

Template Week 4 – Software

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Assignment 4.1: ARM assembly

Screenshot of working assembly code of factorial calculation:

The screenshot shows the OakSim software interface. At the top, there are buttons for Open, Run, 250, Step, and Reset. Below these is a text area containing ARM assembly code. To the right is a register table and a memory dump.

Assembly Code:

```
1 Main:
2     mov r2,#5
3     subs r3, r2, #1
4     ble End
5 Loop:
6     mul r2, r3, r2
7     subs r3, r3, #1
8     bne Loop
9 End:
10    mov r1, r2
11    mov r2, #0
```

Register Table:

Register	Value
R0	0
R1	78
R2	0
R3	0
R4	0
R5	0
R6	0
R7	0
R8	0
R9	0
R10	0

Memory Dump:

0x00010000:	05 20 A0 E3 01 30 52 E2 02 00
0x00010010:	01 30 53 E2 FC FF FF 1A 02 10
0x00010020:	00 00 00 00 00 00 00 00 00 00 00
0x00010030:	00 00 00 00 00 00 00 00 00 00 00
0x00010040:	00 00 00 00 00 00 00 00 00 00 00
0x00010050:	00 00 00 00 00 00 00 00 00 00 00
0x00010060:	00 00 00 00 00 00 00 00 00 00 00
0x00010070:	00 00 00 00 00 00 00 00 00 00 00
0x00010080:	00 00 00 00 00 00 00 00 00 00 00
0x00010090:	00 00 00 00 00 00 00 00 00 00 00
0x000100A0:	00 00 00 00 00 00 00 00 00 00 00
0x000100B0:	00 00 00 00 00 00 00 00 00 00 00
0x000100C0:	00 00 00 00 00 00 00 00 00 00 00
0x000100D0:	00 00 00 00 00 00 00 00 00 00 00
0x000100E0:	00 00 00 00 00 00 00 00 00 00 00
0x000100F0:	00 00 00 00 00 00 00 00 00 00 00
0x00010100:	00 00 00 00 00 00 00 00 00 00 00
0x00010110:	00 00 00 00 00 00 00 00 00 00 00
0x00010120:	00 00 00 00 00 00 00 00 00 00 00

A small window in the foreground displays personal information:

Angela Visser
587707
26-12-2025

Assignment 4.2: Programming languages

Take screenshots that the following commands work:

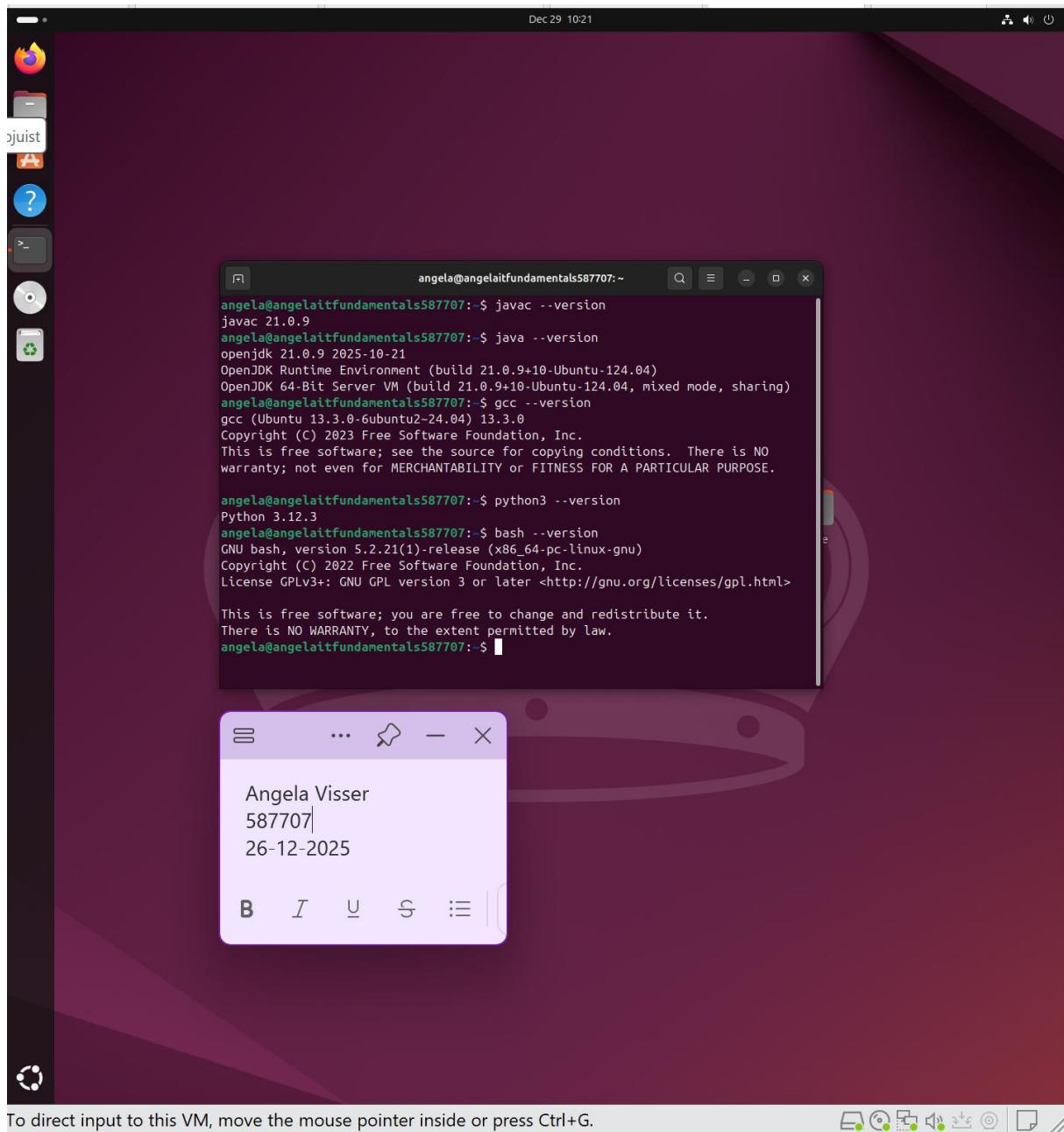
```
javac --version
```

```
java --version
```

```
gcc --version
```

```
python3 --version
```

```
bash --version
```



Assignment 4.3: Compile

O output

D disassemble

Fibonacci.java -java source code

fib.c -c source code

fib.py -python3 source code

fib.sh -bash script source code

Which of the above files need to be compiled before you can run them?

Fibonacci.java en fib.c

Which source code files are compiled into machine code and then directly executable by a processor?

Fib.c, c is a language that is compiled directly into machine code.
java is compiled into bytecode and runs on the java virtual machine.
the other two are interpreted languages.

Which source code files are compiled to byte code?

Fibonacci.java, see explanation above.

Which source code files are interpreted by an interpreter?

Fib.py and fib.sh

These source code files will perform the same calculation after compilation/interpretation. Which one is expected to do the calculation the fastest?

Fib.c is expected to run the fastest. This is because c is compiled directly into machine code.

How do I run a Java program?

First, Java has to be compiled into bytecode, which then runs within the Java virtual machine.

How do I run a Python program?

A python program is read and executed by the interpreter. And the interpreter's machine code runs on the CPU.

How do I run a C program?

Because c is a compiled language, the source code is converted into machine instructions that can be directly executed by a processor.

How do I run a Bash script?

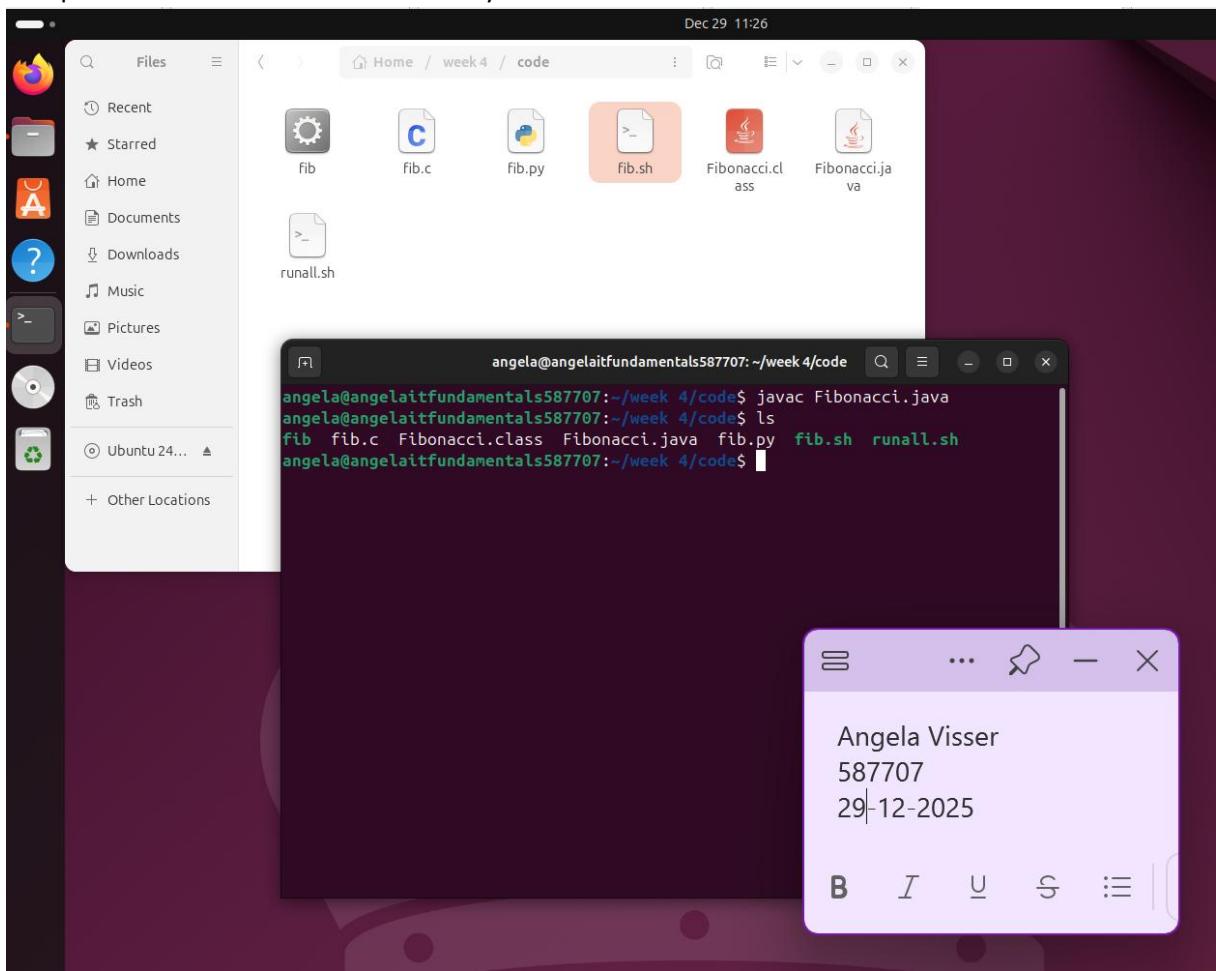
A bash script needs to be interpreted by an interpreter (Bash shell). Do note that we are trying to execute it on Ubuntu, so it needs to be made executable by changing the rights using the command: [sudo chmod a+x fib.sh].

If I compile the above source code, will a new file be created? If so, which file?

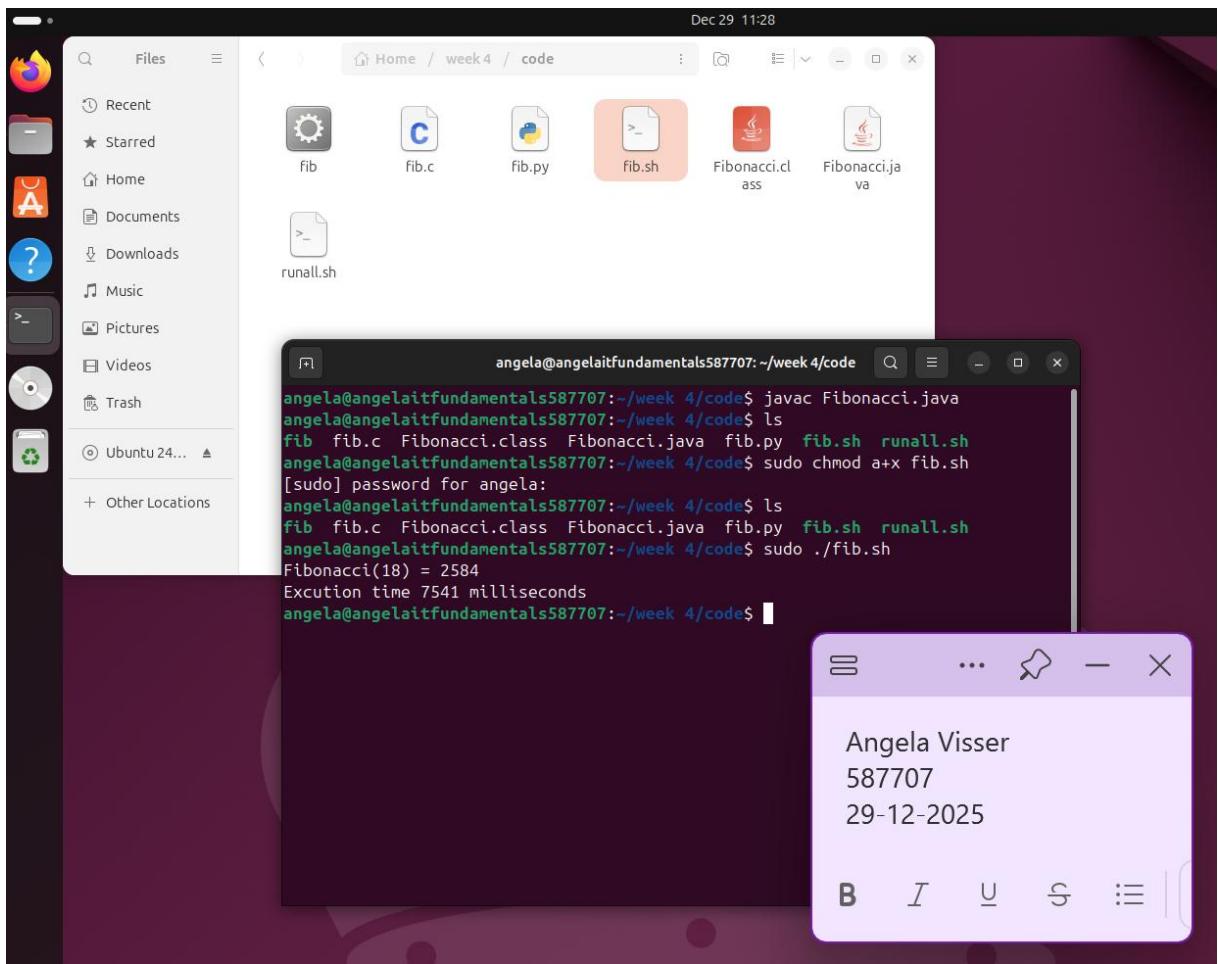
The compiled languages will add a file after compilation. The interpreted languages will not.
Fibonacci.java → Fibonacci.class
fib.c → fib.

Take relevant screenshots of the following commands:

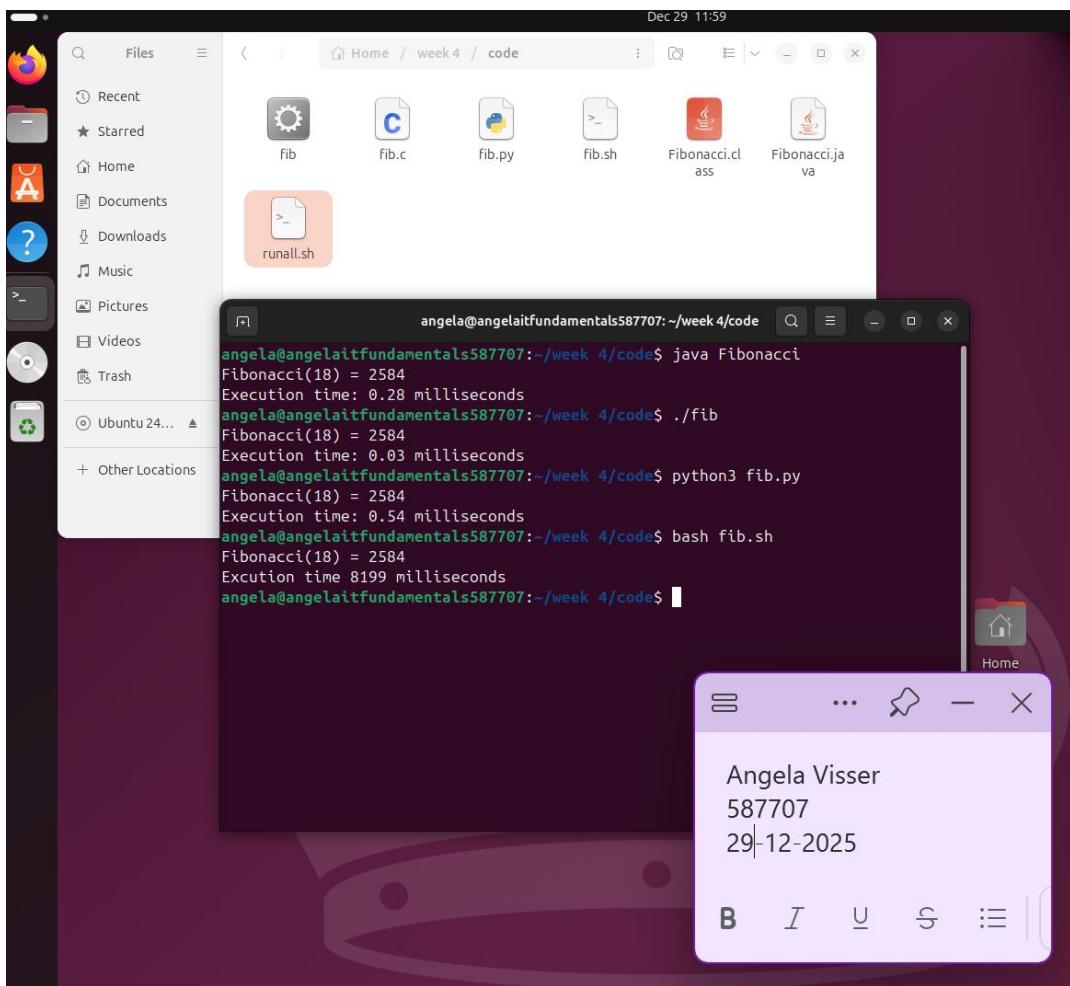
- Compile the source files where necessary



- Make them executable



- Run them



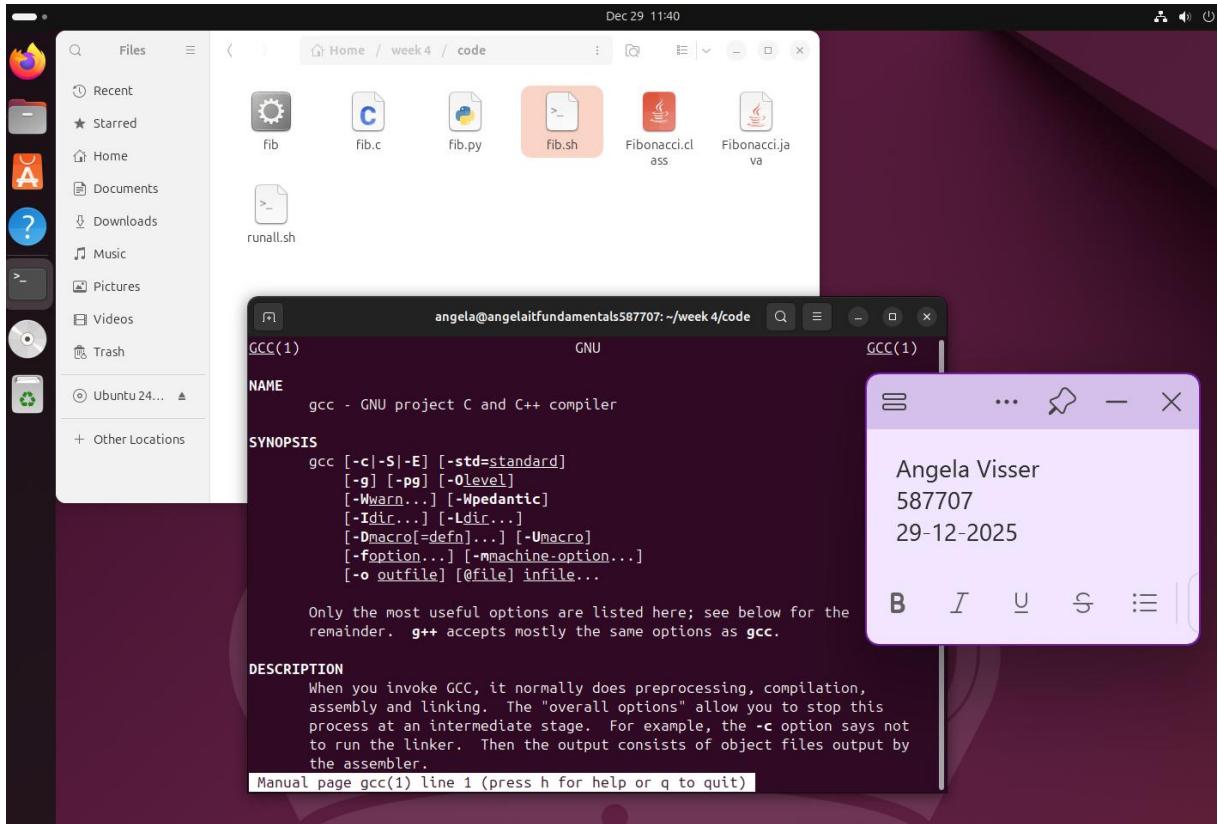
- Which (compiled) source code file performs the calculation the fastest?

The c source code performs the fastest.

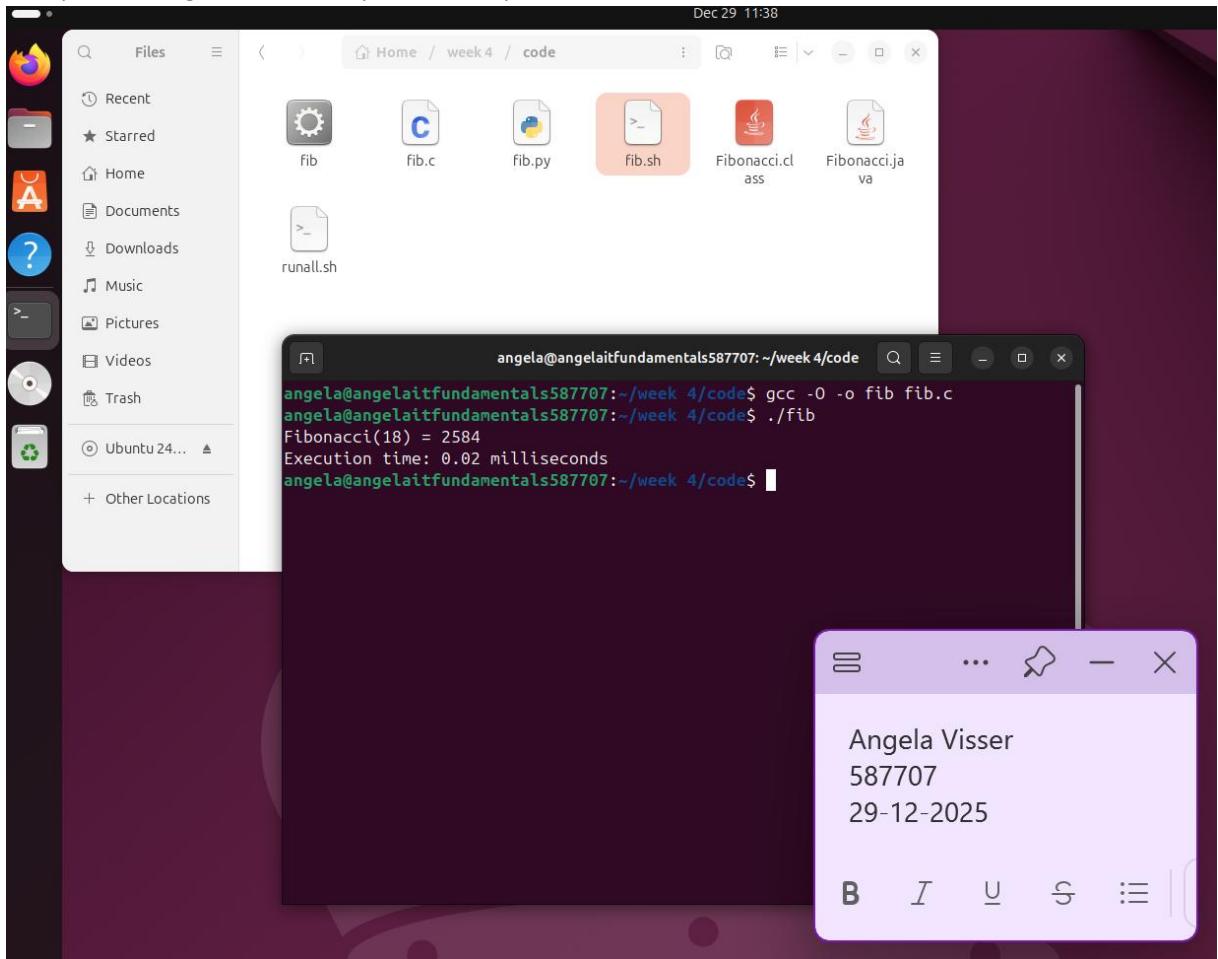
Assignment 4.4: Optimize

Take relevant screenshots of the following commands:

- a) Figure out which parameters you need to pass to the **gcc** compiler so that the compiler performs a number of optimizations that will ensure that the compiled source code will run faster. **Tip!** The parameters are usually a letter followed by a number. Also read **page 191** of your book, but find a better optimization in the man pages. Please note that Linux is case sensitive.



- b) Compile **fib.c** again with the optimization parameters



- c) Run the newly compiled program. Is it true that it now performs the calculation faster?

Yes

- d) Edit the file `runall.sh`, so you can perform all four calculations in a row using this Bash script. So the (compiled/interpreted) C, Java, Python and Bash versions of Fibonacci one after the other.

The screenshot shows a Linux desktop environment with a dark theme. A terminal window is open in the foreground, displaying the output of a script named `runall.sh`. The terminal window has a title bar that reads "angela@angelaitfundamentals587707: ~/week 4/code". The output of the script is as follows:

```
Running C program:  
Fibonacci(19) = 4181  
Execution time: 0.05 milliseconds  
  
Running Java program:  
Fibonacci(19) = 4181  
Execution time: 0.47 milliseconds  
  
Running Python program:  
Fibonacci(19) = 4181  
Execution time: 0.66 milliseconds  
  
Running BASH Script  
Fibonacci(19) = 4181  
Execution time: 15650 milliseconds
```

Below the terminal window, the command prompt is shown: `angela@angelaitfundamentals587707:~/week 4/code$`.

In the background, a file manager window is open, showing a directory structure under "Home / week 4 / code". The files listed include `copy_runall.sh`, `fib`, `fib.c`, `fib.py`, `fib.sh`, `Fibonacci.class`, `Fibonacci.java`, and `runall.sh`. The `runall.sh` file is highlighted with a red border.

A small purple callout box in the bottom right corner contains the student's information:

Angela Visser
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29-12-2025

Assignment 4.5: More ARM Assembly

Like the factorial example, you can also implement the calculation of a power of 2 in assembly. For example you want to calculate $2^4 = 16$. Use iteration to calculate the result. Store the result in r0.

Main:

mov r1, #2

mov r2, #4

Loop:

End:

Complete the code. See the PowerPoint slides of week 4.

Screenshot of the completed code here.

The screenshot shows a debugger interface with the following sections:

- Registers:** Shows the state of various CPU registers (R0-R10) with their corresponding values.
- Memory Dump:** Displays memory starting at address 0x00010000, showing hex values and ASCII representation.
- Assembly Code:** The assembly code for the program, including labels like Main, Loop, and End, and instructions like mov, add, and mul.
- _tooltip:** A tooltip for the assembly line at address 0x00010000 displays the assembly instruction and its binary representation.

Ready? Save this file and export it as a pdf file with the name: **week4.pdf**