Programming Lab

2024

CS1PC20 Sample: Programming in C/C++

This tutorial is an example from the Computer Science module Programming in C/C++, which has recently been a first year module. It demonstrates how the lab practicals have been organized:

- *Lectures deliver theoretical knowledge.*
- *Lab practicals apply the theory in practice and provide training for skills such as programming.*
- *In the Programming module, lab practicals use tutorials consisting of individual work and group work.*

If you were a first year student taking a Programming module, by this point, you would already have been given additional exercises to help you practise the basics before attempting these tasks. For this session, though, we have decided to jump straight into the more interesting part of the practical.

If you have any questions, we encourage you to attract the attention of the lecturer or the assistants, for example, by raising your hand.

Learning Objectives

By the end of the tutorial, you will be able to:

- Use Visual Studio to execute and modify a program.
- Describe the behaviour of the structured programming theorem constructs (sequence, selection, iteration).

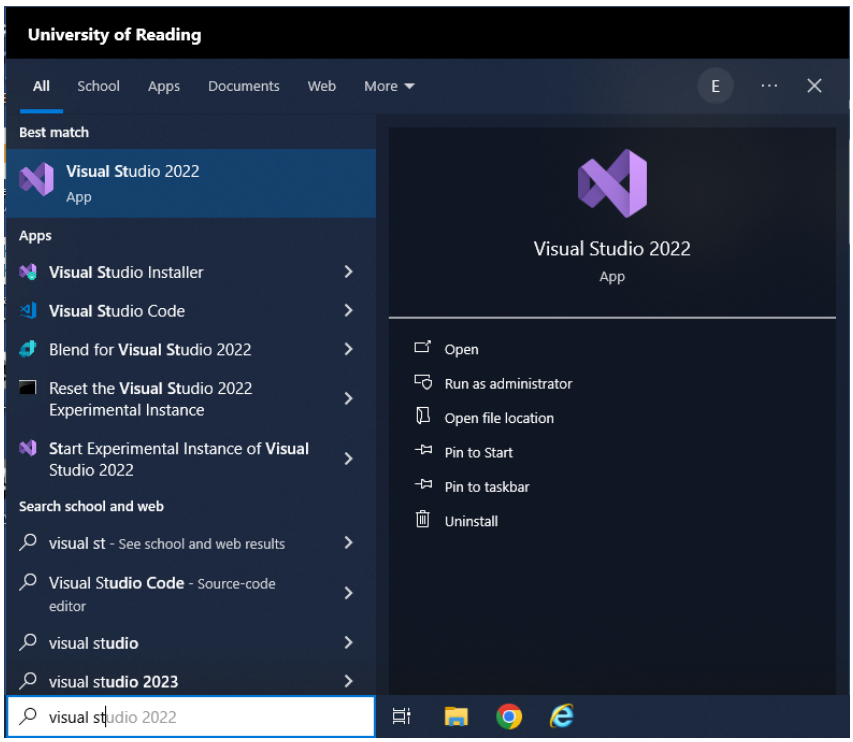
Contents

1. Tutorial (20 Minutes): Compiling a Program using Visual Studio

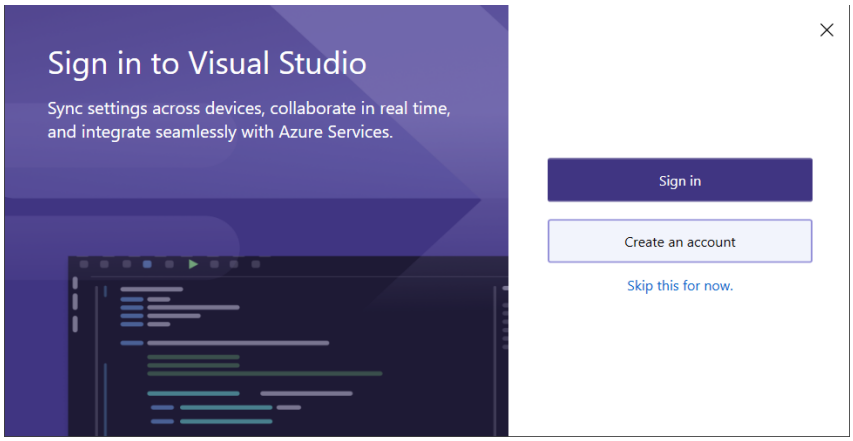
As part of this tutorial, we will use Visual Studio to download, modify and build an existing program.

Steps

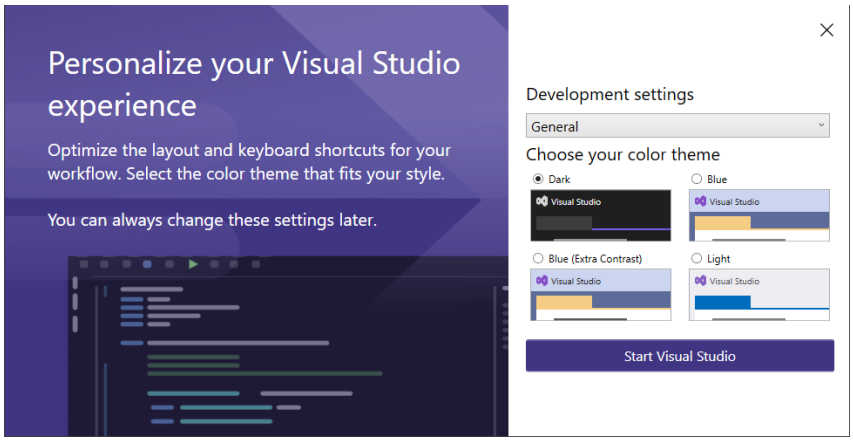
1. In the Start menu, search for and start **Visual Studio 2022**.



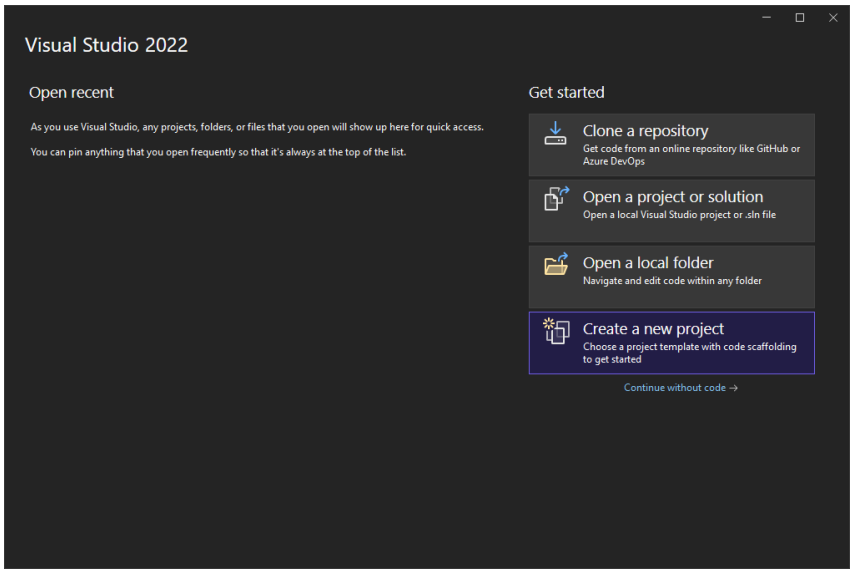
2. Once Visual Studio is loaded, you are likely to be asked whether you want to "Sign in to Visual Studio". Select: "**Skip this for now.**" at the bottom.



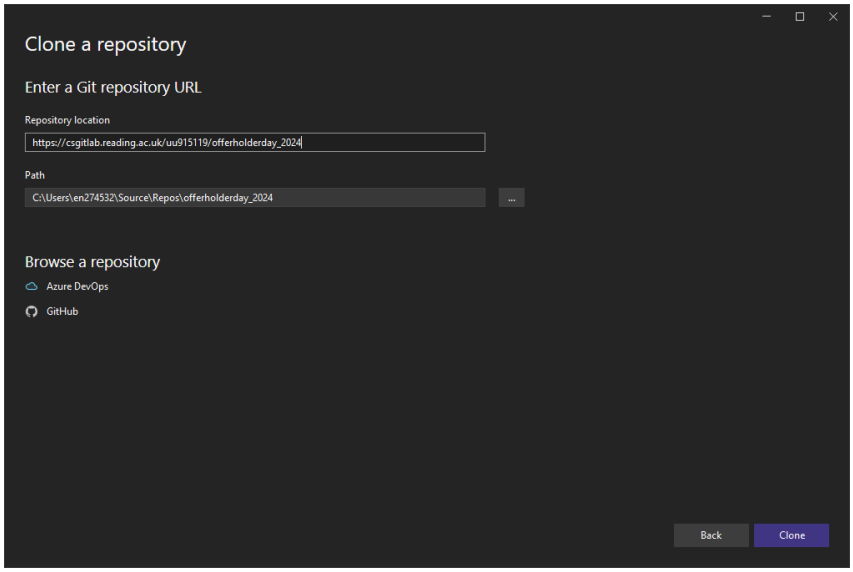
3. Choose **General** Development settings. Select the **Dark** theme to match the following images. Then, click **Start Visual Studio**.



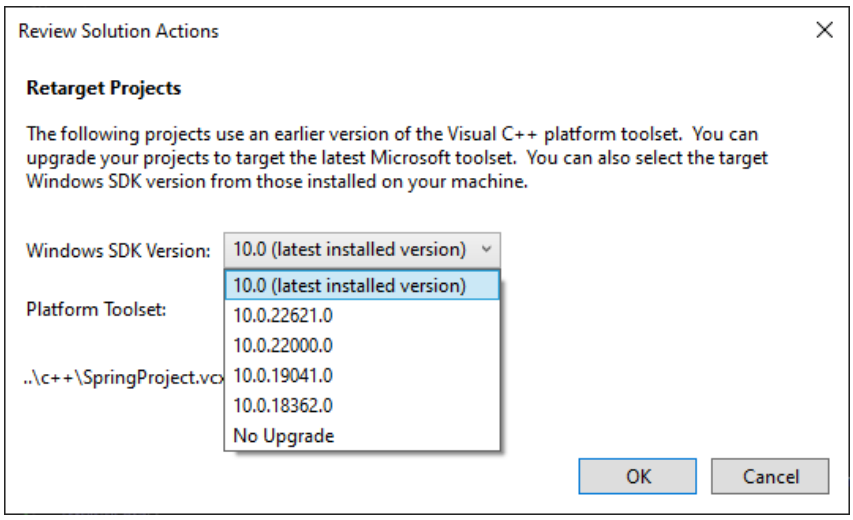
4. Wait a few moments for the system to configure the settings.
5. On the opening splash screen, select "**Clone a repository**".



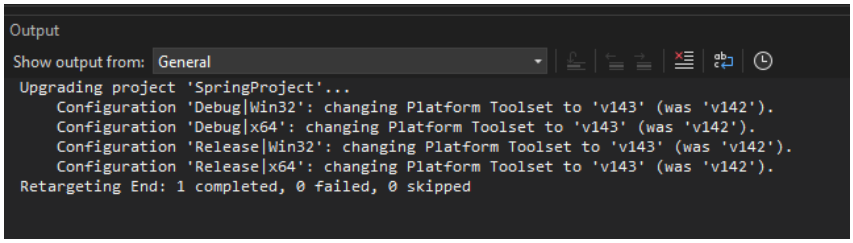
6. Input the URL: https://csgitlab.reading.ac.uk/uu915119/offerholderday_2024.git and click **Clone**.



7. You may further be prompted to **Retarget Projects**. Please do so by selecting the **latest installed version** and clicking **OK**.

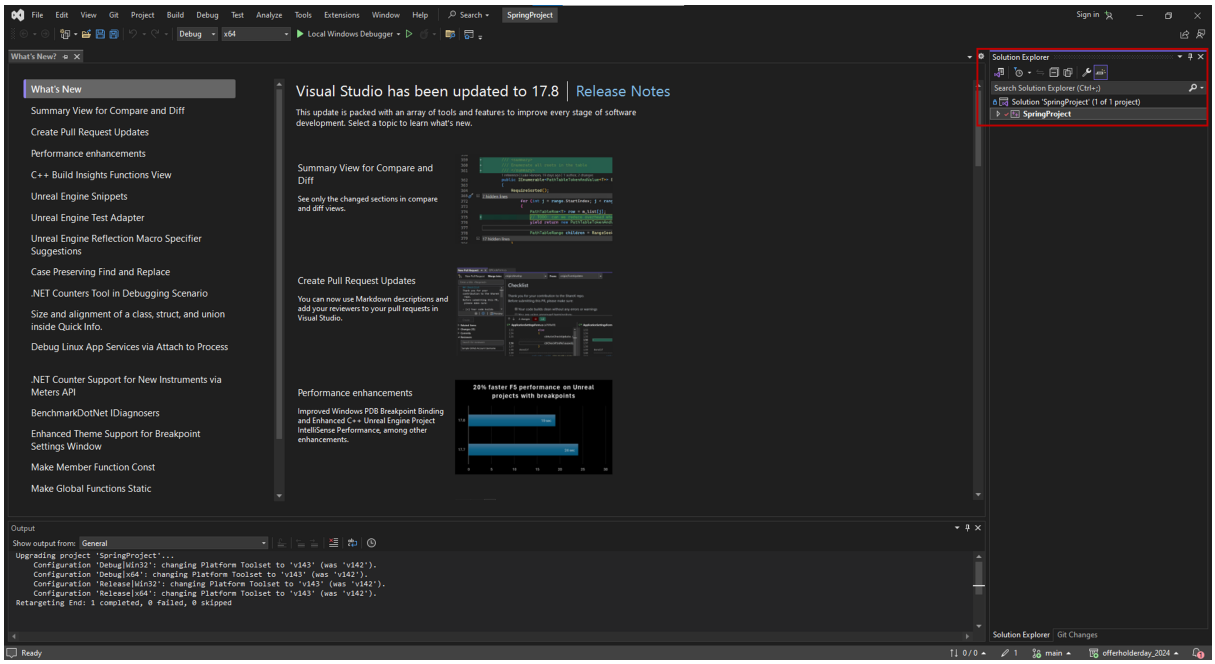


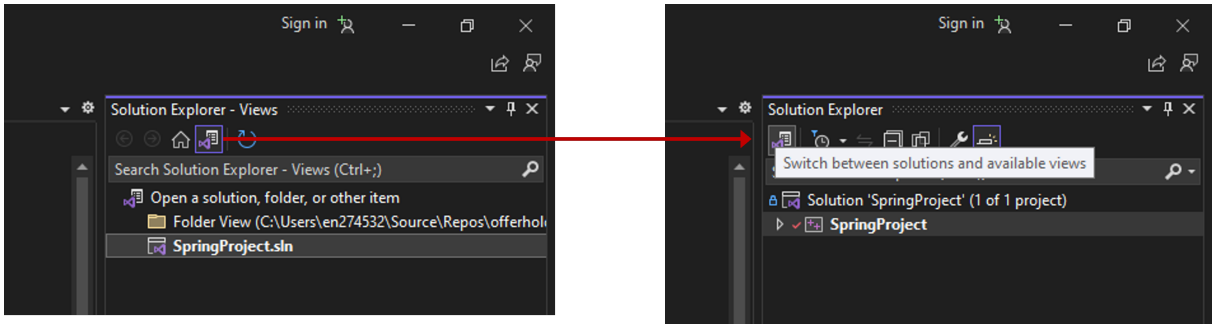
On successful completion of this step, the following will appear in the **Output** panel at the bottom of the screen.



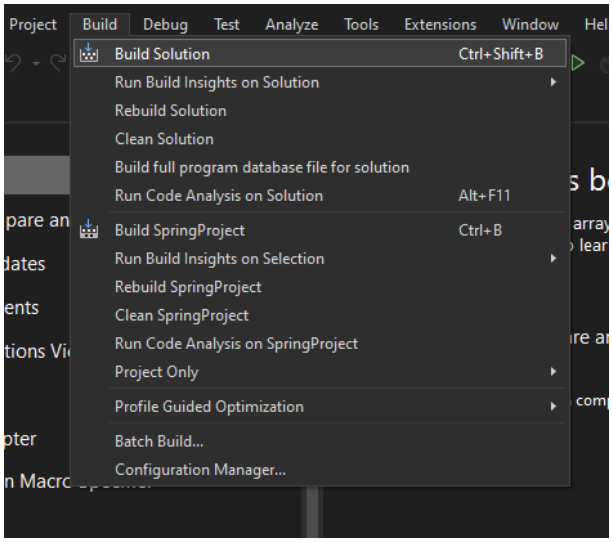
8. Next, we will look at the basics of Visual Studio to understand the Main Editor and Solution Explorer. For a detailed introduction, you might have a look at https://learn.microsoft.com/en-us/visualstudio/get-started/visual-studio-ide?view=vs-2022 in a web browser, but this is not required for this session.

9. In the **Solution Explorer** (see below), select the file `SpringProject.sln`; **double-click** on it to open the solution. You might need to click the button as highlighted below to "switch between solutions and available views."





10. Compile[1] and run the program by selecting the **Build Configuration**.

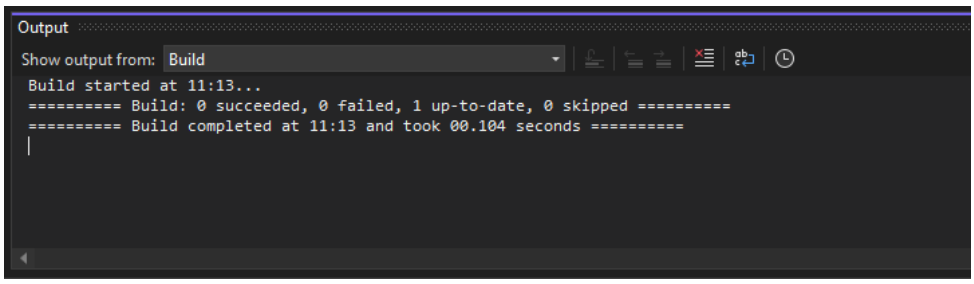


This action will open an output interface at the bottom, in which the output of the compilation process is shown. Once the build is complete, a console window should open containing the expected output, and Visual Studio will switch into the **Debugger**

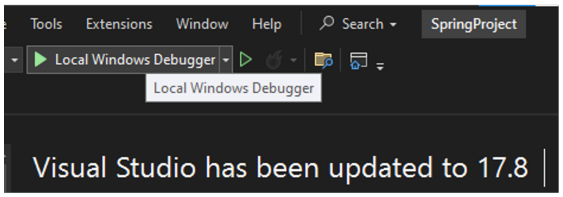
[1] A compilation process generates a executable program from source code.

interface. This process might take some time on the first run, so do not be surprised if it takes a while to load and start the first time you compile and run.

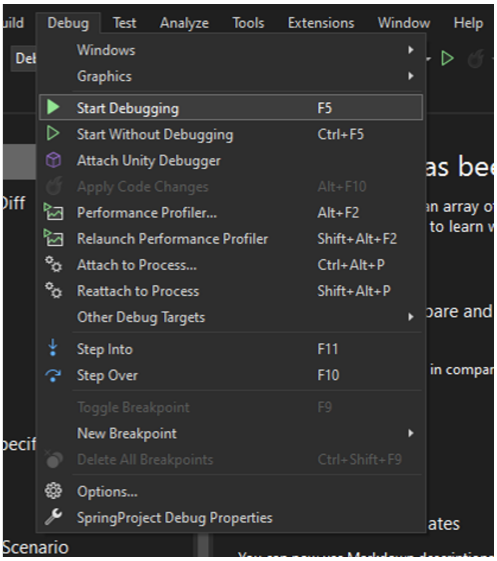
Note: If the code contains an error (e.g., one that you might introduce while editing the code) and is not well-formed, Visual Studio will not run the code.



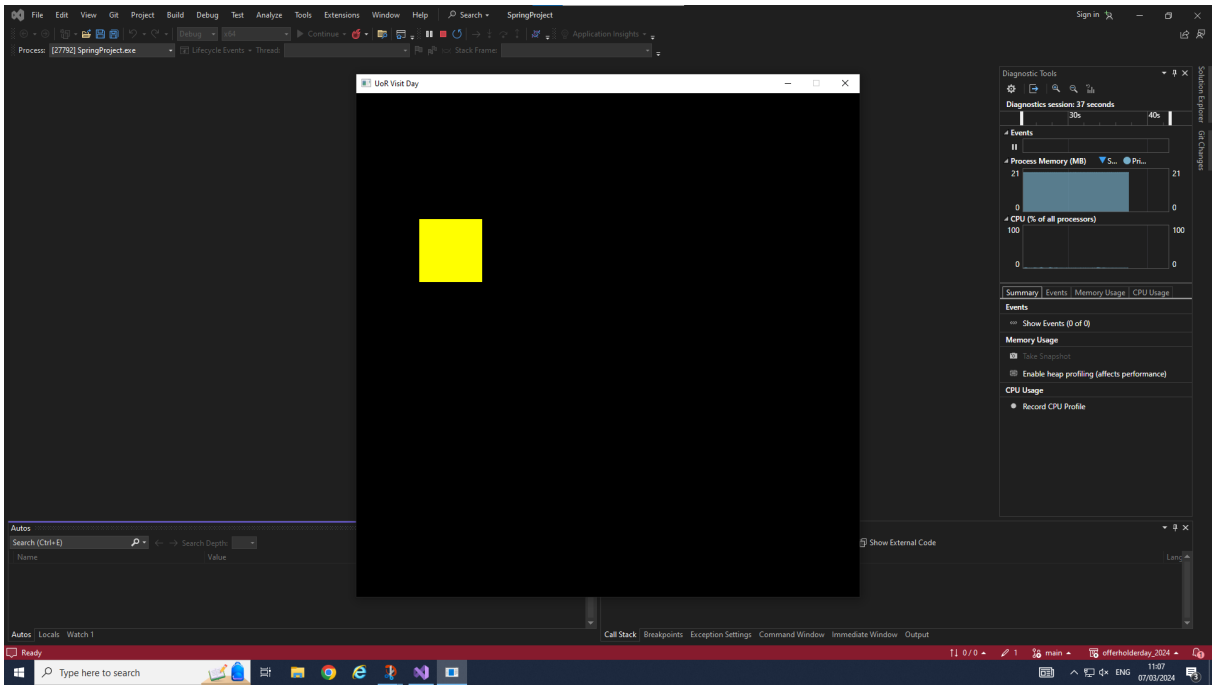
11. Next, we can run the code by selecting the **Local Windows Debugger** at the top of the interface (see image below). The key `F5` also triggers execution.



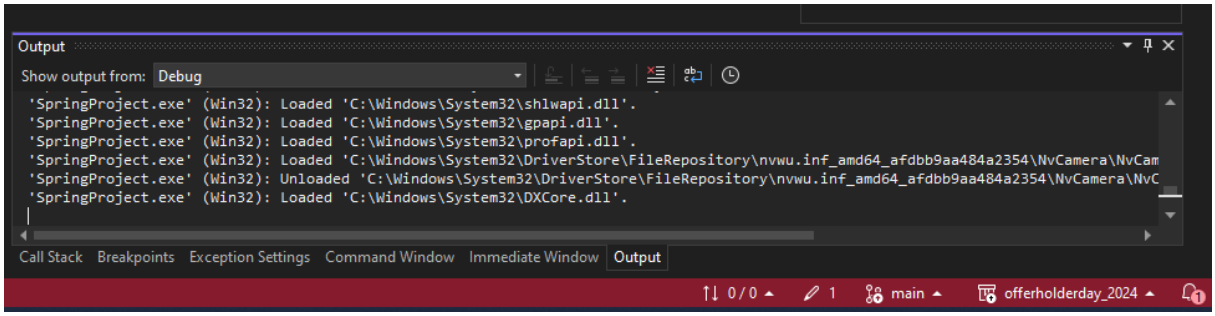
or

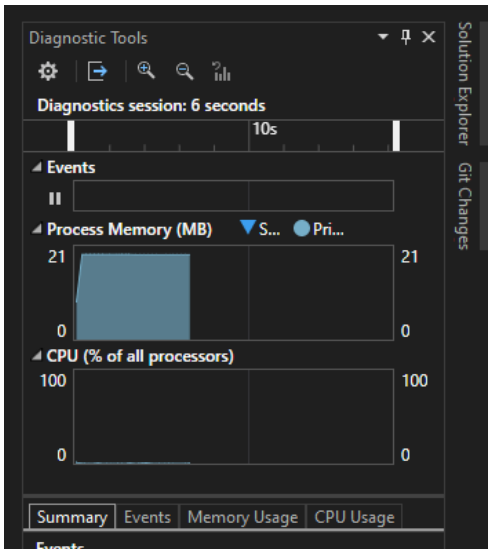


12. You should see a **new window** open with a colored rectangle. This is our application. It is not very interesting yet, so **close the window** containing the yellow square.

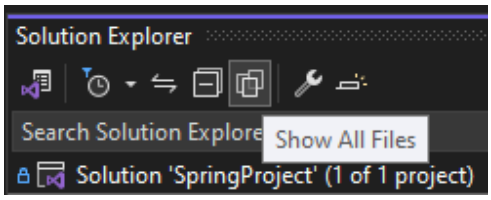


You might also note that while the code is running, the contents of the **Output panel** becomes filled with information, and the **Diagnostic Tools panel** appears to display information about the resources being used by the program.





13. We will now start to experiment by modifying the source code in the main window. First, open the file "`draw.c`" in the Solution Explorer. You may need to "Show All Files", then double-click the code file, residing under the **source or src file directory**



14. The file contains comments starting with the characters "//" that describe the behavior of the program. At the top of `draw.c`, you find this code:

```
3  // we will modify this "function" to draw a rectangle
4  void draw(int frame){
5    // This is the base version
6
7    // define the properties of a color
8    rgb_t color;
9    color.red = 255;
10   color.green = 255;
11   color.blue = 0;
12
13   SDL_Rect rect1;
14   // define the properties of the rectangle
15   rect1.x = 100; // coordinate x
16   rect1.y = 200; // coordinate y
17   rect1.h = 100; // height
18   rect1.w = 100; // width
19   // draw a specified rectangle with the given color
20   draw_rect(rect1, color);
21 }
```

Listing 1: `draw.c`

This code uses our concept of "**Sequence**" to run several instructions, one after the other, sequentially. It first defines a color (Lines 8-11) using the RGB color mode (0 means no color in the respective channel and 255 means maximum brightness). Then, it defines the dimensions of a rectangle (Lines 13-18). Finally, it draws the rectangle by calling the "function" `draw_rect()` in Line 20.

Note: the coordinates are pixel distances denoting the position of the upper left corner of the rectangle, relative to the upper left of the

15. **Experiment** by changing some **values** for color, position, or size in the `draw` function code as you like and rerun the code to see the effects of your changes.

16. **Test** changing one of the fixed numbers to depend on the `frame` variable (an integer value) that is passed into this `draw()` function (with new values as each frame of the output image of the square is drawn). You might not be immediately sure what we are asking you to do. Please raise your hand and ask for help if this is the case.

Further Reading

Explore Visual Studio (in your own time):

- Welcome to the Visual Studio IDE: https://learn.microsoft.com/en-us/visualstudio/get-started/visual-studio-ide?view=vs-2022

- Tour of Visual Studio: https://learn.microsoft.com/en-us/visualstudio/ide/quickstart-ide-orientation?view=vs-2022

2. Group Work (25 Minutes): Control Structures for Structured Programming

As part of this task, we will explore basic control structures in C that implement **selection** and **iteration**. We have already seen **sequence** in action because the program is executed step by step.

We will modify our `draw()` function in the same project that we used before, exploring several options. There are several different ways you can achieve each goal.

Please feel free to explore and play with the code. Some steps are marked as **advanced**; only perform them if you feel comfortable. The hints section underneath provides some support.

Steps

1. Team up with one of your neighbours, and sit in front of one computer.
2. Work through the following tasks:

   (a) First, modify the code so that the *graphics change over time*. To do this, we will rely upon the variable `frame`, which is an **integer** value indicating how many times the image has been re-drawn (like counting the frames in an animation).

   After some initial experimentation, think about how you could make the image **alternate** between two states every other frame. To do this, you can use the C construct for **selection**, which is illustrated in the following code:

```
1    if ( condition ){ // if condition != 0, then
2      // run this code
3    } else {
4       // run this other code
5    }
```

Listing 2: C Selection Construct

So, you could create, for instance, code like this:

```
1    if ( 5 < 10 ){ rect1.x = 100;
2    } else {
3    rect1.x = 200;
4    }
```

Listing 3: Example Selection

Which means that if 5 is smaller than 10, which it is, then set the x coordinate of our rectangle to 100. The condition here is fixed, but normally we use **variables** in the condition. Here, you should try to make a modification involving the variable `frame`. Modify the `if` statement above to make the coordinates of the rectangle alternate between two locations depending on the frame.

(b) Try to make the rectangle move from left to right (using the `frame` variable to modify the value of `rect1.x`).

- Can you **stop** the rectangle from moving out of the window?
- **Advanced**: Can you make it **bounce** back and forth between the boundaries of the window?

(c) Next, try to create **5 rectangles** and place them next to each other. (You can choose the orientation of this layout.) This can be achieved using the `for` loop. Remember that this loop runs code for initialisation, then checks the condition and, if it is true, runs the loop body. In each **iteration**, it runs the code in the **iteration** expression again.

The following example runs the loop body 5 times; the variable `i` can be used to distinguish the individual iterations.

```
1    for(int i=0; i < 5; i++){
2    // loop body
3
4    }
```

Listing 4: Example Iteration

(d) Modify your code from the previous step to give each rectangle a different color. That is, the first rectangle should have a different color than the next one and so on.

(e) Modify your code again and make the color vary depending on the frame.

- **Advanced**: You may see that the color is flickering. For example, if you modified the green channel, the rectangle might get more and more green and then black again. Can you change the code so that the color alternates; that is, it gets gradually more intense (say for 20 frames) and then gradually less intense again?
- **Advancded:** Organize a 2D shape of 5×5 rectangles next to each other, each with a different color.

3. Discuss the outcome of the practical with **2 other student pairs** nearby. Reflect on the task:
   - Where did you struggle?
   - What did you learn?
4. Group discussion: The lecturer will discuss the outcome of the practical with the class; potentially, we will look at a program and discuss it. If you feel comfortable, feel free to present one of your programs to the rest of the class.

If you are already an experienced programmer and finish early you may check out the Easter Egg program Section 3.

Hints

- The following calculates the remainder of division by two: 5 % 2 (result is 1).

- The file "`src/code-snippets.c`" contains our base version of the code and sample solutions for each different step above. In order to use these sample solutions, locate the point of `draw.c` where there is a comment that says "`// draw something`" and the expression "`draw(frame);`". Here, `draw` is calling the function written at the top of the `draw.c` file. If you change this to be one of the names of a function in `src/code-snippets.c`, (e.g., `draw_b_1`) and re-run the code, the new drawing functionality will be displayed in the window.
- The constant `SIZE` represents the width and height of the window. This is defined in the file "`Header.h`".
- If you receive a compilation error referring to something called "`SDL`", check that you have opened the "Solution SpringProject" and not another C file.

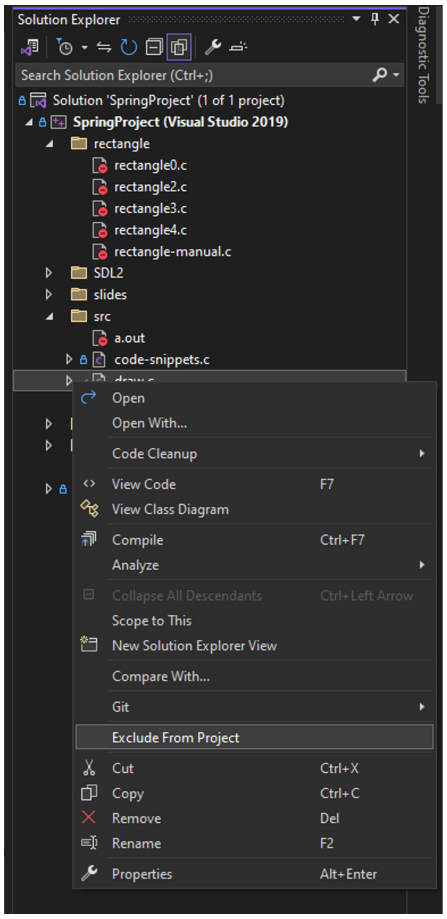
3. Easter Eggs: A Bouncy Reading

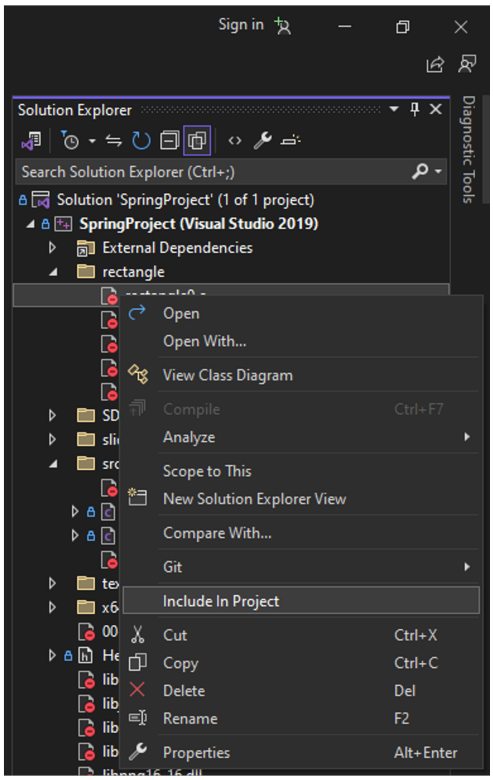
If you have time and feel comfortable with the group work, you could try some fun programs that can be derived from our example.

In the directory `rectangle`, you will find an example program with a moving logo that you can try. The program `rectangle3.c`, for example, provides a logo that bounces from the corners and `rectangle-manual.c` allows you to control its movement using the arrow keys.

These each contain their own `main` functions that start processing the program, just like in `draw.c`.

In order to use one of the rectangle programs without confusing the system with multiple definitions of the `main` function, you must **exclude** `code-snippets.c` and `draw.c` from the project in the solution explorer and also **enable** one of the rectangle files (image below).

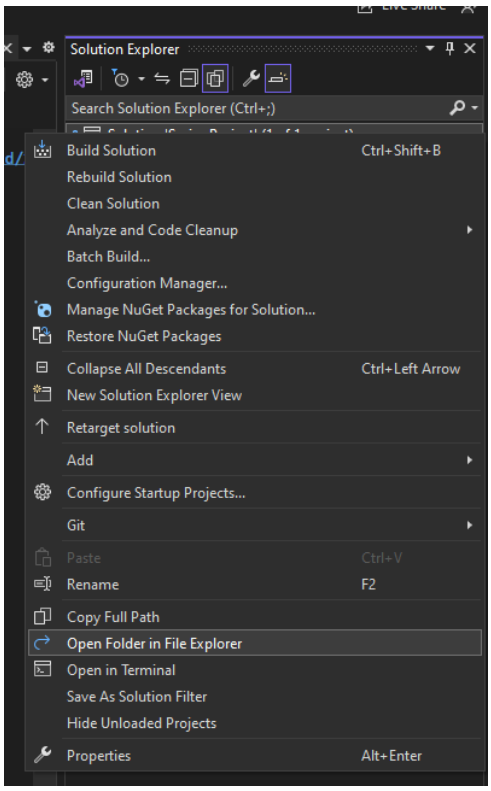




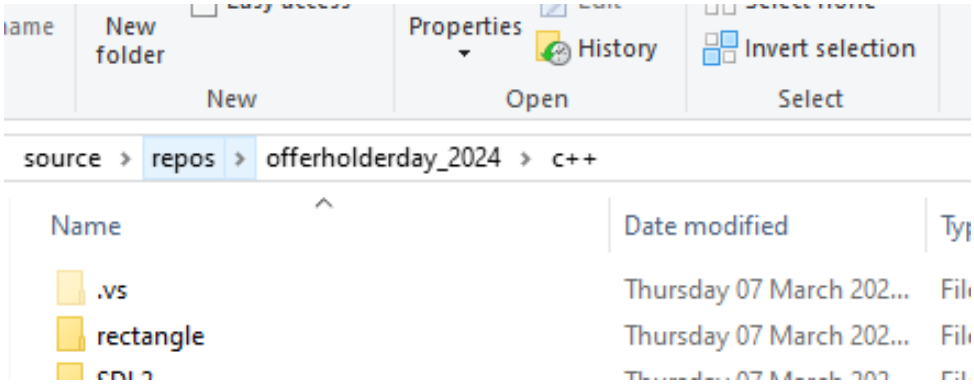
Note that there can be **only one** of the rectangle examples used at a given time, as they are all complete programs. Now you should be able to compile and run these programs.

4. Cleaning Up

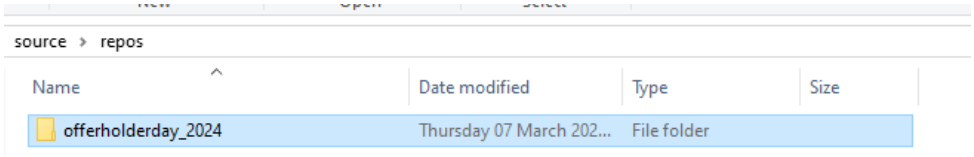
- When you are done working, go to the **Solution Explorer**, right-click on the top level of the solution package and select **Open Folder in File Explorer**.



- Next, close **close Visual Studio 2022** application, and select the **repos** directory.



- Select the **offerholderday_2024** directory and **delete** it.



- When done, you should see an empty directory: