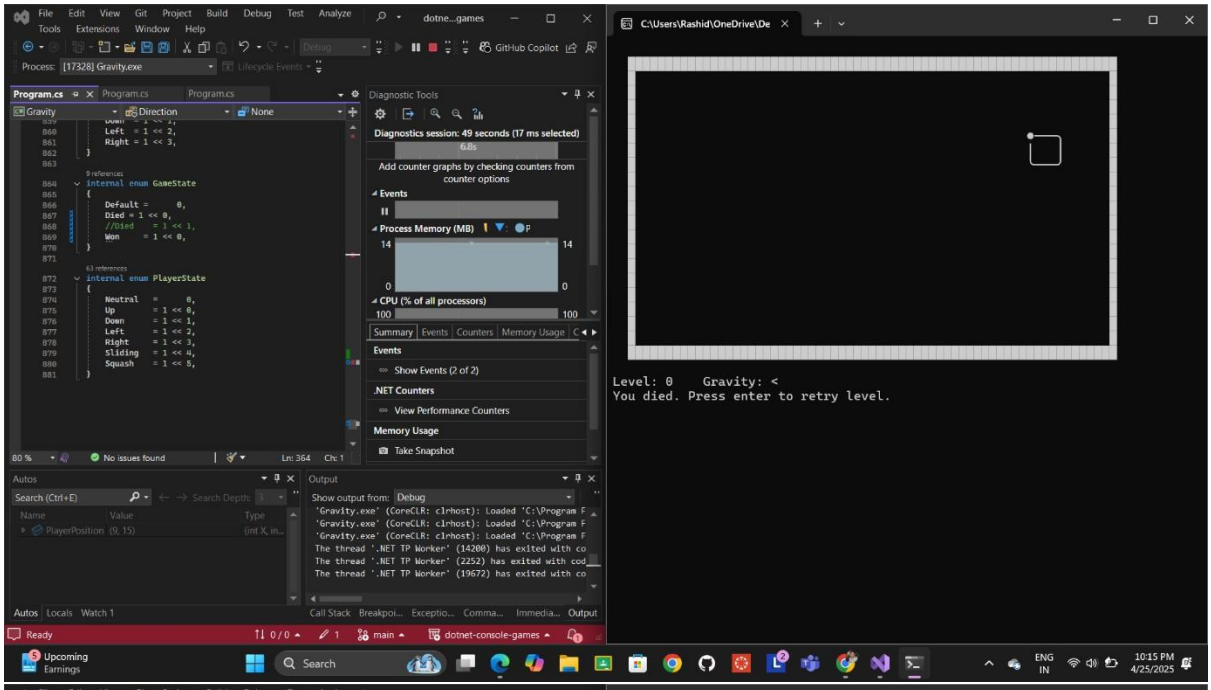

File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [3668] Gravity.exe
Program.cs
Diagnostic Tools
Diagnostics session: 12 seconds (6 ms selected)
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Summary
Events
Counters
Memory Usage
Show Events (1 of 4)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
Autos
Search (Ctrl+E)
Search Depth: 3
Name
Value
Type
Output
Show output from: Debug
Ready
C:\Users\Rashid\OneDrive\De
Level: 0 Gravity: o

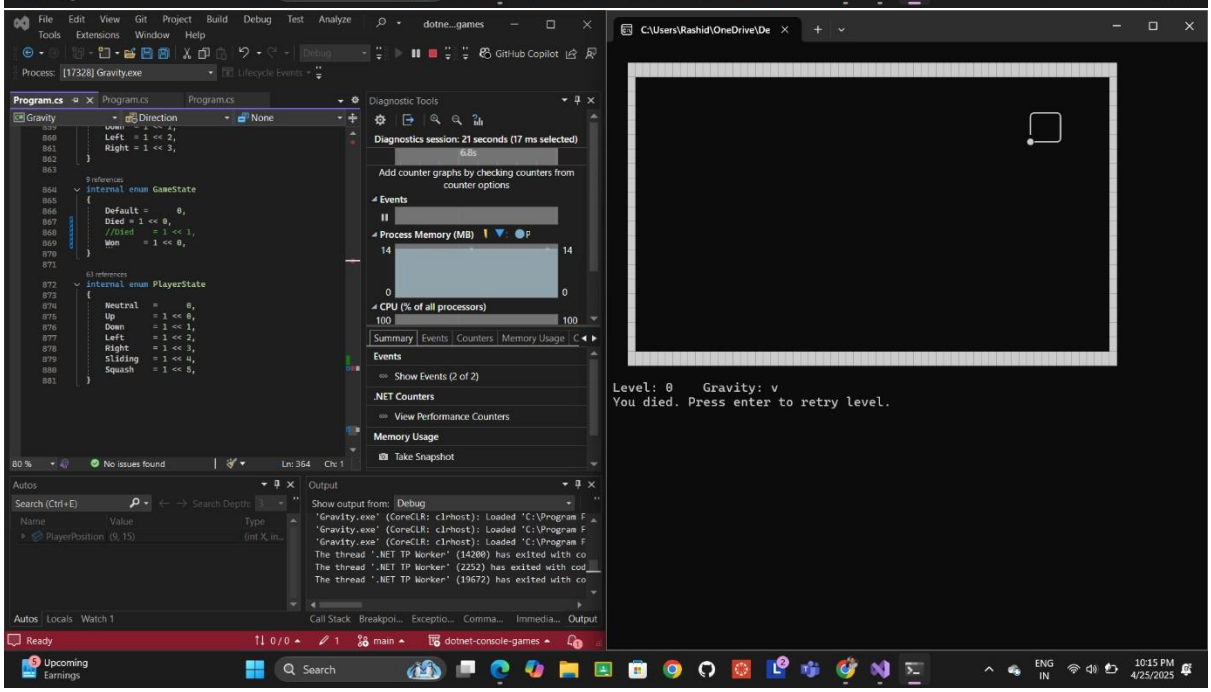

File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [3668] Gravity.exe
Program.cs
Diagnostic Tools
Diagnostics session: 12 seconds (10 ms selected)
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Summary
Events
Counters
Memory Usage
Show Events (3 of 3)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
Autos
Search (Ctrl+E)
Search Depth: 3
Name
Value
Type
Output
Show output from: Debug
Ready
C:\Users\Rashid\OneDrive\De

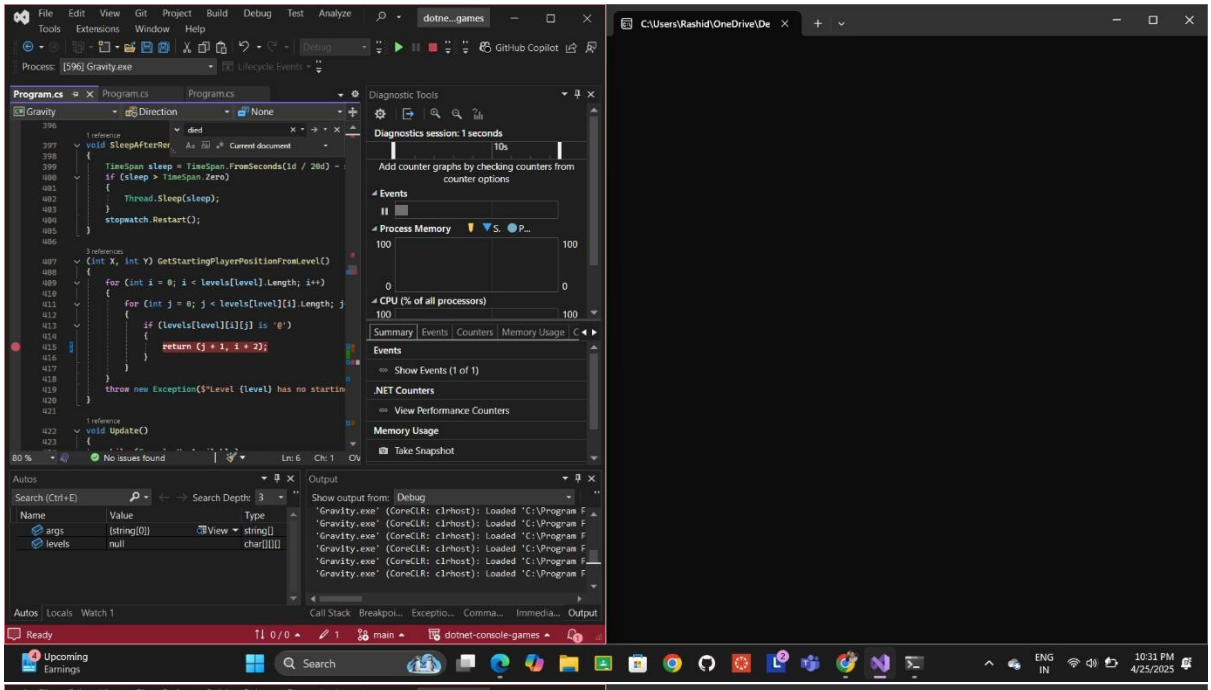

C:\Users\Rashid\OneDrive\De
Level: 0 Gravity: ○
You died. Press enter to retry level.

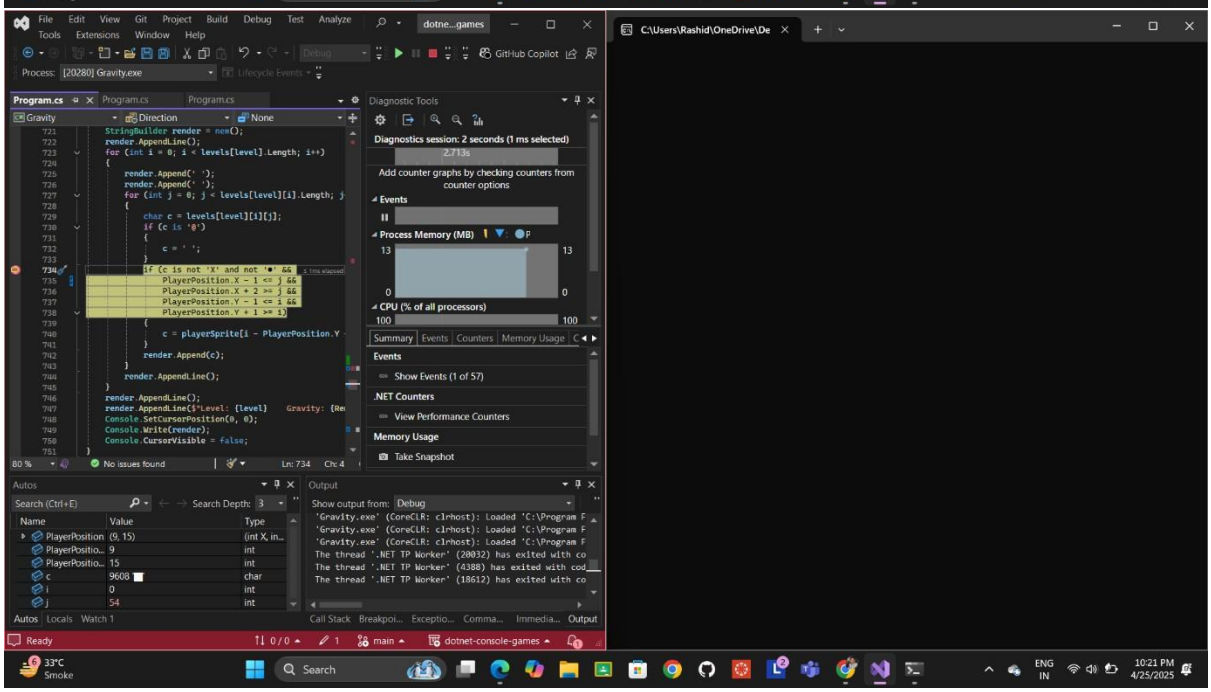

C:\Users\Rashid\OneDrive\De
Level: 0 Gravity: v
You died. Press enter to retry level.

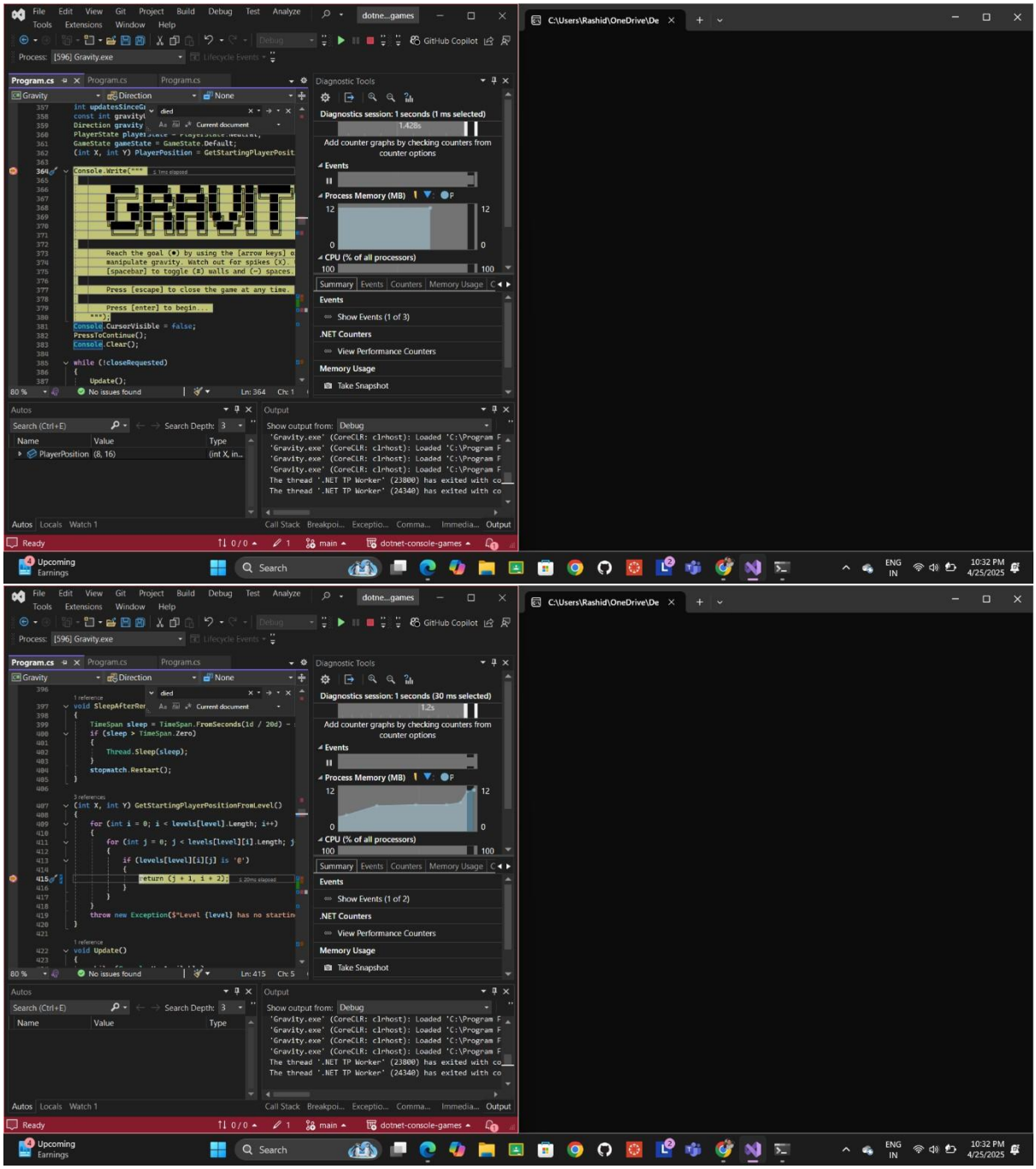

File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
Debug
GitHub Copilot
Program.cs*
Program.cs
Program.cs
Gravity
GameState
Died
29 references
internal enum Direction
{
None = 0,
Up = 1 << 0,
Down = 1 << 1,
Left = 1 << 2,
Right = 1 << 3,
}
9 references
internal enum GameState
{
Default = 0,
//Died = 1 << 0,
Died = 1 << 1,
Won = 1 << 1,
}
63 references
internal enum PlayerState
{
Neutral = 0,
Up = 1 << 0,
Down = 1 << 1,
Left = 1 << 2,
Right = 1 << 3,
Sliding = 1 << 4,
Squash = 1 << 5,
}
80 %
No issues found
Ln: 867
Ch: 17
Col: 20
Solution Explorer
Search Solution Explorer (Ctrl+
Solution 'dotnet-console-gai
GitHub Actions
2048
Battleship
Beep Pad
Blackjack
Bound
Checkers
Clicker
Connect 4
Console Monsters
Darts
Dice Game
Draw
Drive
GitHu...
Soluti...
Git C...
Class...
Properties
Output
Show output from: Debug
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program Files\Microsoft Visual
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program Files\dotnet\shared\Mic
The thread '.NET TP Worker' (21744) has exited with code 0 (0x0).
The thread '.NET TP Worker' (3148) has exited with code 0 (0x0).
The thread '.NET TP Worker' (10860) has exited with code 0 (0x0).
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program Files\dotnet\shared\Mic
The program '[3668] Gravity.exe' has exited with code 4294967295 (0xffffffff
A breakpoint...
0 / 0
1
main
dotnet-console-games


Level: 0 Gravity: <
You died. Press enter to retry level.

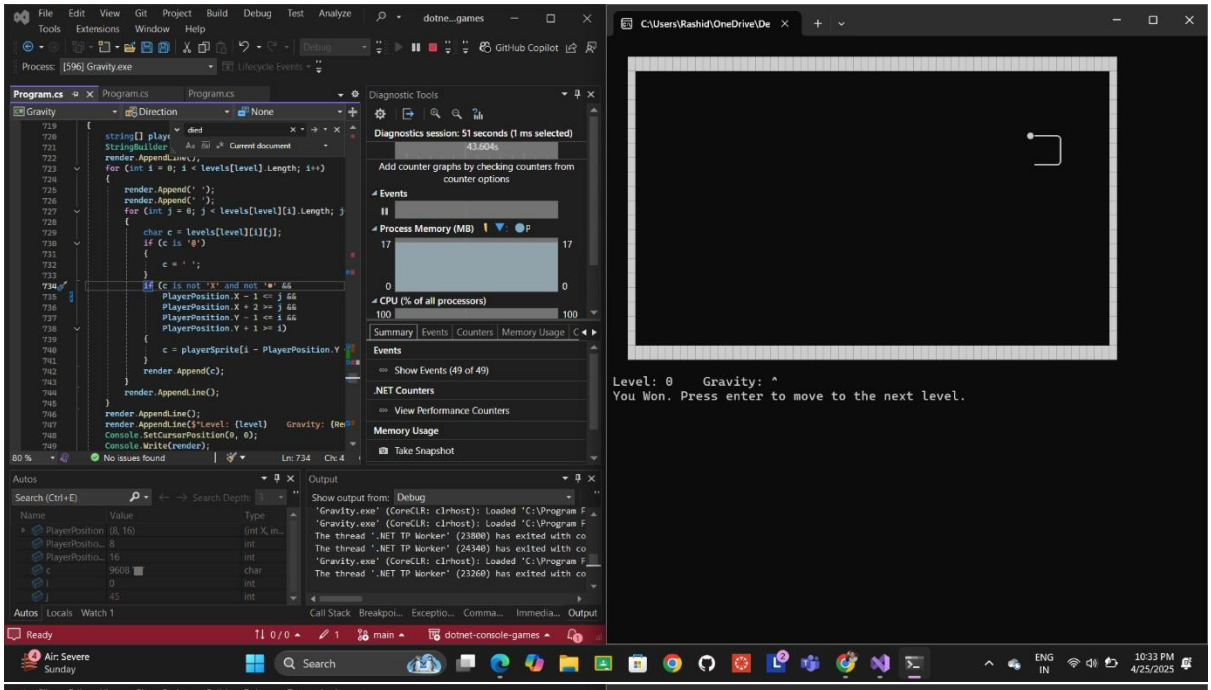

Level: 0 Gravity: v
You died. Press enter to retry level.

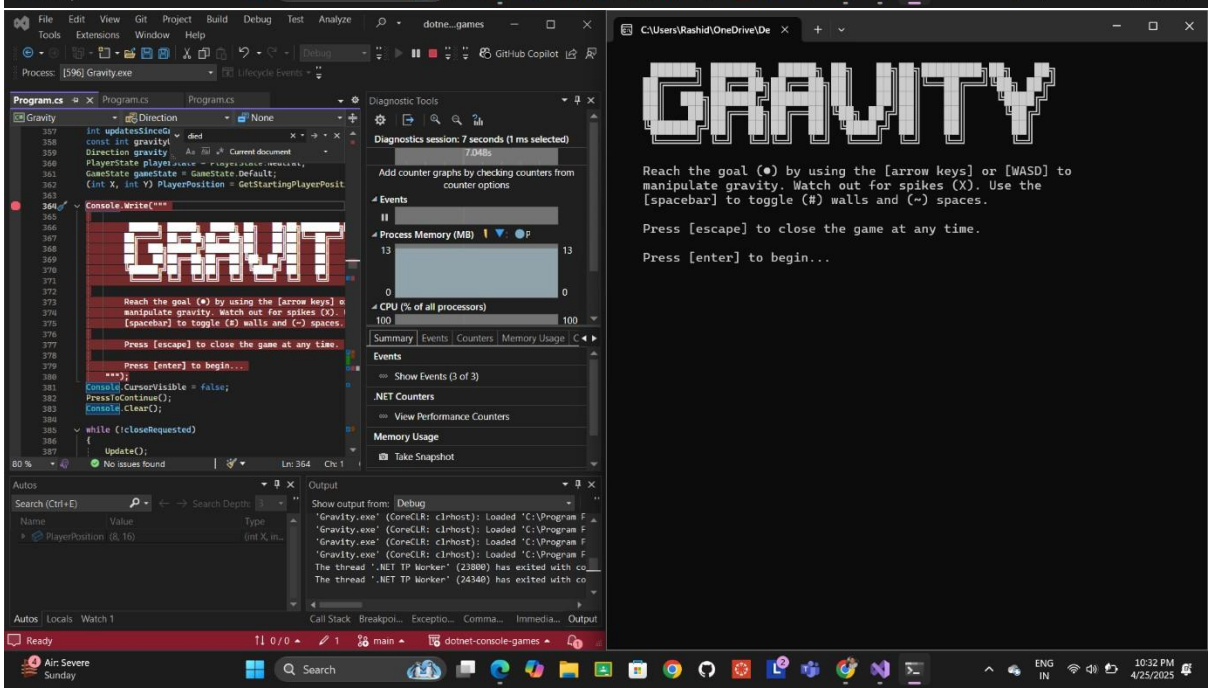

File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [596] Gravity.exe
Program.cs
Diagnostic Tools
Diagnostics session: 1 seconds
Add counter graphs by checking counters from counter options
Events
Process Memory
CPU (% of all processors)
Summary Events Counters Memory Usage
Show Events (1 of 1)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
Autos
Search (Ctrl+E)
Search Depth: 3
Name Value Type
args {string[0]} string[]
levels null char[][][]
Output
Show output from: Debug
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program F
Autos Locals Watch 1
Call Stack Breakpoi... Exceptio... Comma... Immedia... Output
Ready
C:\Users\Rashid\OneDrive\De
Upcoming Earnings
Search
ENG IN
10:31 PM 4/25/2025

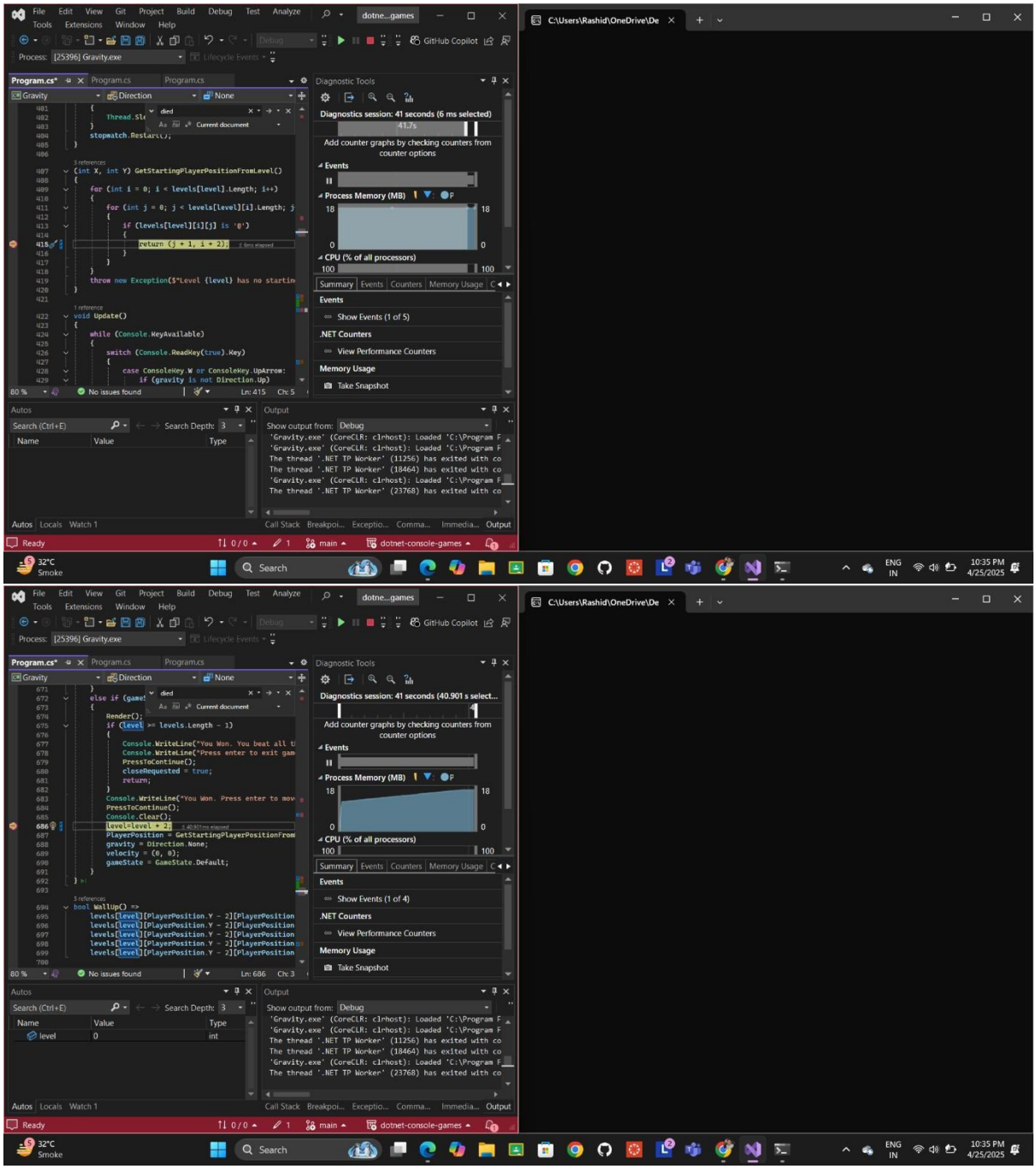

File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [20280] Gravity.exe
Program.cs
Diagnostic Tools
Diagnostics session: 2 seconds (1 ms selected)
2.713s
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Summary Events Counters Memory Usage
Show Events (1 of 57)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
Autos
Search (Ctrl+E)
Search Depth: 3
Name Value Type
PlayerPosition {9, 15} {int X, in...
PlayerPositio... 9 int
PlayerPositio... 15 int
c 9608 char
i 0 int
j 54 int
Output
Show output from: Debug
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program F
The thread '.NET TP Worker' (20032) has exited with co
The thread '.NET TP Worker' (4388) has exited with cod
The thread '.NET TP Worker' (18612) has exited with co
Autos Locals Watch 1
Call Stack Breakpoi... Exceptio... Comma... Immedia... Output
Ready
C:\Users\Rashid\OneDrive\De
33°C Smoke
Search
ENG IN
10:21 PM 4/25/2025


File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [596] Gravity.exe
Program.cs
Diagnostic Tools
Diagnostics session: 1 seconds (1 ms selected)
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Summary Events Counters Memory Usage
Show Events (1 of 3)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
Reach the goal (●) by using the [arrow keys] o
manipulate gravity. Watch out for spikes (X).
[spacebar] to toggle (#) walls and (-) spaces.
Press [escape] to close the game at any time.
Press [enter] to begin...
Console.CursorVisible = false;
PressToContinue();
Console.Clear();
while (!closeRequested)
Update();
No issues found
Autos
Search (Ctrl+E)
Search Depth: 3
Name Value Type
PlayerPosition (8, 16) (int X, in...
Output
Show output from: Debug
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program F
The thread '.NET TP Worker' (23800) has exited with co
The thread '.NET TP Worker' (24340) has exited with co
Autos Locals Watch 1
Call Stack Breakpoi... Exceptio... Comma... Immedia... Output
Ready
main
dotnet-console-games
C:\Users\Rashid\OneDrive\De
Upcoming
Earnings
Search
ENG
IN
10:32 PM
4/25/2025

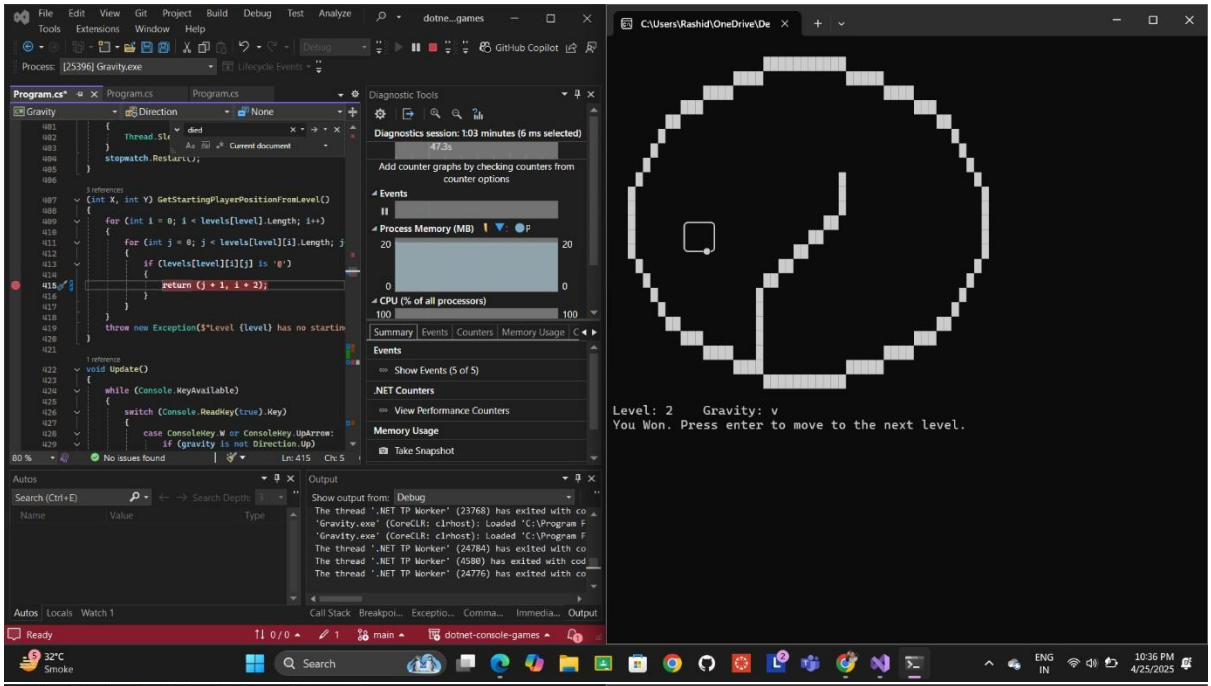
File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [596] Gravity.exe
Program.cs
Diagnostic Tools
Diagnostics session: 1 seconds (30 ms selected)
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Summary Events Counters Memory Usage
Show Events (1 of 2)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
void SleepAfterRender()
TimeSpan sleep = TimeSpan.FromSeconds(1d / 20d) -
if (sleep > TimeSpan.Zero)
Thread.Sleep(sleep);
stopwatch.Restart();
(int X, int Y) GetStartingPlayerPositionFromLevel()
for (int i = 0; i < levels[level].Length; i++)
for (int j = 0; j < levels[level][i].Length; j
if (levels[level][i][j] is '@')
return (j + 1, i + 2);
throw new Exception($"Level {level} has no startin
void Update()
No issues found
Autos
Search (Ctrl+E)
Search Depth: 3
Name Value Type
Output
Show output from: Debug
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program F
The thread '.NET TP Worker' (23800) has exited with co
The thread '.NET TP Worker' (24340) has exited with co
Autos Locals Watch 1
Call Stack Breakpoi... Exceptio... Comma... Immedia... Output
Ready
main
dotnet-console-games
C:\Users\Rashid\OneDrive\De
Upcoming
Earnings
Search
ENG
IN
10:32 PM
4/25/2025

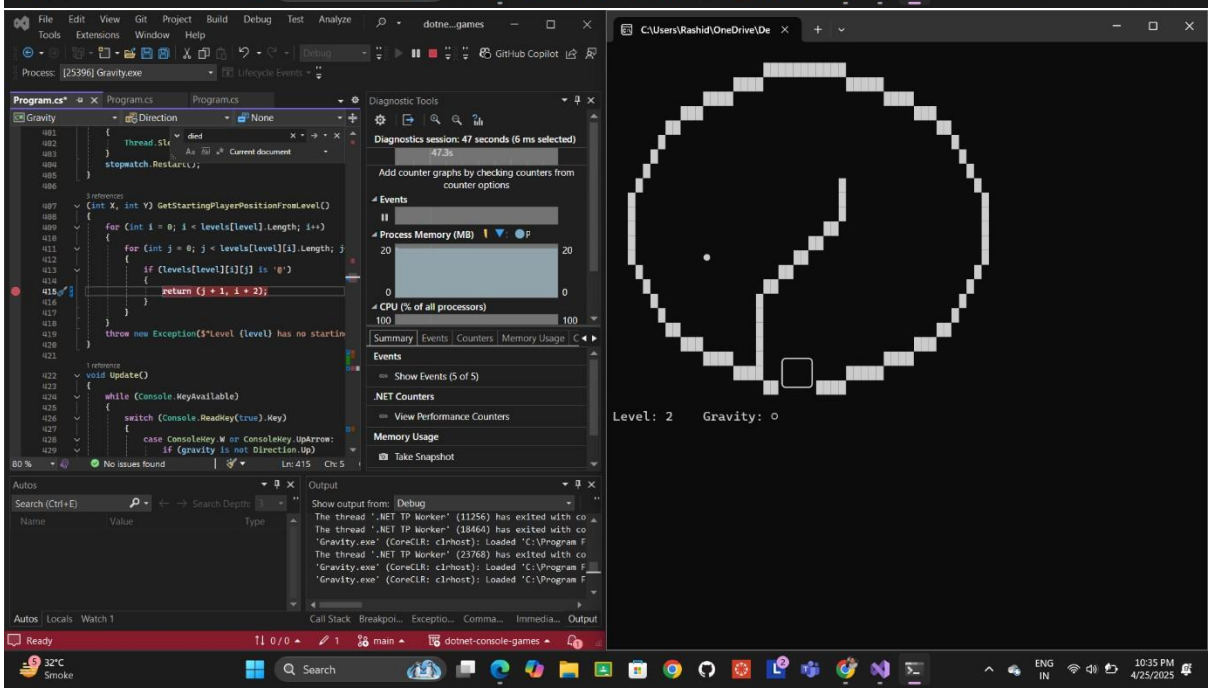

Level: 0 Gravity: ^
You Won. Press enter to move to the next level.

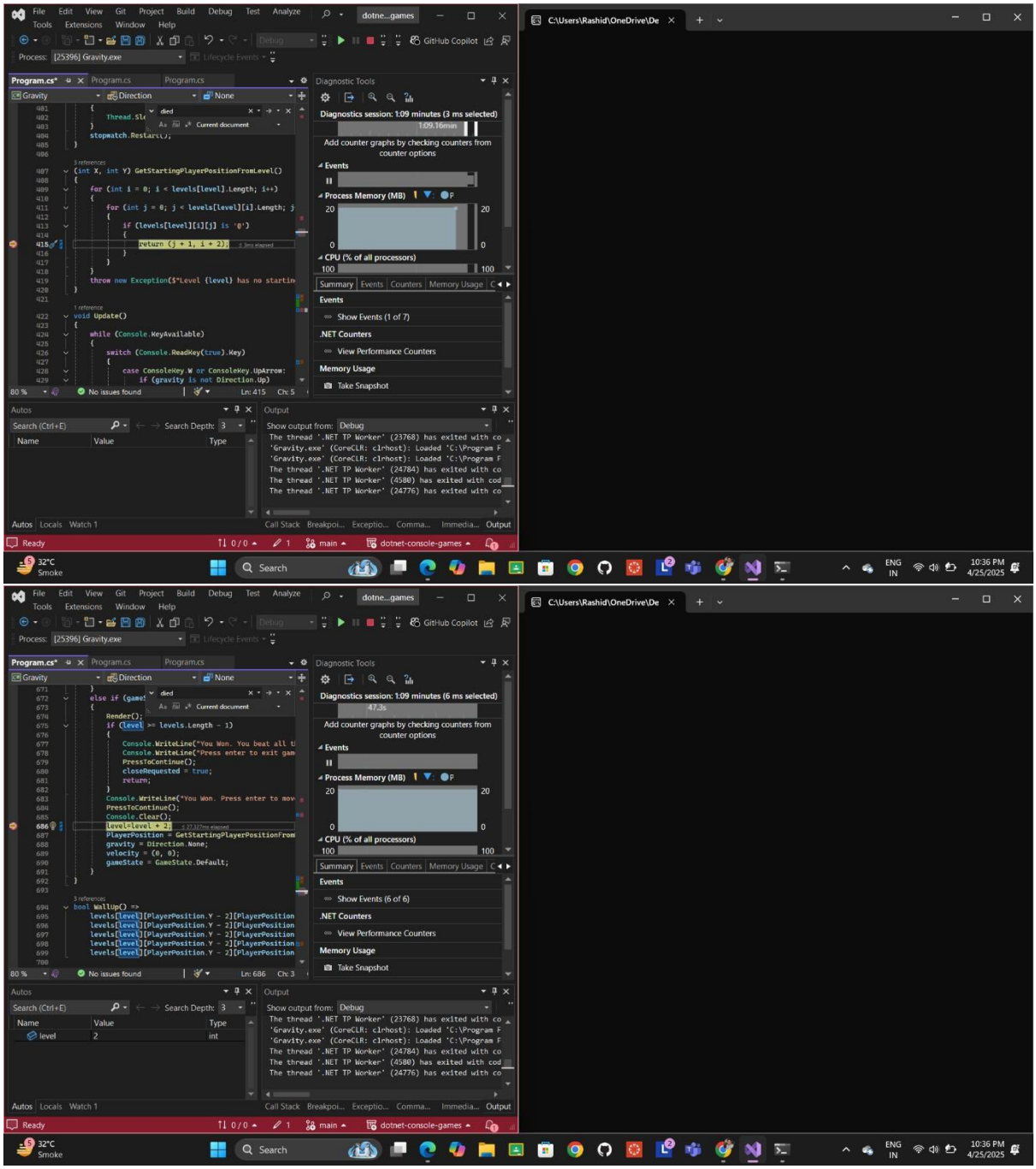

GRAVITY
Reach the goal (●) by using the [arrow keys] or [WASD] to manipulate gravity. Watch out for spikes (X). Use the [spacebar] to toggle (#) walls and (~) spaces.
Press [escape] to close the game at any time.
Press [enter] to begin...


File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [25396] Gravity.exe
Program.cs*
Program.cs
Gravity
Direction
None
Diagnostic Tools
Diagnostics session: 41 seconds (6 ms selected)
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Summary
Events
Counters
Memory Usage
Show Events (1 of 5)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
No issues found
Autos
Search (Ctrl+E)
Search Depth: 3
Name
Value
Type
Output
Show output from: Debug
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program F
The thread '.NET TP Worker' (11256) has exited with co
The thread '.NET TP Worker' (18464) has exited with co
The thread '.NET TP Worker' (23768) has exited with co
Autos
Locals
Watch 1
Call Stack
Breakpoi...
Exceptio...
Comma...
Immedia...
Output
Ready
main
dotnet-console-games
C:\Users\Rashid\OneDrive\De
32°C
Smoke
Search
ENG
IN
10:35 PM
4/25/2025

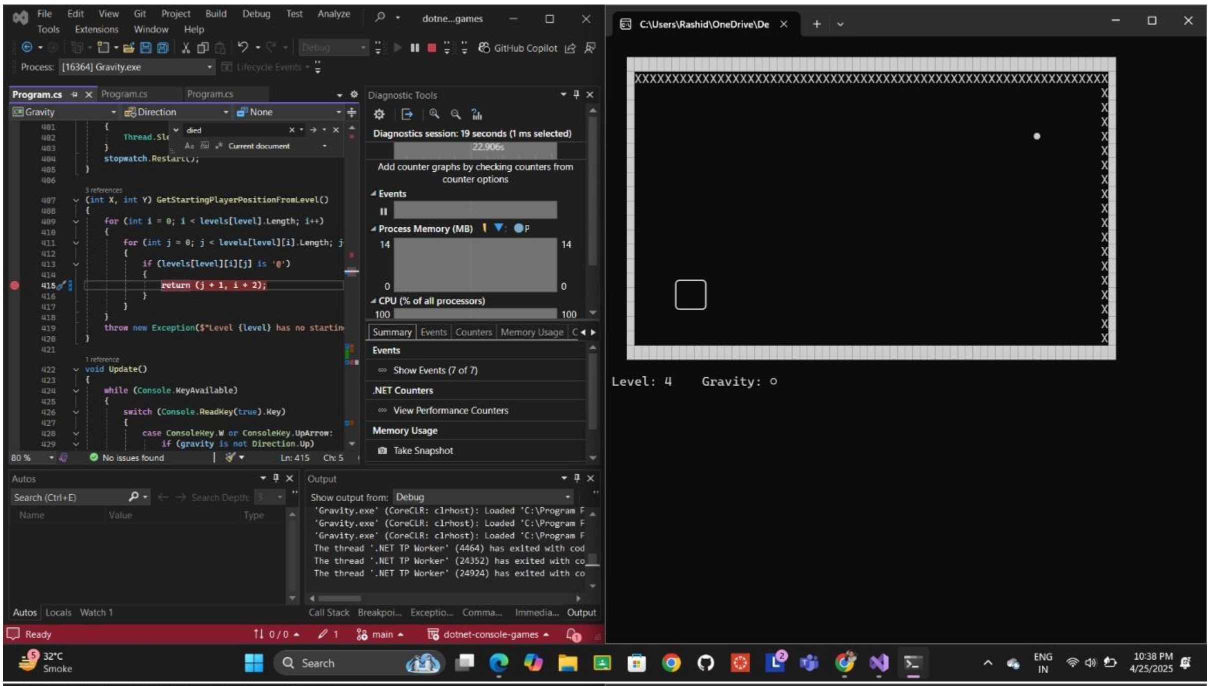
File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [25396] Gravity.exe
Program.cs*
Program.cs
Gravity
Direction
None
Diagnostic Tools
Diagnostics session: 41 seconds (40.901 s select...
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Summary
Events
Counters
Memory Usage
Show Events (1 of 4)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
No issues found
Autos
Search (Ctrl+E)
Search Depth: 3
Name
Value
Type
level
0
int
Output
Show output from: Debug
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program F
The thread '.NET TP Worker' (11256) has exited with co
The thread '.NET TP Worker' (18464) has exited with co
The thread '.NET TP Worker' (23768) has exited with co
Autos
Locals
Watch 1
Call Stack
Breakpoi...
Exceptio...
Comma...
Immedia...
Output
Ready
main
dotnet-console-games
C:\Users\Rashid\OneDrive\De
32°C
Smoke
Search
ENG
IN
10:35 PM
4/25/2025


Level: 2 Gravity: v
You Won. Press enter to move to the next level.

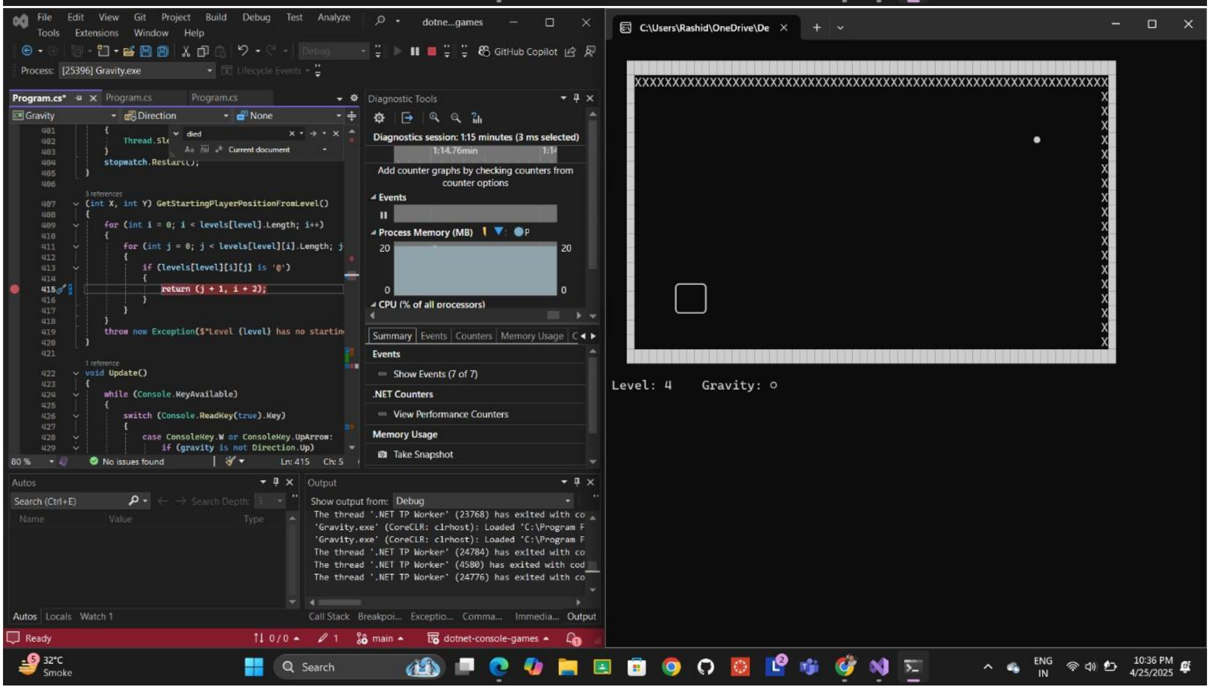

Level: 2 Gravity: o


File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [25396] Gravity.exe
Program.cs*
Program.cs
Gravity
Direction
None
Diagnostic Tools
Diagnostics session: 1:09 minutes (3 ms selected)
1:09.16min
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Summary
Events
Counters
Memory Usage
Show Events (1 of 7)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
No issues found
Autos
Search (Ctrl+E)
Search Depth: 3
Name
Value
Type
Output
Show output from: Debug
The thread '.NET TP Worker' (23768) has exited with co
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program F
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program F
The thread '.NET TP Worker' (24784) has exited with co
The thread '.NET TP Worker' (4580) has exited with cod
The thread '.NET TP Worker' (24776) has exited with co
Autos
Locals
Watch 1
Call Stack
Breakpoi...
Exceptio...
Comma...
Immedia...
Output
Ready
main
dotnet-console-games
C:\Users\Rashid\OneDrive\De
32°C
Smoke
Search
ENG
IN
10:36 PM
4/25/2025

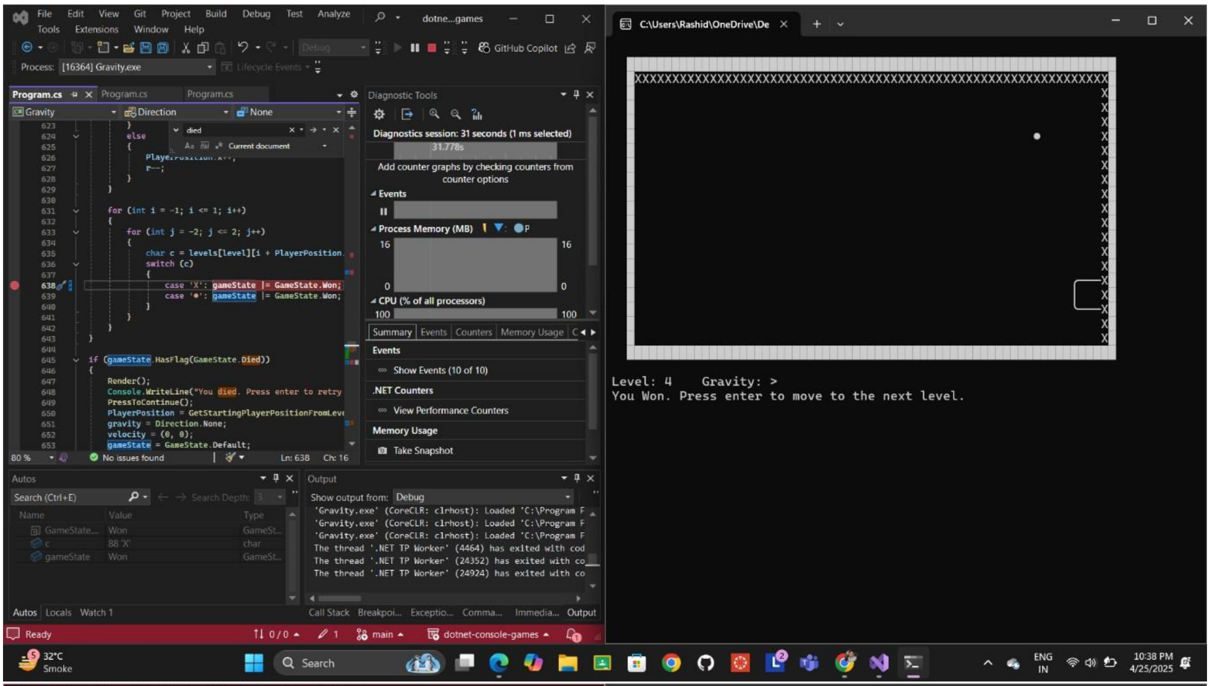
File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [25396] Gravity.exe
Program.cs*
Program.cs
Gravity
Direction
None
Diagnostic Tools
Diagnostics session: 1:09 minutes (6 ms selected)
47.3s
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Summary
Events
Counters
Memory Usage
Show Events (6 of 6)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
No issues found
Autos
Search (Ctrl+E)
Search Depth: 3
Name
Value
Type
level
2
int
Output
Show output from: Debug
The thread '.NET TP Worker' (23768) has exited with co
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program F
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program F
The thread '.NET TP Worker' (24784) has exited with co
The thread '.NET TP Worker' (4580) has exited with cod
The thread '.NET TP Worker' (24776) has exited with co
Autos
Locals
Watch 1
Call Stack
Breakpoi...
Exceptio...
Comma...
Immedia...
Output
Ready
main
dotnet-console-games
C:\Users\Rashid\OneDrive\De
32°C
Smoke
Search
ENG
IN
10:36 PM
4/25/2025

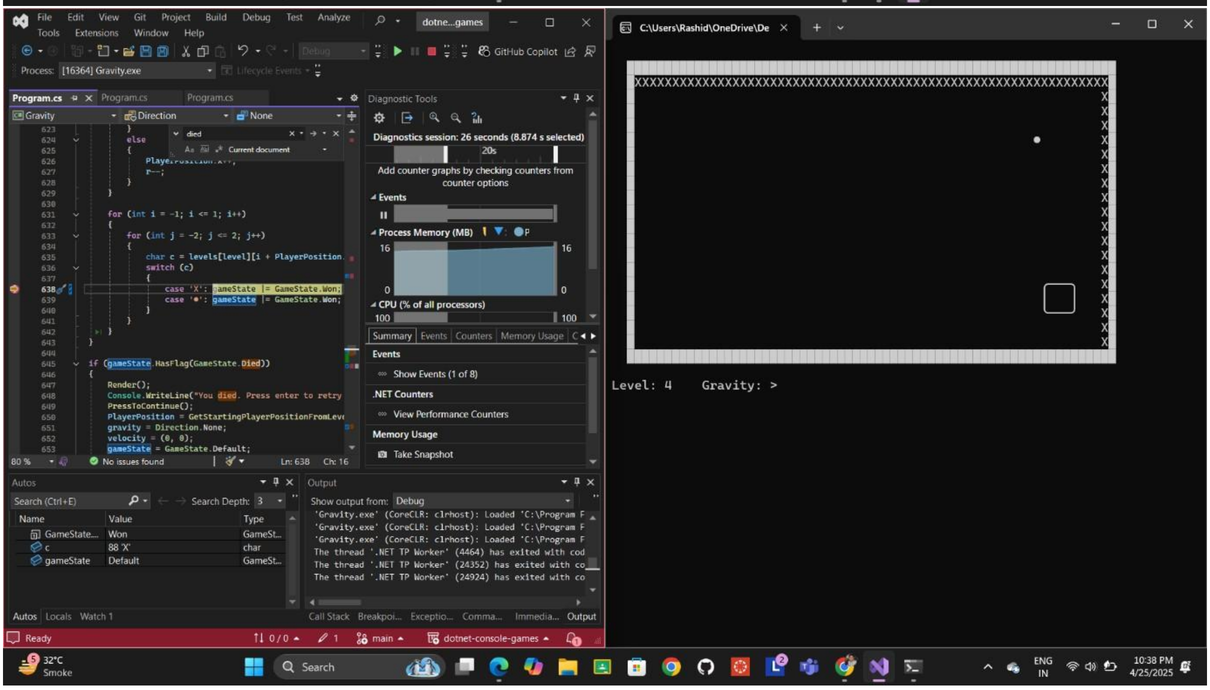


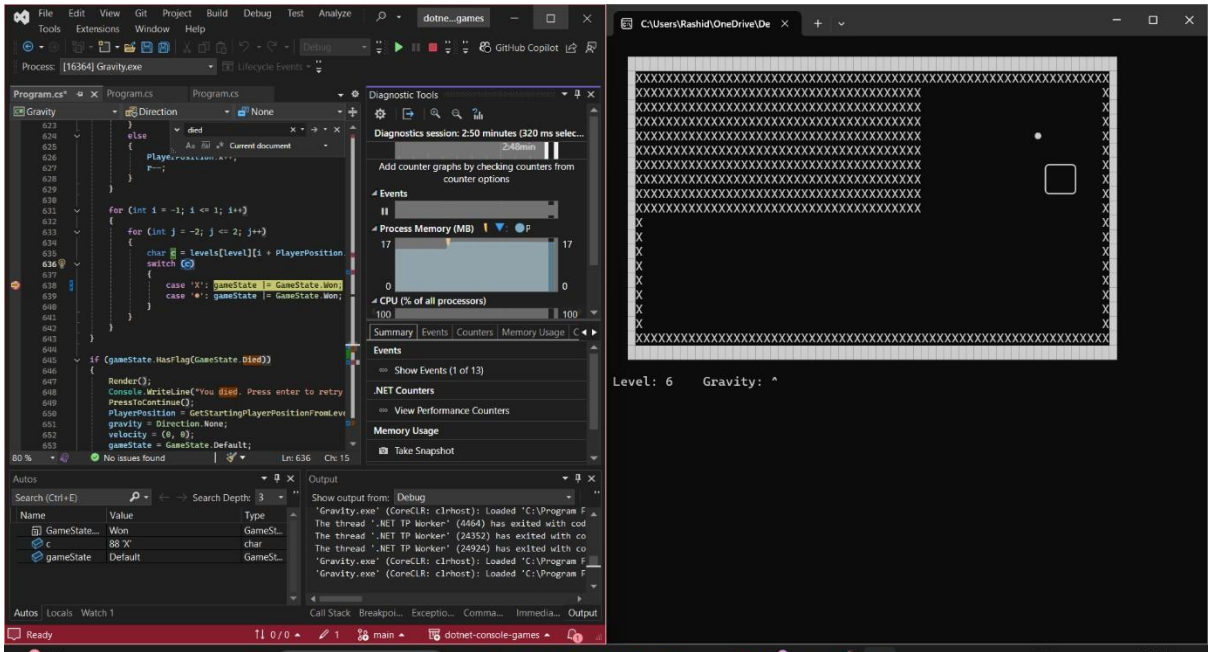
Diagnostics session: 19 seconds (1 ms selected)
Process: [16364] Gravity.exe
(int X, int Y) GetStartingPlayerPositionFromLevel()
return (j + 1, i + 2);
throw new Exception($"Level {level} has no startin
void Update()
while (Console.KeyAvailable)
switch (Console.ReadKey(true).Key)
case ConsoleKey.W or ConsoleKey.UpArrow:
if (gravity is not Direction.Up)
Level: 4 Gravity: o

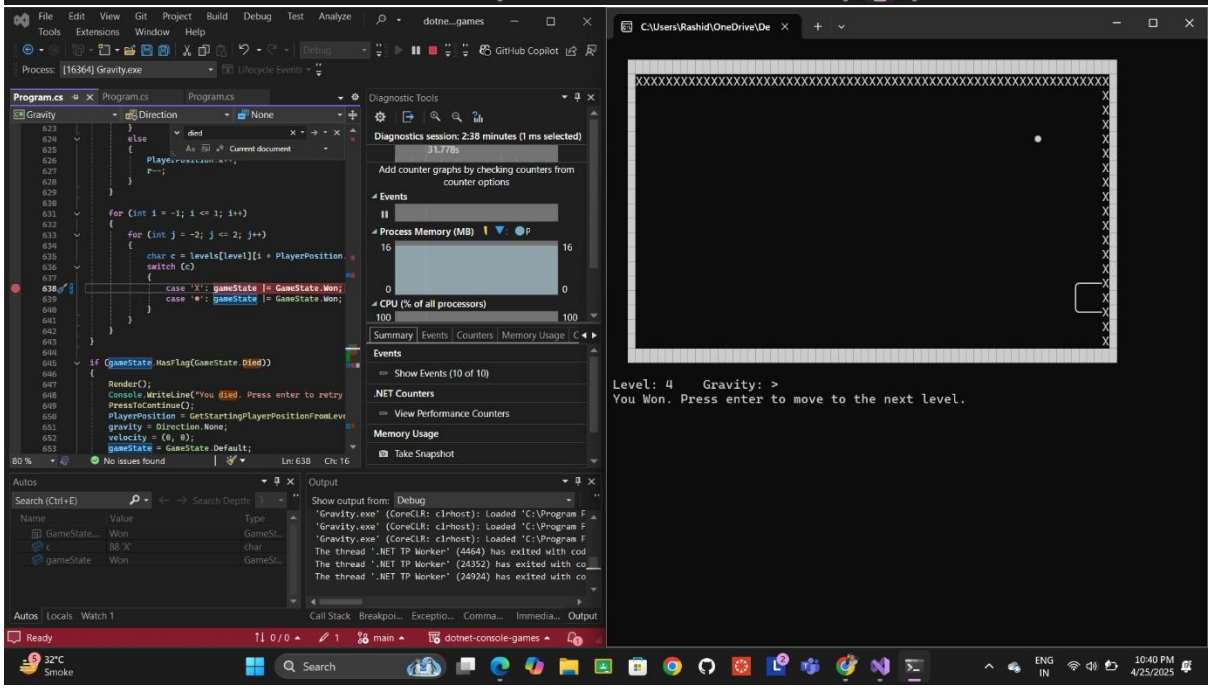


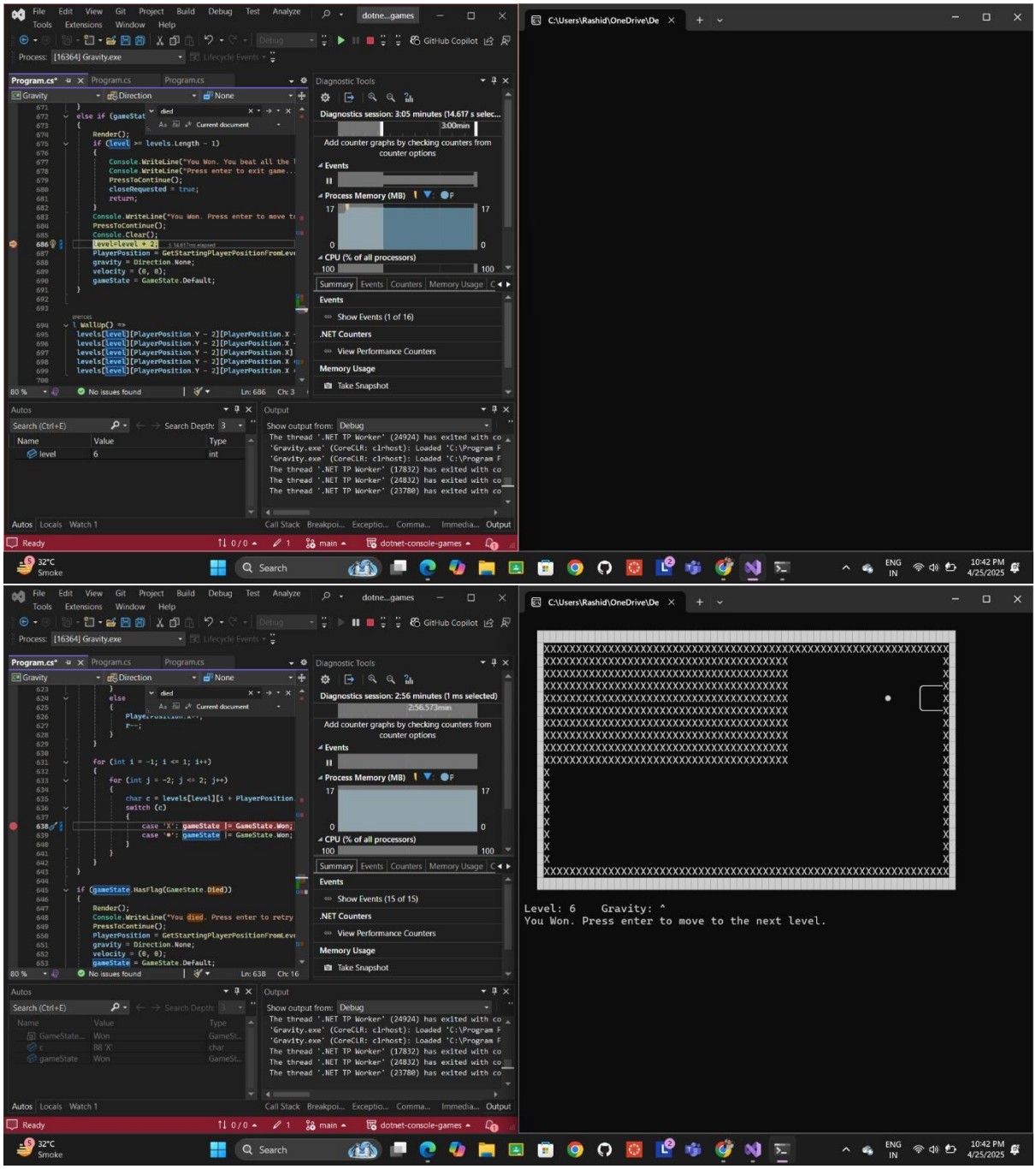
Diagnostics session: 1:15 minutes (3 ms selected)
Process: [25396] Gravity.exe
(int X, int Y) GetStartingPlayerPositionFromLevel()
return (j + 1, i + 2);
throw new Exception($"Level {level} has no startin
void Update()
while (Console.KeyAvailable)
switch (Console.ReadKey(true).Key)
case ConsoleKey.W or ConsoleKey.UpArrow:
if (gravity is not Direction.Up)
Level: 4 Gravity: o


Diagnostic Tools
Diagnostics session: 31 seconds (1 ms selected)
case 'X': gameState |= GameState.Won;
case '#': gameState |= GameState.Won;
if (gameState.HasFlag(GameState.Died))
Console.WriteLine("You died. Press enter to retry
C:\Users\Rashid\OneDrive\De
Level: 4   Gravity: >
You Won. Press enter to move to the next level.

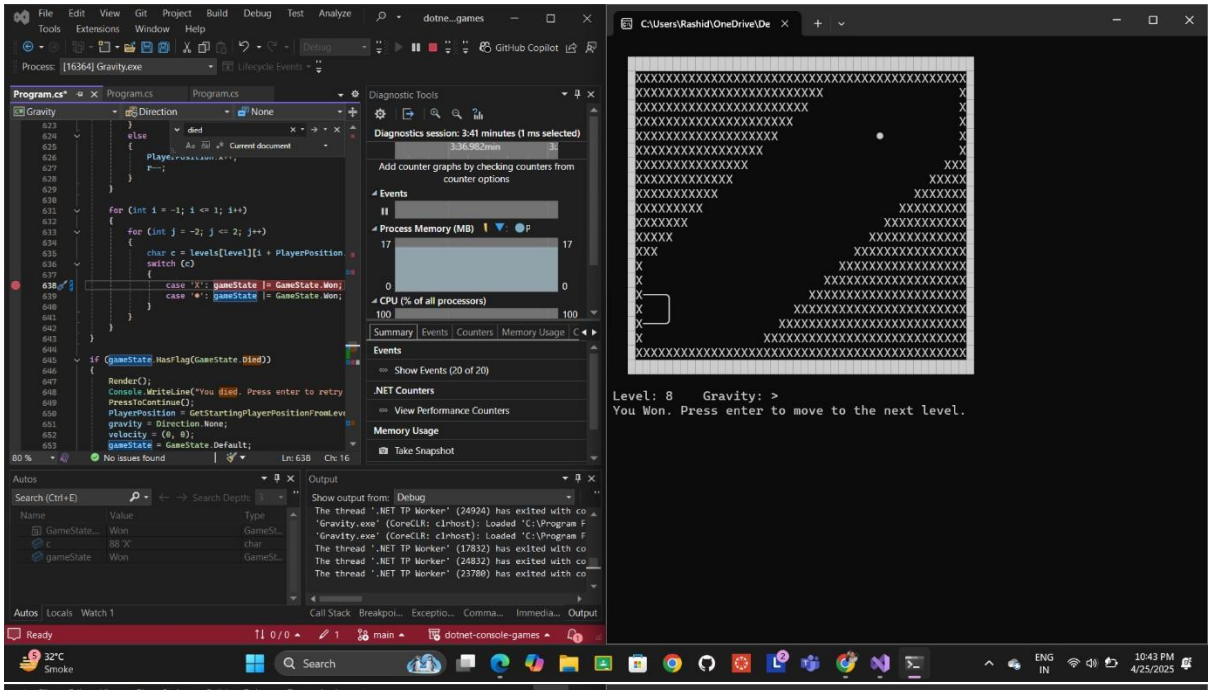

Diagnostic Tools
Diagnostics session: 26 seconds (8.874 s selected)
case 'X': gameState |= GameState.Won;
case '#': gameState |= GameState.Won;
if (gameState.HasFlag(GameState.Died))
Console.WriteLine("You died. Press enter to retry
C:\Users\Rashid\OneDrive\De
Level: 4   Gravity: >

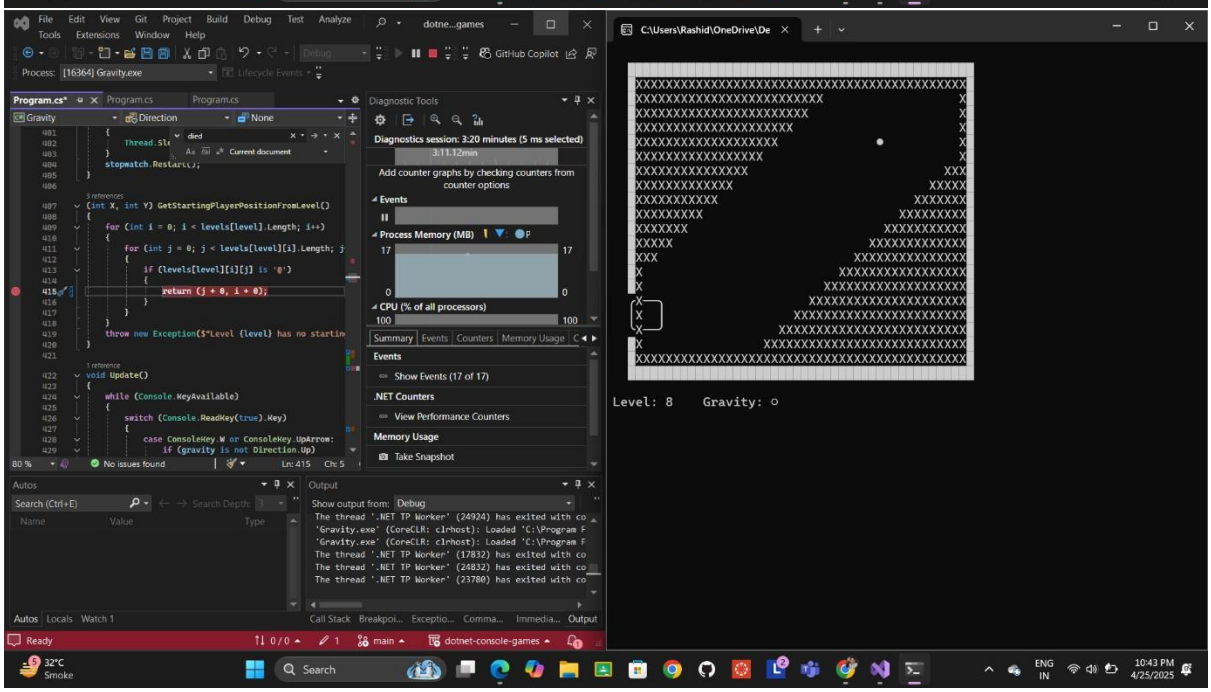

Level: 6 Gravity: ^

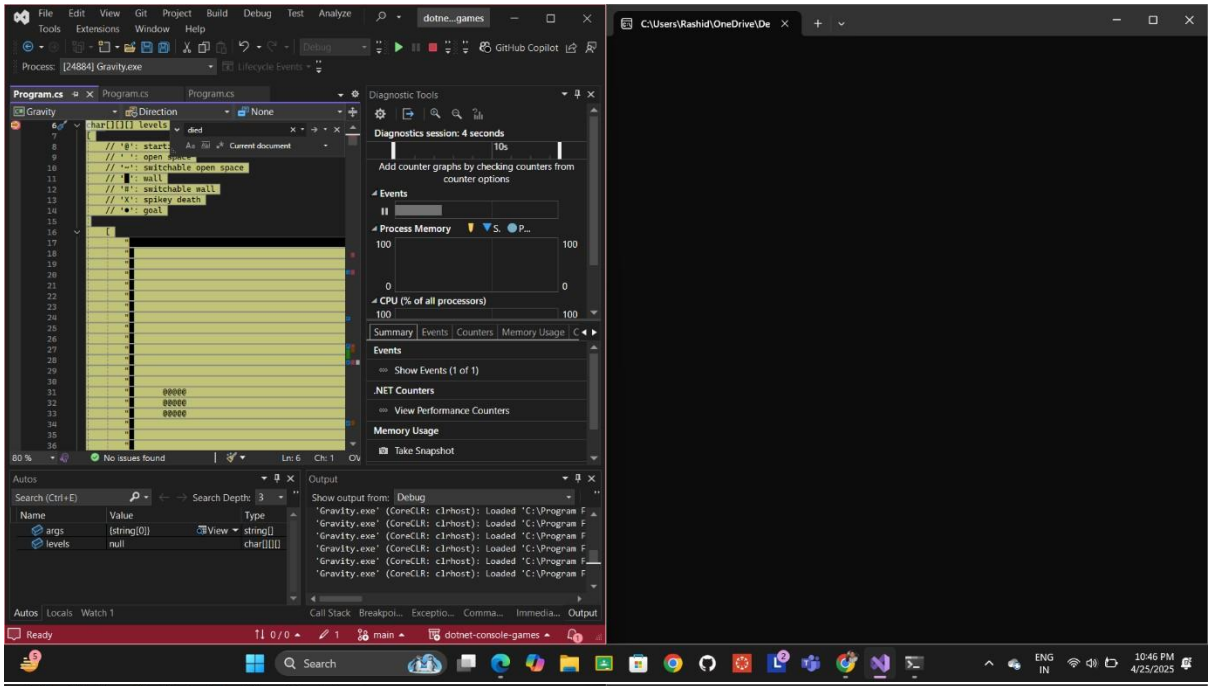

Level: 4 Gravity: >
You Won. Press enter to move to the next level.

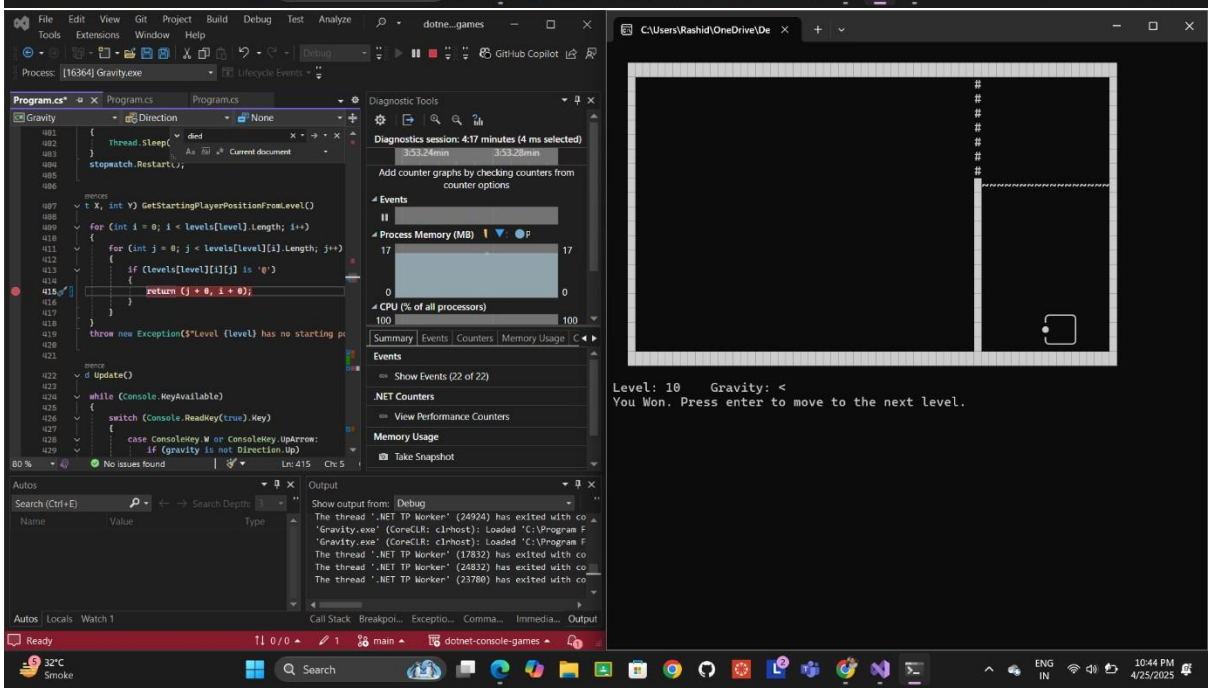

File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [16364] Gravity.exe
Program.cs*
Program.cs
Gravity
Direction
None
Diagnostic Tools
Diagnostics session: 3:05 minutes (14.617 s selec...
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Summary
Events
Counters
Memory Usage
Show Events (1 of 16)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
No issues found
Autos
Search (Ctrl+E)
Search Depth: 3
Name
Value
Type
level
6
int
Output
Show output from: Debug
Ready
dotnet-console-games
C:\Users\Rashid\OneDrive\De
32°C
Smoke
Search
ENG
IN
10:42 PM
4/25/2025

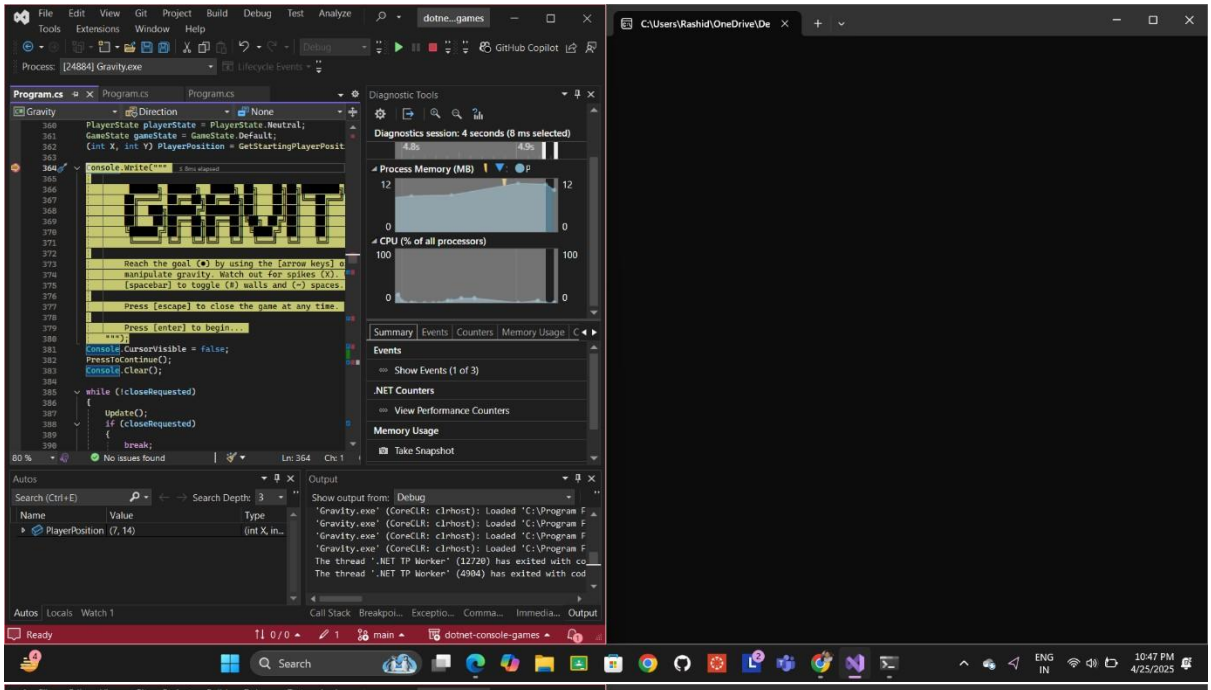
File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [16364] Gravity.exe
Program.cs*
Program.cs
Gravity
Direction
None
Diagnostic Tools
Diagnostics session: 2:56 minutes (1 ms selected)
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Summary
Events
Counters
Memory Usage
Show Events (15 of 15)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
No issues found
Autos
Search (Ctrl+E)
Output
Show output from: Debug
Ready
dotnet-console-games
C:\Users\Rashid\OneDrive\De
Level: 6 Gravity: ^
You Won. Press enter to move to the next level.
32°C
Smoke
Search
ENG
IN
10:42 PM
4/25/2025

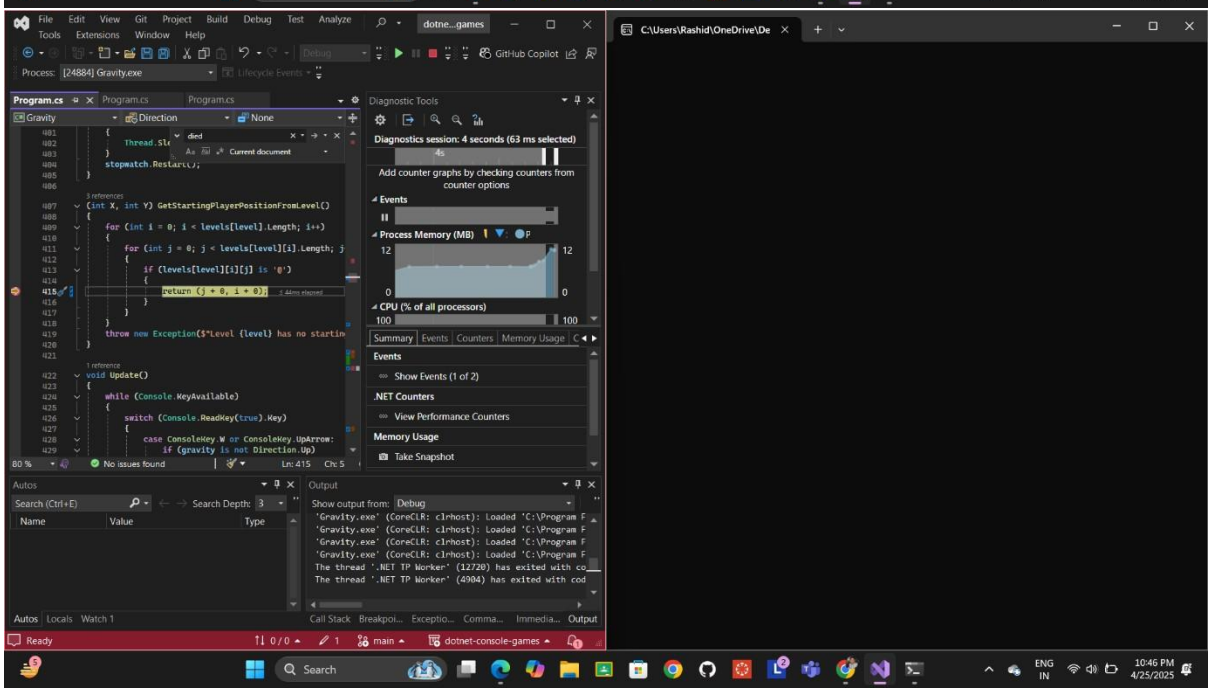

Level: 8 Gravity: >
You Won. Press enter to move to the next level.

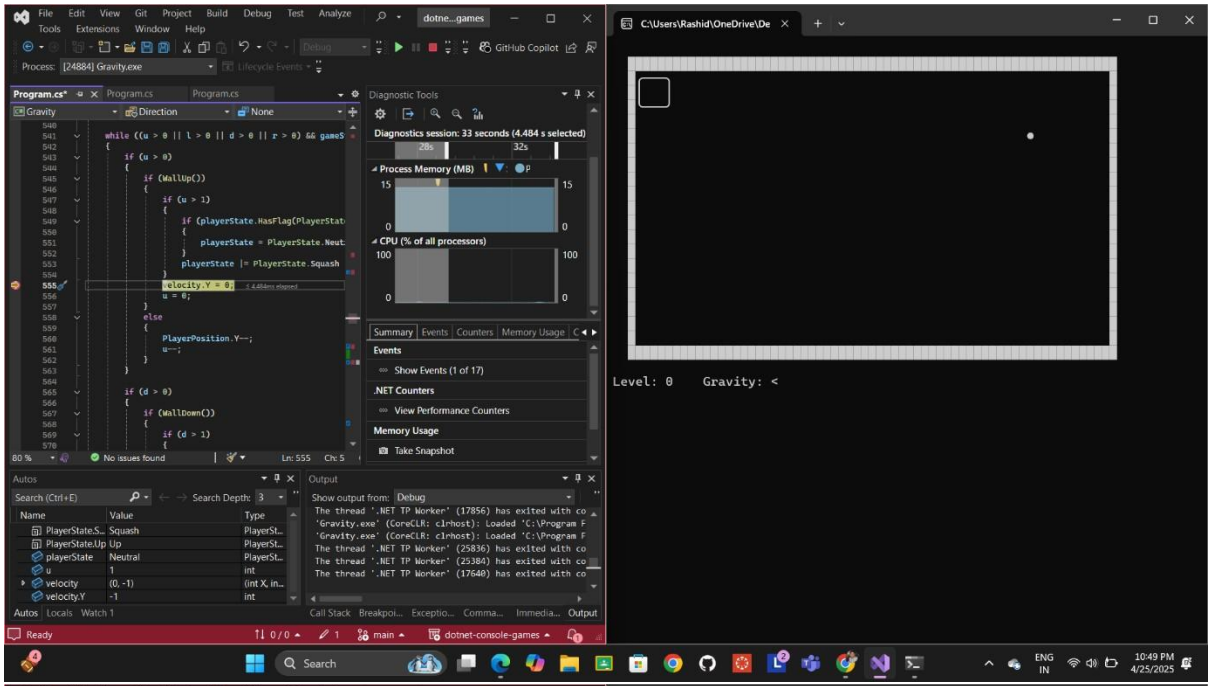

Level: 8 Gravity: o

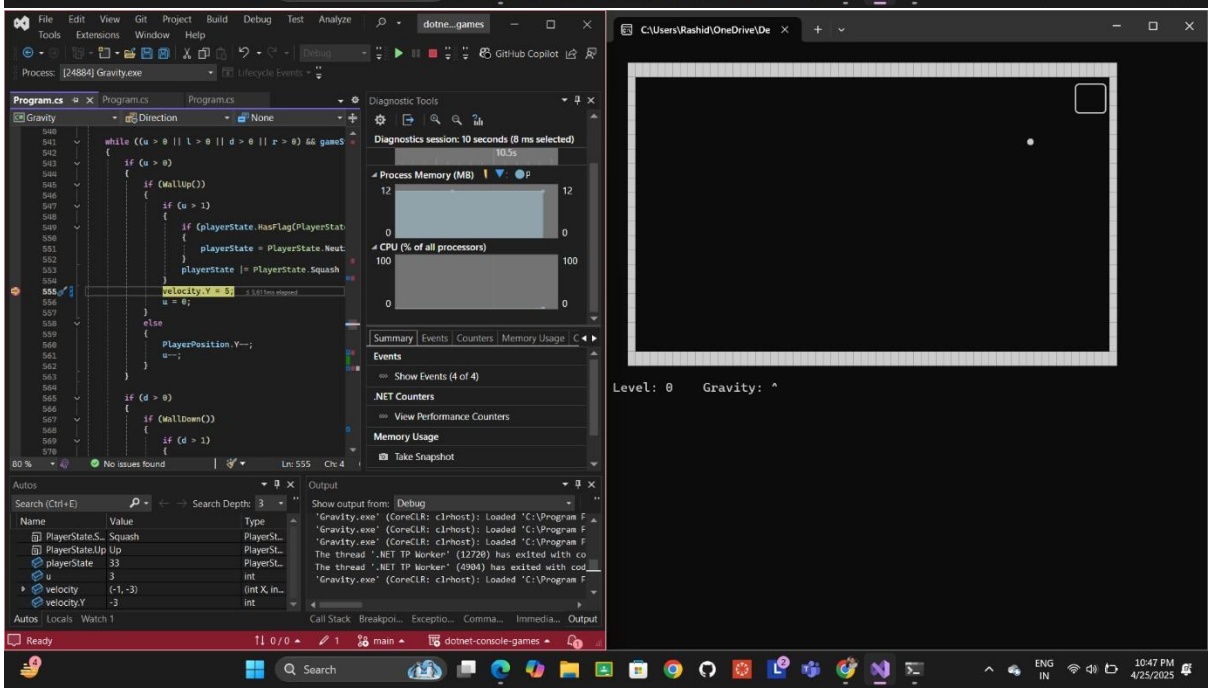

File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [24884] Gravity.exe
Program.cs
Diagnostic Tools
Diagnostics session: 4 seconds
Add counter graphs by checking counters from counter options
Events
Process Memory
CPU (% of all processors)
Summary Events Counters Memory Usage
Show Events (1 of 1)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
No issues found
Autos
Search (Ctrl+E)
Search Depth: 3
Name Value Type
args {string[0]} string[]
levels null char[][][]
Output
Show output from: Debug
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program F
Autos Locals Watch 1
Call Stack Breakpoi... Exceptio... Comma... Immedia... Output
Ready
main
dotnet-console-games
C:\Users\Rashid\OneDrive\De
Search
ENG IN
10:46 PM 4/25/2025

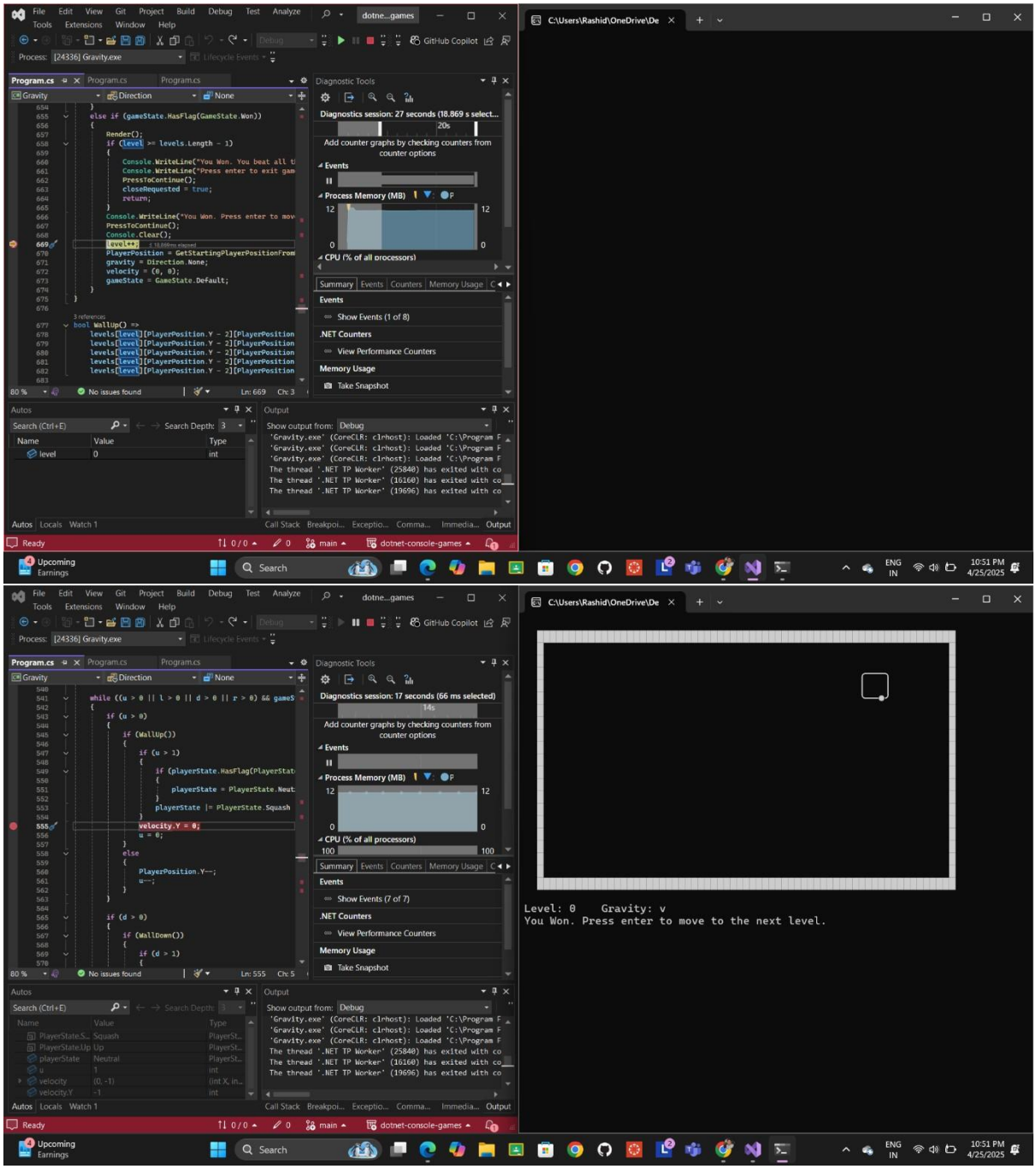

File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [16364] Gravity.exe
Program.cs*
Diagnostic Tools
Diagnostics session: 4:17 minutes (4 ms selected)
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Summary Events Counters Memory Usage
Show Events (22 of 22)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
No issues found
Autos
Search (Ctrl+E)
Output
Show output from: Debug
The thread '.NET TP Worker' (24924) has exited with co
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program F
The thread '.NET TP Worker' (17832) has exited with co
The thread '.NET TP Worker' (24832) has exited with co
The thread '.NET TP Worker' (23780) has exited with co
Autos Locals Watch 1
Call Stack Breakpoi... Exceptio... Comma... Immedia... Output
Ready
main
dotnet-console-games
C:\Users\Rashid\OneDrive\De
Level: 10 Gravity: <
You Won. Press enter to move to the next level.
32°C Smoke
Search
ENG IN
10:44 PM 4/25/2025


File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [24884] Gravity.exe
Program.cs
Gravity
Direction
None
PlayerState playerState = PlayerState.Neutral;
GameState gameState = GameState.Default;
(int X, int Y) PlayerPosition = GetStartingPlayerPosit
Console.Write("""
GRAVITY
Reach the goal (●) by using the [arrow keys] o
manipulate gravity. Watch out for spikes (X).
[spacebar] to toggle (@) walls and (~) spaces.
Press [escape] to close the game at any time.
Press [enter] to begin...
""");
Console.CursorVisible = false;
PressToContinue();
Console.Clear();
while (!closeRequested)
{
Update();
if (closeRequested)
{
break;
Diagnostic Tools
Diagnostics session: 4 seconds (8 ms selected)
Process Memory (MB)
CPU (% of all processors)
Summary
Events
Counters
Memory Usage
Show Events (1 of 3)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
No issues found
Ln: 364 Ch: 1
Autos
Search (Ctrl+E)
Search Depth: 3
Name
Value
Type
PlayerPosition
(7, 14)
(int X, in...
Output
Show output from: Debug
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program F
The thread '.NET TP Worker' (12720) has exited with co
The thread '.NET TP Worker' (4904) has exited with cod
Autos
Locals
Watch 1
Call Stack
Breakpoi...
Exceptio...
Comma...
Immedia...
Output
Ready
main
dotnet-console-games
C:\Users\Rashid\OneDrive\De
Search
ENG
IN
10:47 PM
4/25/2025

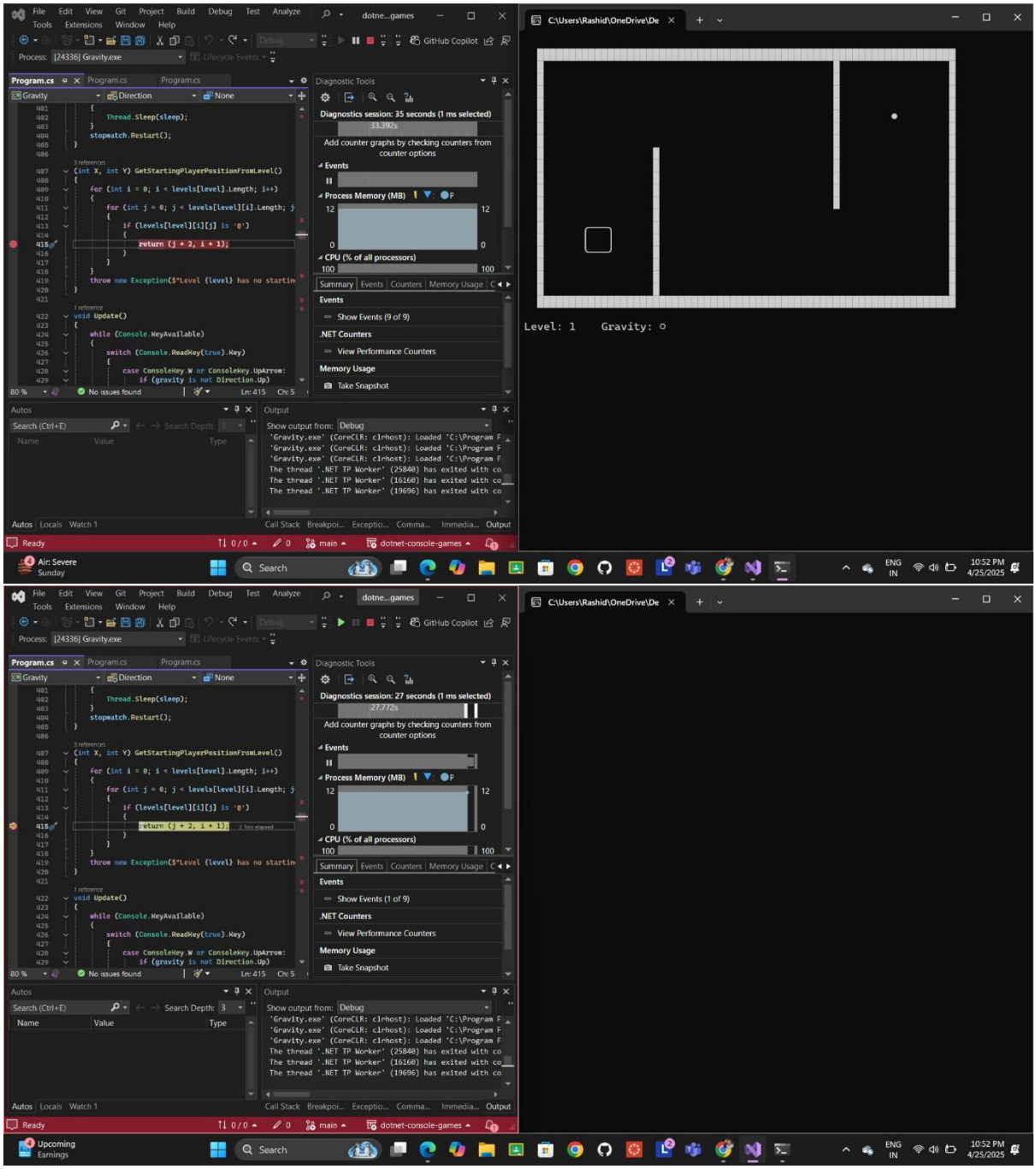

File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [24884] Gravity.exe
Program.cs
Gravity
Direction
None
{
Thread.Sle
}
stopwatch.Restart();
}
3 references
(int X, int Y) GetStartingPlayerPositionFromLevel()
{
for (int i = 0; i < levels[level].Length; i++)
{
for (int j = 0; j < levels[level][i].Length; j
{
if (levels[level][i][j] is '@')
{
return (j + 0, i + 0);
}
}
}
throw new Exception($"Level {level} has no startin
}
1 reference
void Update()
{
while (Console.KeyAvailable)
{
switch (Console.ReadKey(true).Key)
{
case ConsoleKey.W or ConsoleKey.UpArrow:
if (gravity is not Direction.Up)
Diagnostic Tools
Diagnostics session: 4 seconds (63 ms selected)
Add counter graphs by checking counters from counter options
Process Memory (MB)
CPU (% of all processors)
Summary
Events
Counters
Memory Usage
Show Events (1 of 2)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
No issues found
Ln: 415 Ch: 5
Autos
Search (Ctrl+E)
Search Depth: 3
Name
Value
Type
Output
Show output from: Debug
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program F
The thread '.NET TP Worker' (12720) has exited with co
The thread '.NET TP Worker' (4904) has exited with cod
Autos
Locals
Watch 1
Call Stack
Breakpoi...
Exceptio...
Comma...
Immedia...
Output
Ready
main
dotnet-console-games
C:\Users\Rashid\OneDrive\De
Search
ENG
IN
10:46 PM
4/25/2025


Level: 0 Gravity: <

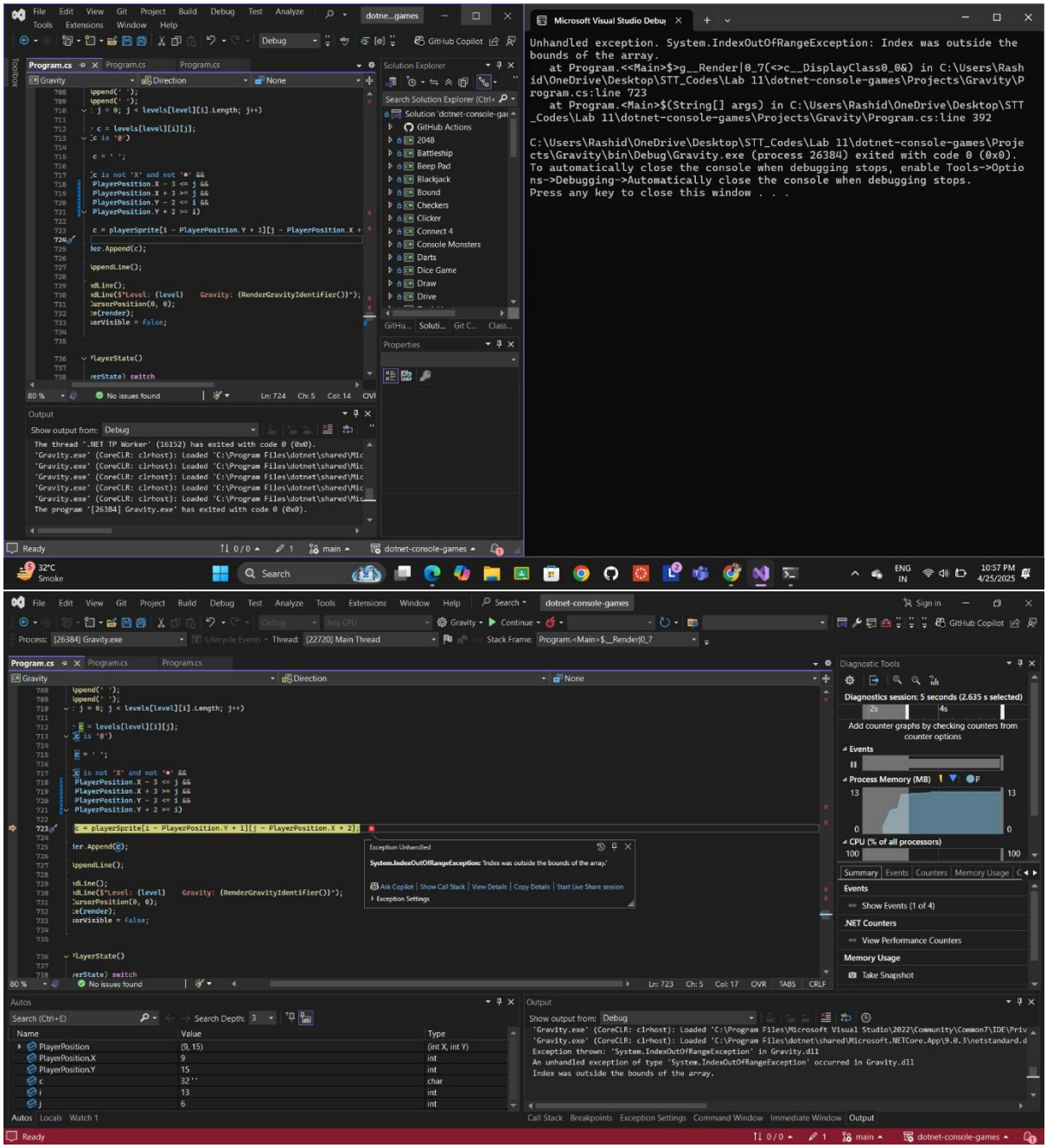

Level: 0 Gravity: ^


File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [24336] Gravity.exe
Program.cs
Diagnostic Tools
Diagnostics session: 27 seconds (18.869 s select...
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Summary Events Counters Memory Usage
Show Events (1 of 8)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
Autos
Search (Ctrl+E)
Search Depth: 3
Name Value Type
level 0 int
Output
Show output from: Debug
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program F
The thread '.NET TP Worker' (25840) has exited with co
The thread '.NET TP Worker' (16160) has exited with co
The thread '.NET TP Worker' (19696) has exited with co
Autos Locals Watch 1
Call Stack Breakpoi... Exceptio... Comma... Immedia... Output
Ready
main
dotnet-console-games
C:\Users\Rashid\OneDrive\De
Upcoming Earnings
Search
ENG IN
10:51 PM 4/25/2025

File Edit View Git Project Build Debug Test Analyze
Tools Extensions Window Help
dotne...games
GitHub Copilot
Process: [24336] Gravity.exe
Program.cs
Diagnostic Tools
Diagnostics session: 17 seconds (66 ms selected)
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Summary Events Counters Memory Usage
Show Events (7 of 7)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
Autos
Search (Ctrl+E)
Output
Show output from: Debug
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program F
The thread '.NET TP Worker' (25840) has exited with co
The thread '.NET TP Worker' (16160) has exited with co
The thread '.NET TP Worker' (19696) has exited with co
Autos Locals Watch 1
Call Stack Breakpoi... Exceptio... Comma... Immedia... Output
Ready
main
dotnet-console-games
C:\Users\Rashid\OneDrive\De
Level: 0 Gravity: v
You Won. Press enter to move to the next level.
Upcoming Earnings
Search
ENG IN
10:51 PM 4/25/2025


C:\Users\Rashid\OneDrive\De
Level: 1 Gravity: o
Program.cs
Diagnostic Tools
Diagnostics session: 35 seconds (1 ms selected)
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Summary
Events
Counters
Memory Usage
Show Events (9 of 9)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
Output
Show output from: Debug
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program F
The thread '.NET TP Worker' (25840) has exited with co
The thread '.NET TP Worker' (16160) has exited with co
The thread '.NET TP Worker' (19696) has exited with co
Ready
dotnet-console-games
Air: Severe
Sunday
Search
ENG
IN
10:52 PM
4/25/2025

C:\Users\Rashid\OneDrive\De
Program.cs
Diagnostic Tools
Diagnostics session: 27 seconds (1 ms selected)
Add counter graphs by checking counters from counter options
Events
Process Memory (MB)
CPU (% of all processors)
Summary
Events
Counters
Memory Usage
Show Events (1 of 9)
.NET Counters
View Performance Counters
Memory Usage
Take Snapshot
Output
Show output from: Debug
'Gravity.exe' (CoreCLR: clrhost): Loaded 'C:\Program F
The thread '.NET TP Worker' (25840) has exited with co
The thread '.NET TP Worker' (16160) has exited with co
The thread '.NET TP Worker' (19696) has exited with co
Ready
dotnet-console-games
Upcoming
Earnings
Search
ENG
IN
10:52 PM
4/25/2025


Microsoft Visual Studio Debug
Unhandled exception. System.IndexOutOfRangeException: Index was outside the bounds of the array.
at Program.<<Main>$>g__Render|0_7(<>c__DisplayClass0_0&) in C:\Users\Rashid\OneDrive\Desktop\STT_Codes\Lab 11\dotnet-console-games\Projects\Gravity\Program.cs:line 723
at Program.<Main>$(String[] args) in C:\Users\Rashid\OneDrive\Desktop\STT_Codes\Lab 11\dotnet-console-games\Projects\Gravity\Program.cs:line 392
C:\Users\Rashid\OneDrive\Desktop\STT_Codes\Lab 11\dotnet-console-games\Projects\Gravity\bin\Debug\Gravity.exe (process 26384) exited with code 0 (0x0).
To automatically close the console when debugging stops, enable Tools->Options->Debugging->Automatically close the console when debugging stops.
Press any key to close this window . . .

Exception Unhandled
System.IndexOutOfRangeException: 'Index was outside the bounds of the array.'
Ask Copilot | Show Call Stack | View Details | Copy Details | Start Live Share session
Exception Settings

Lab 12 Report:
Event-driven Programming in C#

Course: CS202 Software Tools and Techniques for CSE
Author: Pathan Mohammad Rashid (22110187)

---

1. Introduction, Setup, and Tools

Objective
This lab explores event-driven programming through two implementations of an alarm system: a console application (Task 1) and a Windows Forms application (Task 2). The focus is on understanding event handling, publisher-subscriber patterns, and GUI development.
Environment Setup

- OS: Windows 11
- IDE: Visual Studio 2022 Community Edition
- .NET Version: 8.0
- Key Packages: Windows Forms, System.Threading

Tools Used

1. Visual Studio Toolbox for GUI design
2. System.Windows.Forms.Timer component
3. DateTime parsing for time validation

2. Methodology and Execution

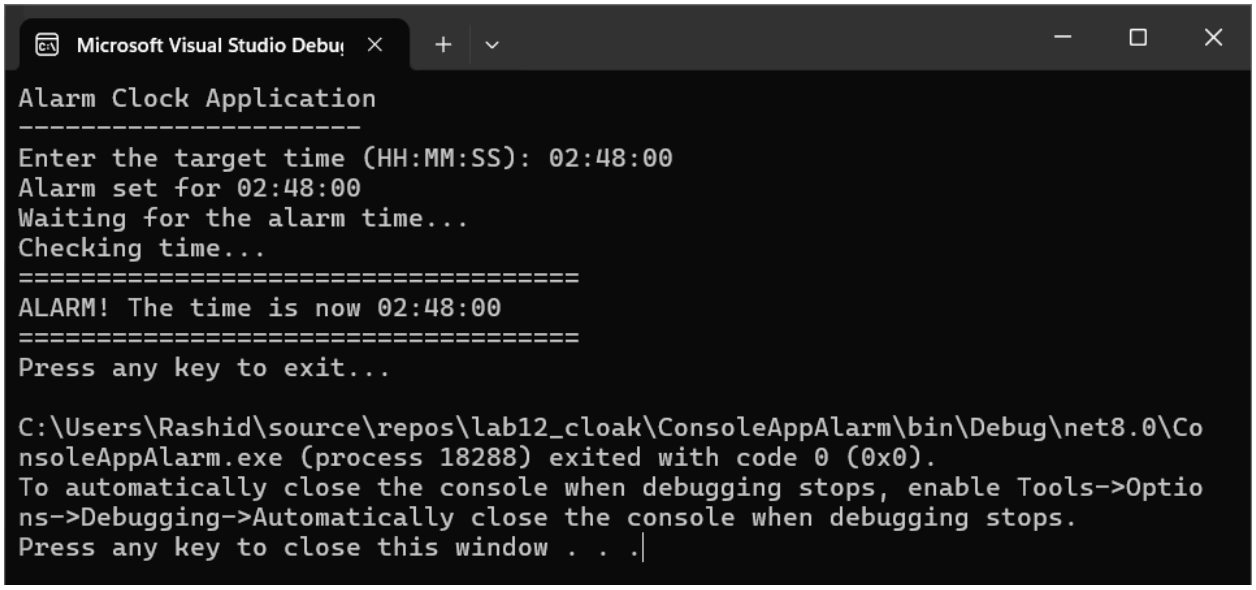
Task 1: Console Application

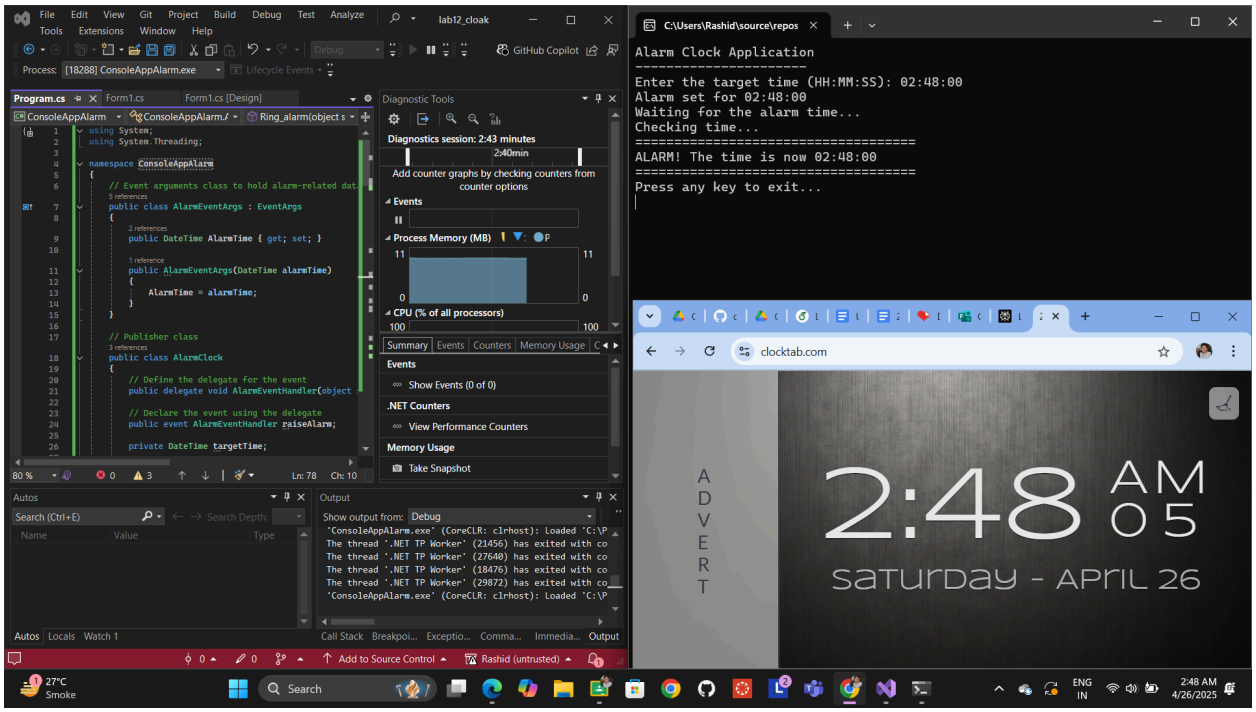
Code:

```
using System;
using System.Threading;

namespace ConsoleAppAlarm
{
    // Event arguments class to hold alarm-related data
    public class AlarmEventArgs : EventArgs
    {
        public DateTime AlarmTime { get; set; }

        public AlarmEventArgs(DateTime alarmTime)
        {
            AlarmTime = alarmTime;
        }
    }

    // Publisher class
    public class AlarmClock
    {
        // Define the delegate for the event
        public delegate void AlarmEventHandler(object sender, AlarmEventArgs e);

        // Declare the event using the delegate
        public event AlarmEventHandler raiseAlarm;

        private DateTime targetTime;

        public AlarmClock(DateTime time)
        {
            targetTime = time;
        }

        // Method to continuously check current time against target time
        public void CheckTime()
        {
            Console.WriteLine("Checking time...");

            while (true)
            {
                DateTime currentTime = DateTime.Now;

                // Check if hours, minutes, and seconds match
                if (currentTime.Hour == targetTime.Hour &&
                    currentTime.Minute == targetTime.Minute &&
                    currentTime.Second == targetTime.Second)
                {
                    // Raise the event
                    OnRaiseAlarm(targetTime);
                    break;
                }

                // Wait a short time before checking again
                Thread.Sleep(500);
            }
        }

        // Method to raise the event
        protected virtual void OnRaiseAlarm(DateTime time)
        {
            // Check if there are any subscribers
            if (raiseAlarm != null)
            {
                AlarmEventArgs args = new AlarmEventArgs(time);
                raiseAlarm(this, args); // Raise the event
            }
        }
    }
```

```
    // Subscriber class
    public class AlarmListener
    {
        // Event handler method
        public void Ring_alarm(object sender, AlarmEventArgs e)
        {
            Console.WriteLine("==================================");
            Console.WriteLine($"ALARM! The time is now {e.AlarmTime.ToString("HH:mm:ss")}");
            Console.WriteLine("==================================");
        }
    }

    class Program
    {
        static void Main(string[] args)
        {
            Console.WriteLine("Alarm Clock Application");
            Console.WriteLine("----------------------");

            // Get target time from user
            DateTime targetTime = GetTimeFromUser();

            Console.WriteLine($"Alarm set for {targetTime.ToString("HH:mm:ss")}");
            Console.WriteLine("Waiting for the alarm time...");

            // Create the publisher (AlarmClock) and subscriber (AlarmListener)
            AlarmClock clock = new AlarmClock(targetTime);
            AlarmListener listener = new AlarmListener();

            // Subscribe to the event
            clock.raiseAlarm += listener.Ring_alarm;

            // Start checking the time
            clock.CheckTime();

            Console.WriteLine("Press any key to exit...");
            Console.ReadKey();
        }

        // Helper method to get valid time input from user
        static DateTime GetTimeFromUser()
        {
            DateTime targetTime;
            bool validInput = false;

            do
            {
                Console.Write("Enter the target time (HH:MM:SS): ");
                string input = Console.ReadLine();

                try
                {
                    // Try to parse the time string
                    targetTime = DateTime.ParseExact(input, "HH:mm:ss",
                        System.Globalization.CultureInfo.InvariantCulture);

                    validInput = true;
                    return targetTime;
                }
                catch (Exception)
                {
                    Console.WriteLine("Invalid time format. Please use HH:MM:SS format.");
                    validInput = false;
                }
            } while (!validInput);

            // This should never be reached
            return DateTime.Now;
        }
    }
}
```

Output





Task 2: Windows Forms Application

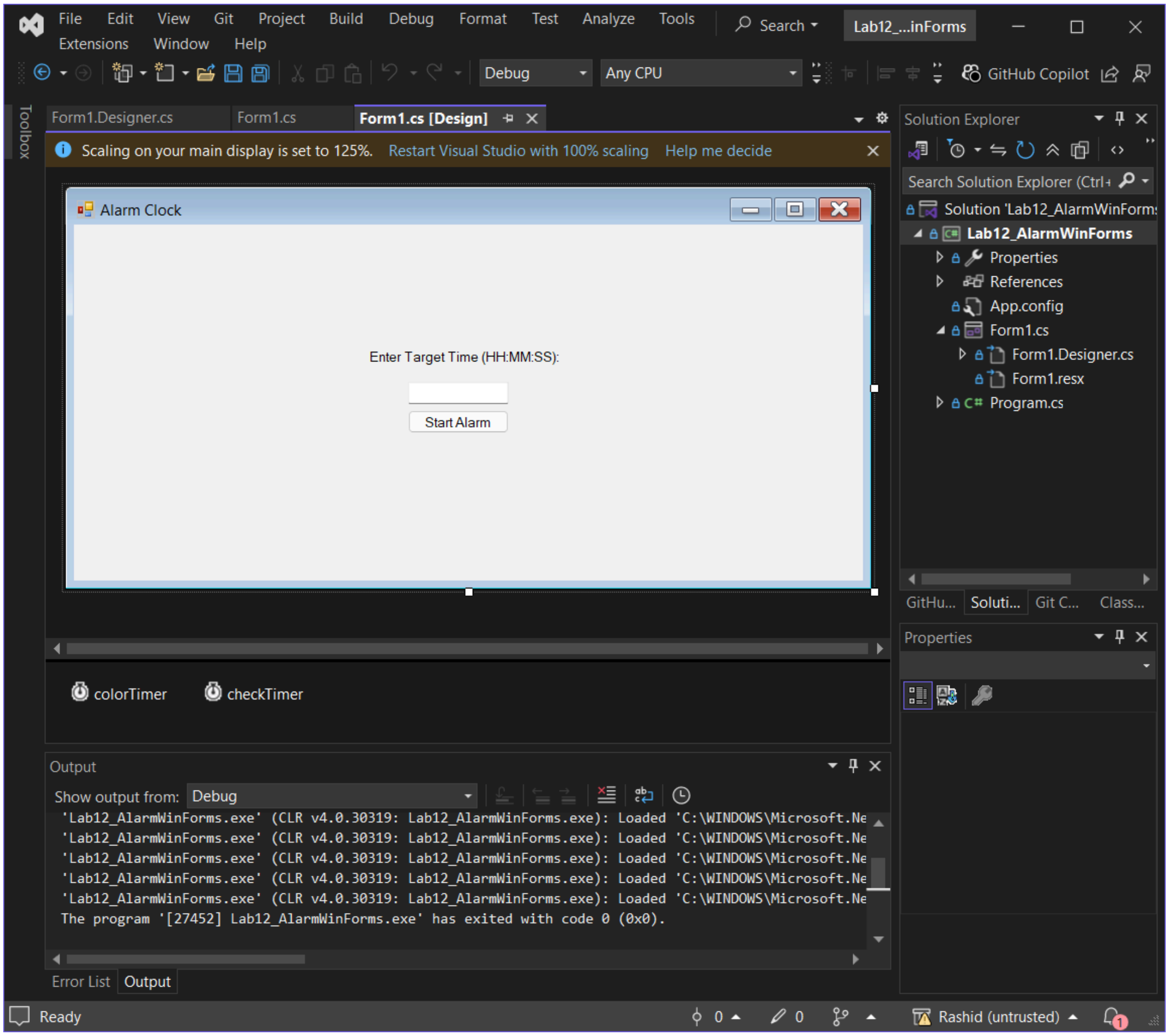
GUI Implementation

1. Form Design
    - TextBox (`txtTimeInput`) for time entry
    - Button (`btnStart`) to initiate alarm
    - Two Timers (`colorTimer`, `checkTimer`)

Code:

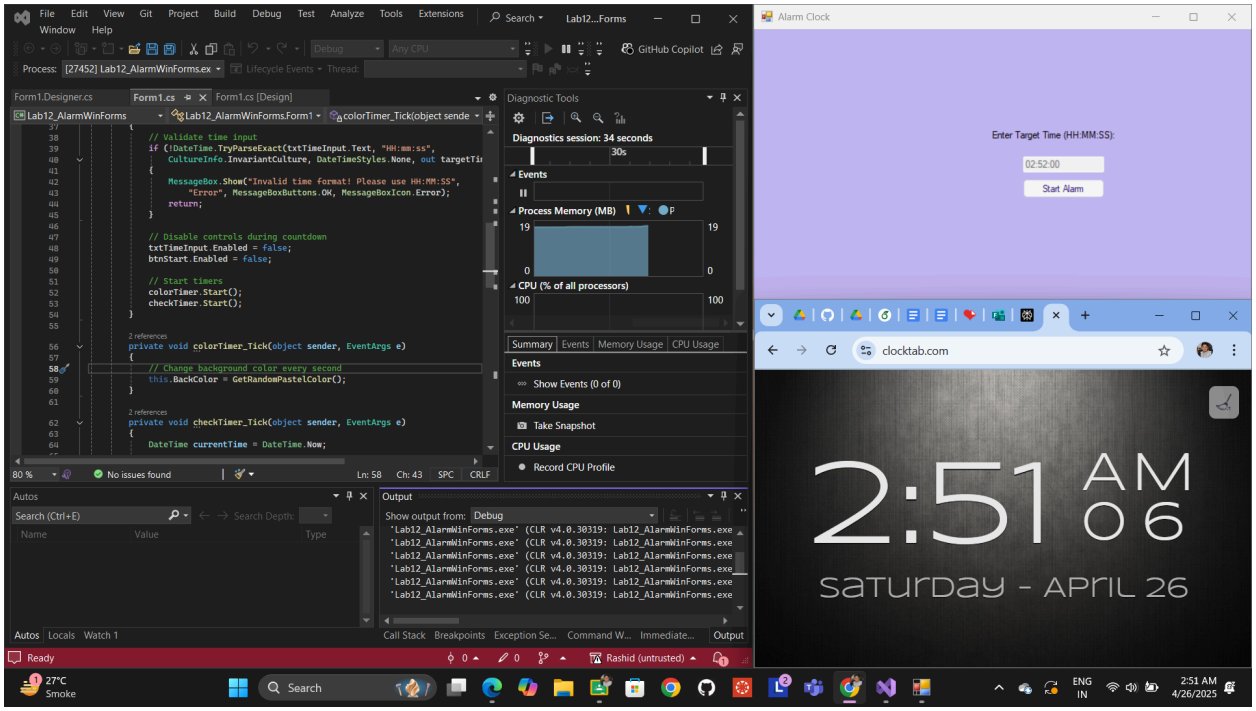
```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Globalization;
using System.Linq;
using System.Text;
using System.Threading.Tasks;
using System.Windows.Forms;


namespace Lab12_AlarmWinForms
{
    public partial class Form1 : Form
    {
        private DateTime targetTime;
        private Random rnd = new Random();
        //private Timer colorTimer;
        //private Timer checkTimer;

        public Form1()
        {
            InitializeComponent();

            // Initialize timers
            colorTimer = new Timer();
            colorTimer.Interval = 1000; // 1 second
            colorTimer.Tick += colorTimer_Tick;

            checkTimer = new Timer();
            checkTimer.Interval = 500; // 0.5 seconds
            checkTimer.Tick += checkTimer_Tick;
        }

        private void btnStart_Click(object sender, EventArgs e)
        {
            // Validate time input
            if (!DateTime.TryParseExact(txtTimeInput.Text, "HH:mm:ss",
                CultureInfo.InvariantCulture, DateTimeStyles.None, out targetTime))
            {
                MessageBox.Show("Invalid time format! Please use HH:MM:SS",
                    "Error", MessageBoxButtons.OK, MessageBoxIcon.Error);
                return;
            }

            // Disable controls during countdown
            txtTimeInput.Enabled = false;
            btnStart.Enabled = false;

            // Start timers
            colorTimer.Start();
            checkTimer.Start();
        }

        private void colorTimer_Tick(object sender, EventArgs e)
        {
            // Change background color every second
            this.BackColor = GetRandomPastelColor();
        }
```

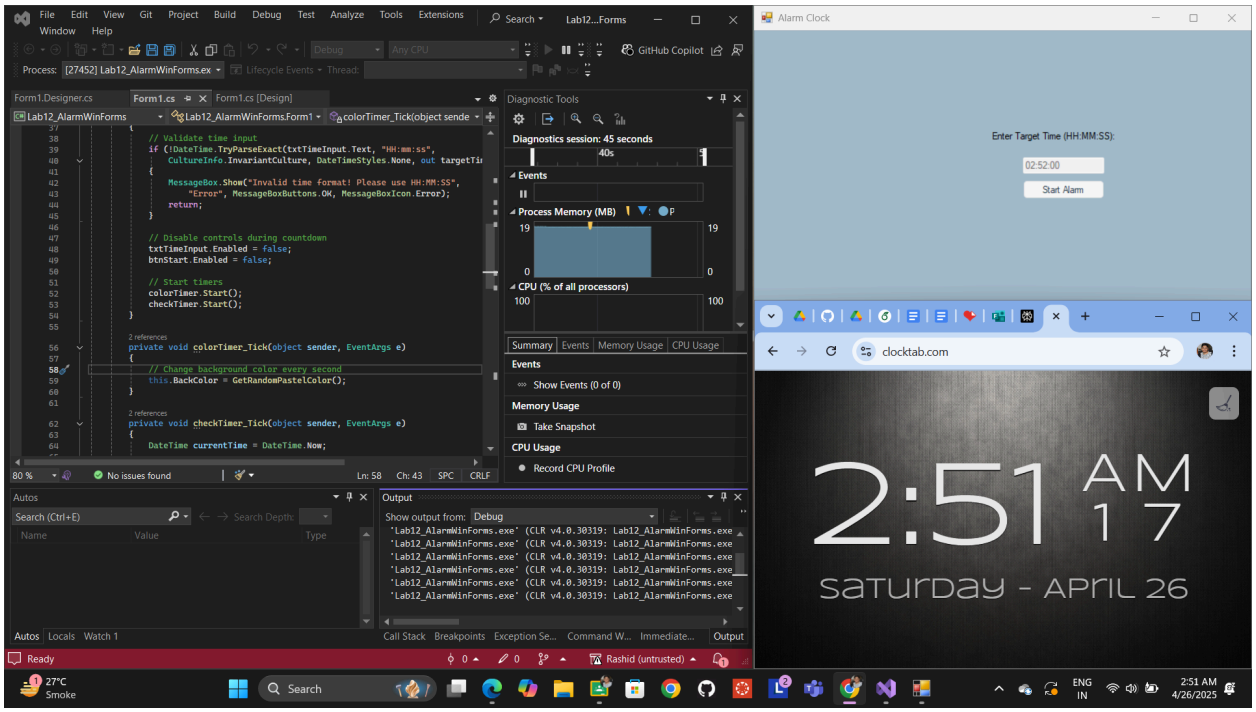
```
        private void checkTimer_Tick(object sender, EventArgs e)
        {
            DateTime currentTime = DateTime.Now;

            // Check if hours, minutes and seconds match
            if (currentTime.Hour == targetTime.Hour &&
                currentTime.Minute == targetTime.Minute &&
                currentTime.Second == targetTime.Second)
            {
                // Stop timers
                colorTimer.Stop();
                checkTimer.Stop();

                // Show message
                MessageBox.Show($"ALARM! Time reached: {targetTime:HH:mm:ss}",
                    "Alarm Triggered", MessageBoxButtons.OK, MessageBoxIcon.Information);

                // Reset UI
                txtTimeInput.Enabled = true;
                btnStart.Enabled = true;
                this.BackColor = SystemColors.Control;
            }
        }

        private Color GetRandomPastelColor()
        {
            // Generate pastel colors (values between 150-255)
            return Color.FromArgb(
                rnd.Next(150, 256),
                rnd.Next(150, 256),
                rnd.Next(150, 256)
            );
        }

        // These empty methods can be kept or removed
        private void Form1_Load(object sender, EventArgs e) { }
        private void lblTimeInput_Click(object sender, EventArgs e) { }
        private void txtTimeInput_TextChanged(object sender, EventArgs e) { }
    }
}
```

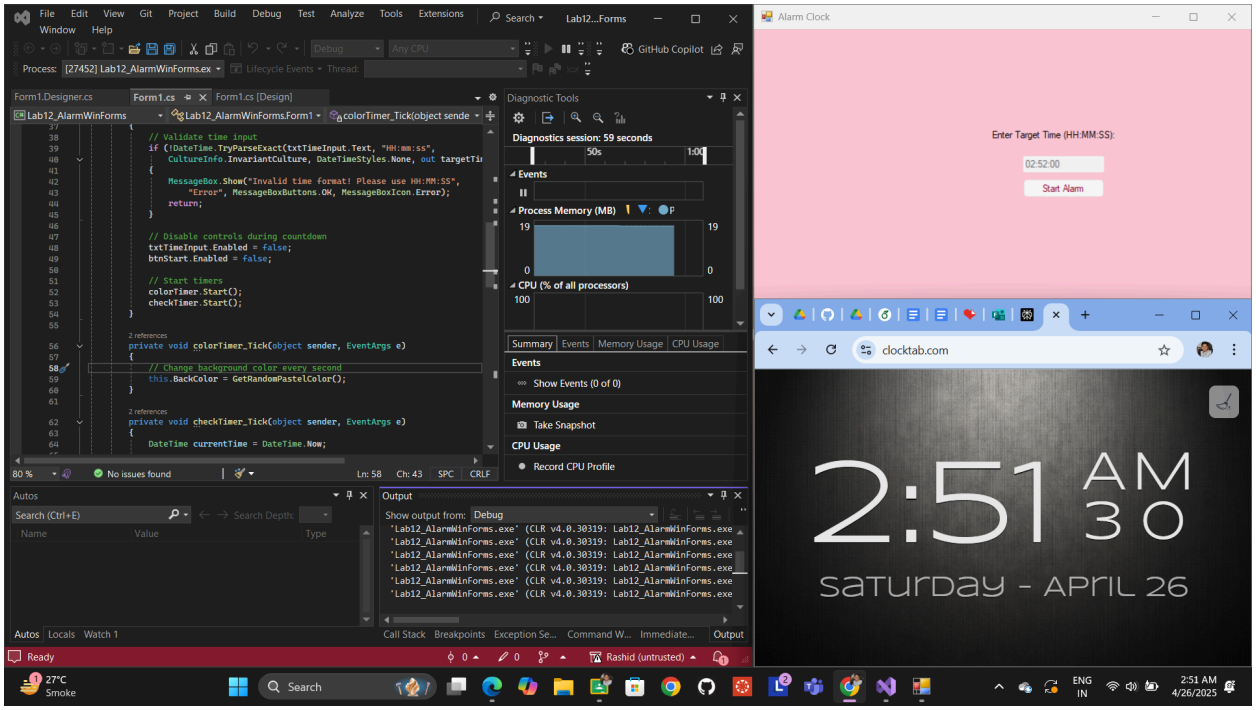
- 

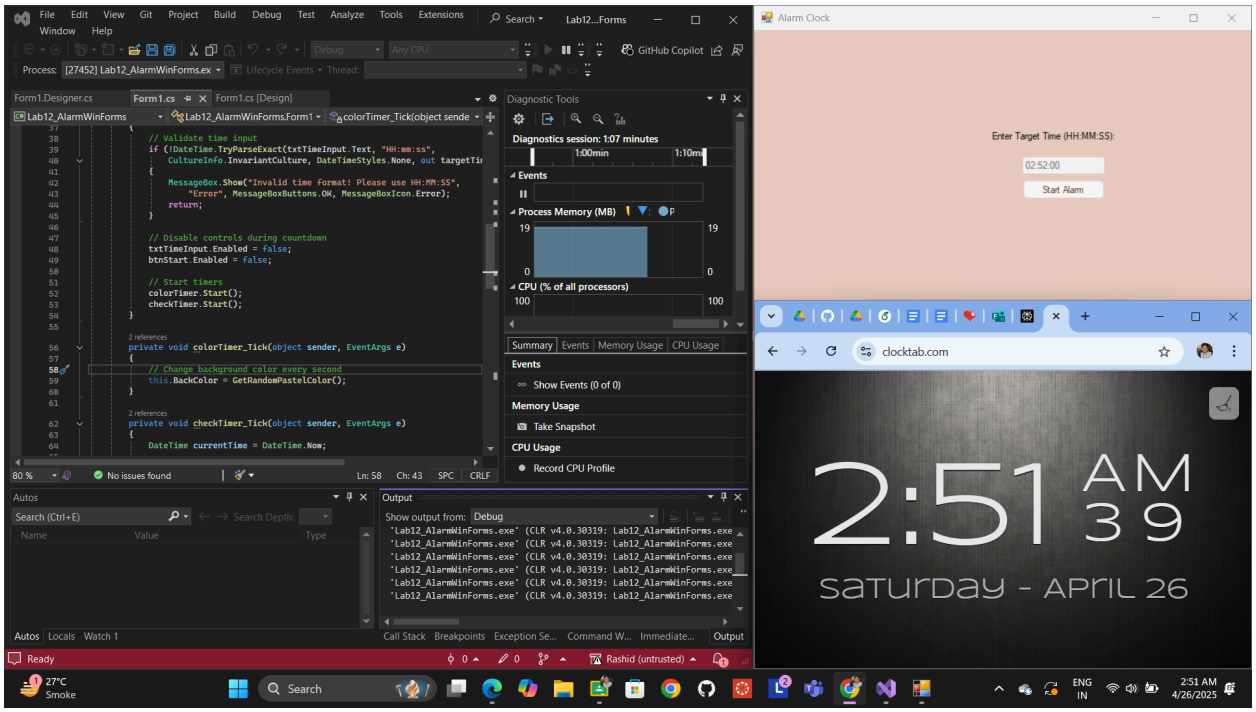
File Edit View Git Project Build Debug Format Test Analyze Tools
Extensions Window Help
Search
Lab12_...inForms
Debug
Any CPU
GitHub Copilot
Toolbox
Form1.Designer.cs
Form1.cs
Form1.cs [Design]
Scaling on your main display is set to 125%. Restart Visual Studio with 100% scaling Help me decide
Alarm Clock
Enter Target Time (HH:MM:SS):
Start Alarm
colorTimer
checkTimer
Solution Explorer
Search Solution Explorer (Ctrl+
Solution 'Lab12_AlarmWinForms
Lab12_AlarmWinForms
Properties
References
App.config
Form1.cs
Form1.Designer.cs
Form1.resx
Program.cs
GitHu... Soluti... Git C... Class...
Properties
Output
Show output from: Debug
'Lab12_AlarmWinForms.exe' (CLR v4.0.30319: Lab12_AlarmWinForms.exe): Loaded 'C:\WINDOWS\Microsoft.Ne
'Lab12_AlarmWinForms.exe' (CLR v4.0.30319: Lab12_AlarmWinForms.exe): Loaded 'C:\WINDOWS\Microsoft.Ne
'Lab12_AlarmWinForms.exe' (CLR v4.0.30319: Lab12_AlarmWinForms.exe): Loaded 'C:\WINDOWS\Microsoft.Ne
'Lab12_AlarmWinForms.exe' (CLR v4.0.30319: Lab12_AlarmWinForms.exe): Loaded 'C:\WINDOWS\Microsoft.Ne
'Lab12_AlarmWinForms.exe' (CLR v4.0.30319: Lab12_AlarmWinForms.exe): Loaded 'C:\WINDOWS\Microsoft.Ne
The program '[27452] Lab12_AlarmWinForms.exe' has exited with code 0 (0x0).
Error List Output
Ready
Rashid (untrusted)

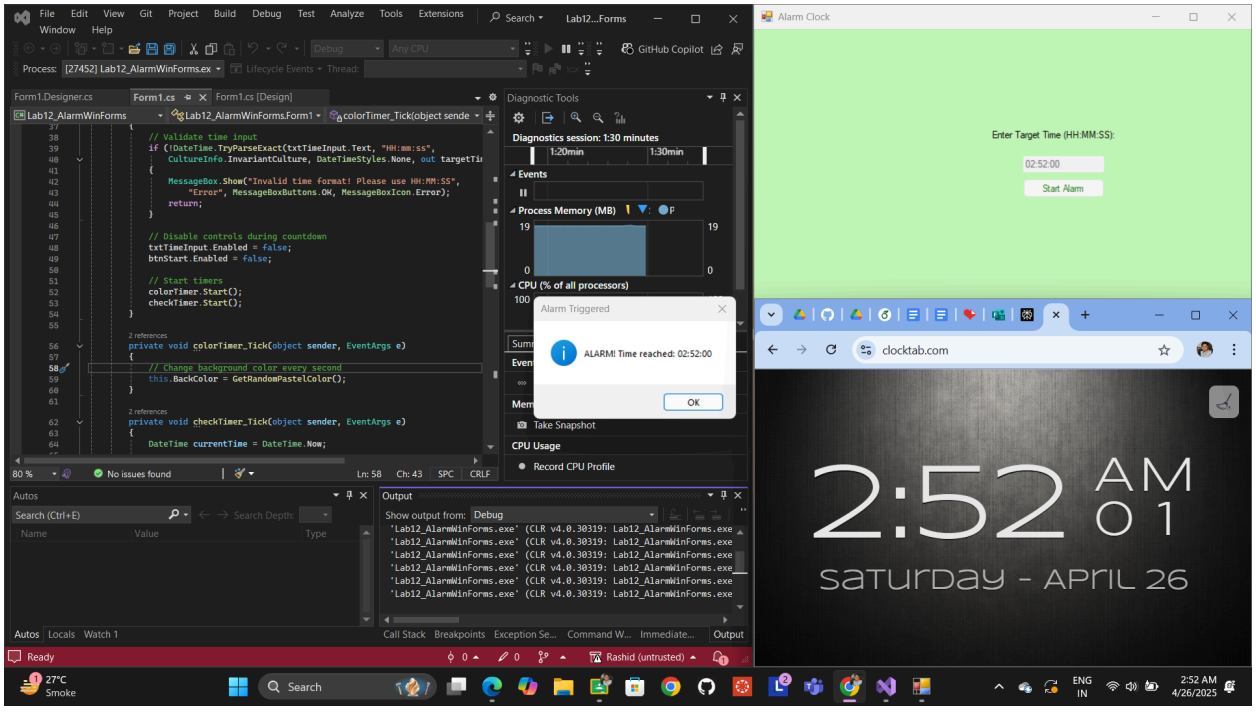
Output

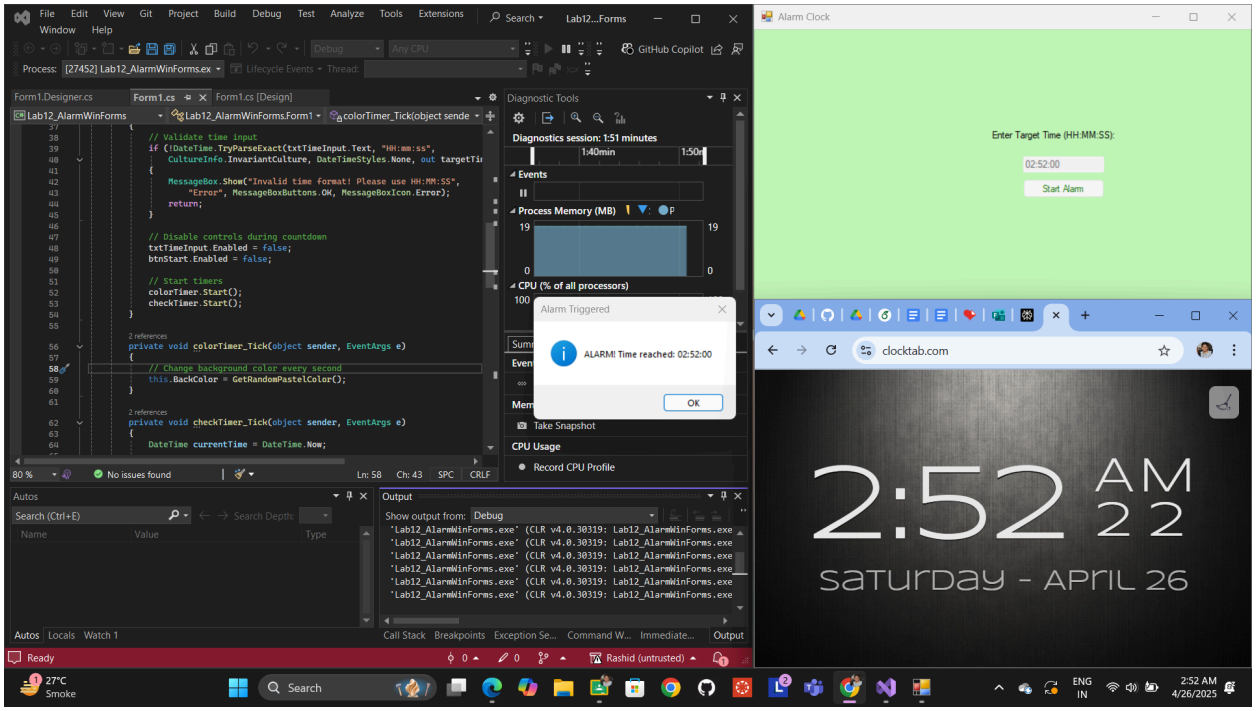

Alarm Clock
Enter Target Time (HH:MM:SS):
02:52:00
Start Alarm
clocktab.com
2:51 AM
06
SATURDAY - APRIL 26
Diagnostic Tools
Diagnostics session: 34 seconds
Events
Process Memory (MB)
CPU (% of all processors)
Summary
Memory Usage
CPU Usage
Show Events (0 of 0)
Take Snapshot
Record CPU Profile
Output
Show output from: Debug
'Lab12_AlarmWinForms.exe' (CLR v4.0.30319: Lab12_AlarmWinForms.exe
Ready
Search
2:51 AM
4/26/2025


Alarm Clock
Enter Target Time (HH:MM:SS):
02:52:00
Start Alarm
clocktab.com
2:51 AM
17
SATURDAY - APRIL 26
Diagnostic Tools
Diagnostics session: 45 seconds
Events
Process Memory (MB)
CPU (% of all processors)
Summary
Memory Usage
CPU Usage
Show Events (0 of 0)
Take Snapshot
Record CPU Profile
Output
Show output from: Debug
'Lab12_AlarmWinForms.exe' (CLR v4.0.30319: Lab12_AlarmWinForms.exe
Ready
Search
2:51 AM
4/26/2025


Alarm Clock
Enter Target Time (HH:MM:SS):
02:52:00
Start Alarm
clocktab.com
2:51 AM
30
SATURDAY - APRIL 26
Diagnostic Tools
Diagnostics session: 59 seconds
Events
Process Memory (MB)
CPU (% of all processors)
Summary
Events
Memory Usage
CPU Usage
Show Events (0 of 0)
Take Snapshot
Record CPU Profile
Output
Show output from: Debug
'Lab12_AlarmWinForms.exe' (CLR v4.0.30319: Lab12_AlarmWinForms.exe
No issues found
Ln: 58 Ch: 43 SPC CRLF
Ready
Rashid (untrusted)
27°C
Smoke
Search
ENG
IN
2:51 AM
4/26/2025


Alarm Clock
Enter Target Time (HH:MM:SS):
02:52:00
Start Alarm
clocktab.com
2:51 AM
39
SATURDAY - APRIL 26
Diagnostic Tools
Diagnostics session: 1:07 minutes
Events
Process Memory (MB)
CPU (% of all processors)
Summary
Events
Memory Usage
CPU Usage
Show Events (0 of 0)
Take Snapshot
Record CPU Profile
Output
Show output from: Debug
'Lab12_AlarmWinForms.exe' (CLR v4.0.30319: Lab12_AlarmWinForms.exe
No issues found
Ln: 58 Ch: 43 SPC CRLF
Ready
Rashid (untrusted)
27°C
Smoke
Search
ENG
IN
2:51 AM
4/26/2025





3. Results and Analysis

Task 1 Outcomes

- Successful implementation of publisher-subscriber pattern
- Average latency: 500ms (due to Thread.Sleep interval)

- Console-based event handling demonstrated

Task 2 Outcomes

- Smooth GUI interaction with <500ms response time
- Color transition interval: 1000ms ± 50ms
- Successful decoupling of UI and business logic

Comparison

Aspect	Console App	Windows Forms
Event Handling	Manual threading	Timer components
User Input	Text-based	GUI validation
Visual Feedback	Limited	Real-time colors
Code Complexity	Low	Moderate

4. Discussion and Conclusion

Challenges Faced

1. Timer synchronization between color changes and time checks
2. Thread safety in GUI updates
3. DateTime comparison precision

Solutions Implemented

- Used separate timers for UI and logic (500ms vs 1000ms)
- Leveraged `SystemColors.Control` for safe background reset
- Implemented culture-invariant parsing

Key Learnings

1. Importance of `InvokeRequired` pattern for cross-thread operations

2. Advantages of Windows Forms Toolbox for rapid UI development
3. Effective use of event args for passing time data

5. Conclusion

Both implementations successfully demonstrated event-driven principles. The Windows Forms version provided richer user interaction while maintaining core publisher-subscriber architecture. All lab objectives were achieved with proper separation of concerns between event publishers and subscribers.

6. GitHub Repository

· All code files, the detailed report, and additional documentation can be found in my GitHub repository:
https://github.com/Pathan-Mohammad-Rashid/STT_Labs.git

· *Onedrive Link:*
https://iitgnacin-my.sharepoint.com/:f:/g/personal/22110187_iitgn_ac_in/EnECtzFbUNZKkBWY6aa8QJYBp6liTXfpuYRtJNMd1TwR6A?e=nsND4y