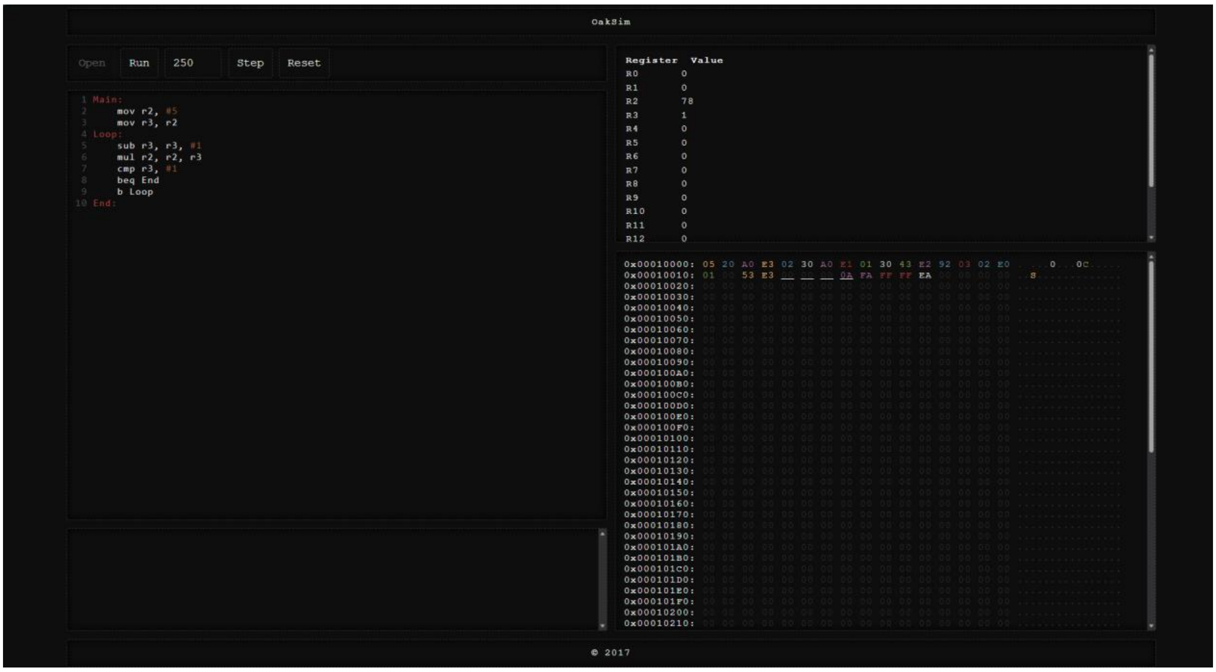
Template Week 4 – Software

Student number: 581429

Assignment 4.1: ARM assembly

Screenshot of working assembly code of factorial calculation:



Assignment 4.2: Programming languages

Take screenshots that the following commands work:

javac --version

java --version

gcc --version

python3 --version

bash --version

```
volodymyr@volodymyr-VMware-Virtual-Platform:~$ javac --version
javac 21.0.8
volodymyr@volodymyr-VMware-Virtual-Platform:~$ java --version
openjdk 21.0.8 2025-07-15
OpenJDK Runtime Environment (build 21.0.8+9-Ubuntu-0ubuntu124.04.1)
OpenJDK 64-Bit Server VM (build 21.0.8+9-Ubuntu-0ubuntu124.04.1, mixed mode, sha
ring)
volodymyr@volodymyr-VMware-Virtual-Platform:~$ gcc --version
gcc (Ubuntu 13.3.0-6ubuntu2~24.04) 13.3.0
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This is free software; see the source for copying conditions.  There is NO
warranty; not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.

volodymyr@volodymyr-VMware-Virtual-Platform:~$ python3 --version
Python 3.12.3
volodymyr@volodymyr-VMware-Virtual-Platform:~$ bash --version
GNU bash, version 5.2.21(1)-release (x86_64-pc-linux-gnu)
Copyright (C) 2022 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>

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There is NO WARRANTY, to the extent permitted by law.
volodymyr@volodymyr-VMware-Virtual-Platform:~$
```

Assignment 4.3: Compile

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

fib.c, Fibonacci.java

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

fib.c

Which source code files are compiled to byte code?

Fibonacci.java

Which source code files are interpreted by an interpreter?

fib.py, 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

How do I run a Java program?

To run a Java program, you first compile the source file using the javac command. This turns the human-readable Java code into Java bytecode. After compilation, you run the program using the java command. So the process has two steps: first you compile the .java file, then you run the resulting class file.

How do I run a Python program?

You simply execute it using the Python interpreter. You type "python3 filename.py" in the terminal, where filename.py is the name of your Python script. The interpreter reads the file and runs it directly.

How do I run a C program?

To run a C program, you must first compile it using a C compiler such as gcc. The compiler turns the C source code into an executable program. After it is compiled, you can run the executable. Example: First type "gcc fib.c -o fib" to compile the file named fib.c into an executable named fib. Then type "./fib" to run the program.

How do I run a Bash script?

You can run it directly using the Bash interpreter. One way is to type "bash scriptname.sh" in the terminal. Another way is to first make the script executable by running "chmod +x scriptname.sh" and then run it using "./scriptname.sh".

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

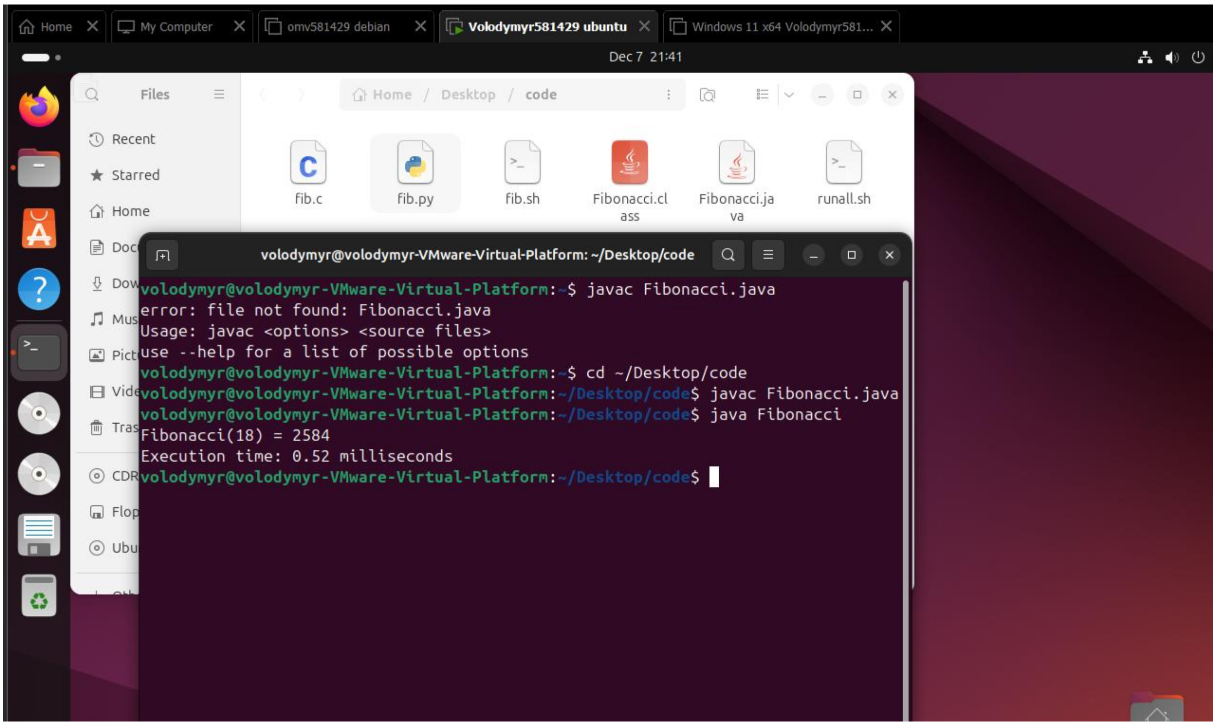
When you compile the C file (fib.c), a new executable file is created, for example named fib or a.out, depending on how you compiled it.

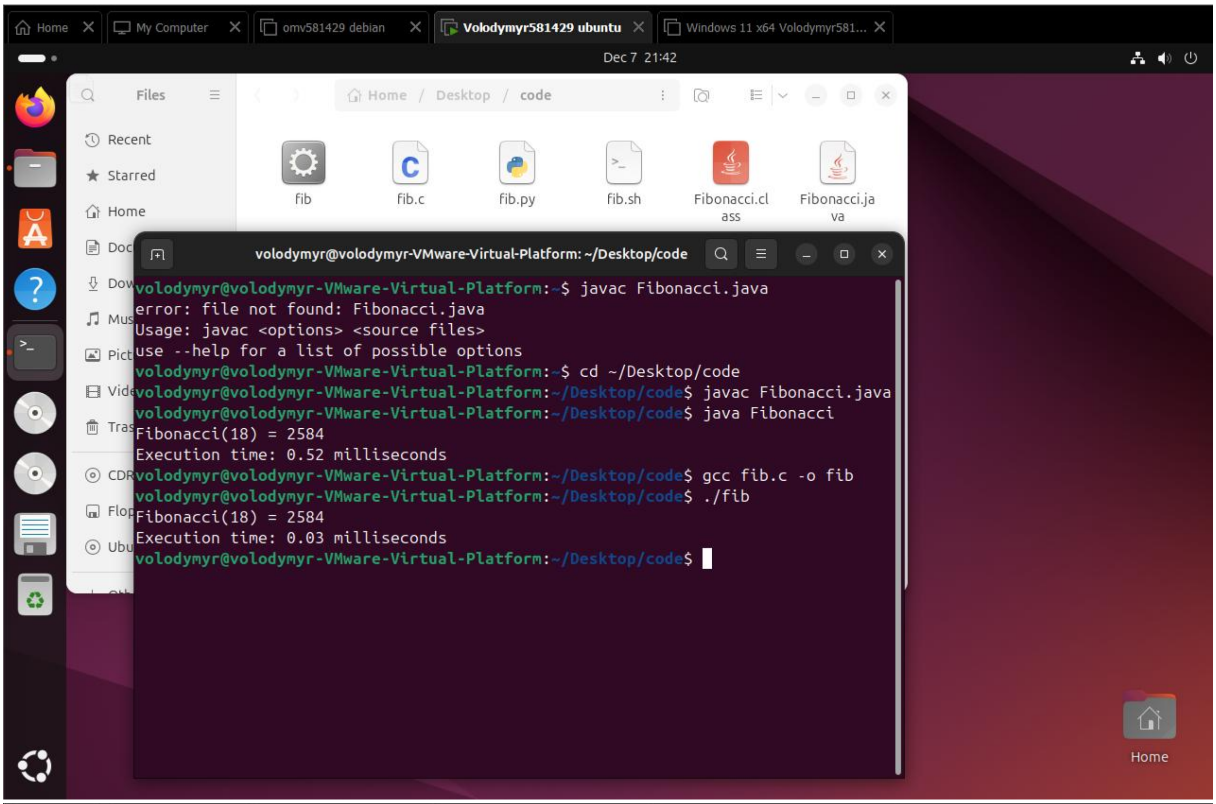
When you compile the Java file (Fibonacci.java), a new file named Fibonacci.class is created. This is the Java bytecode file.

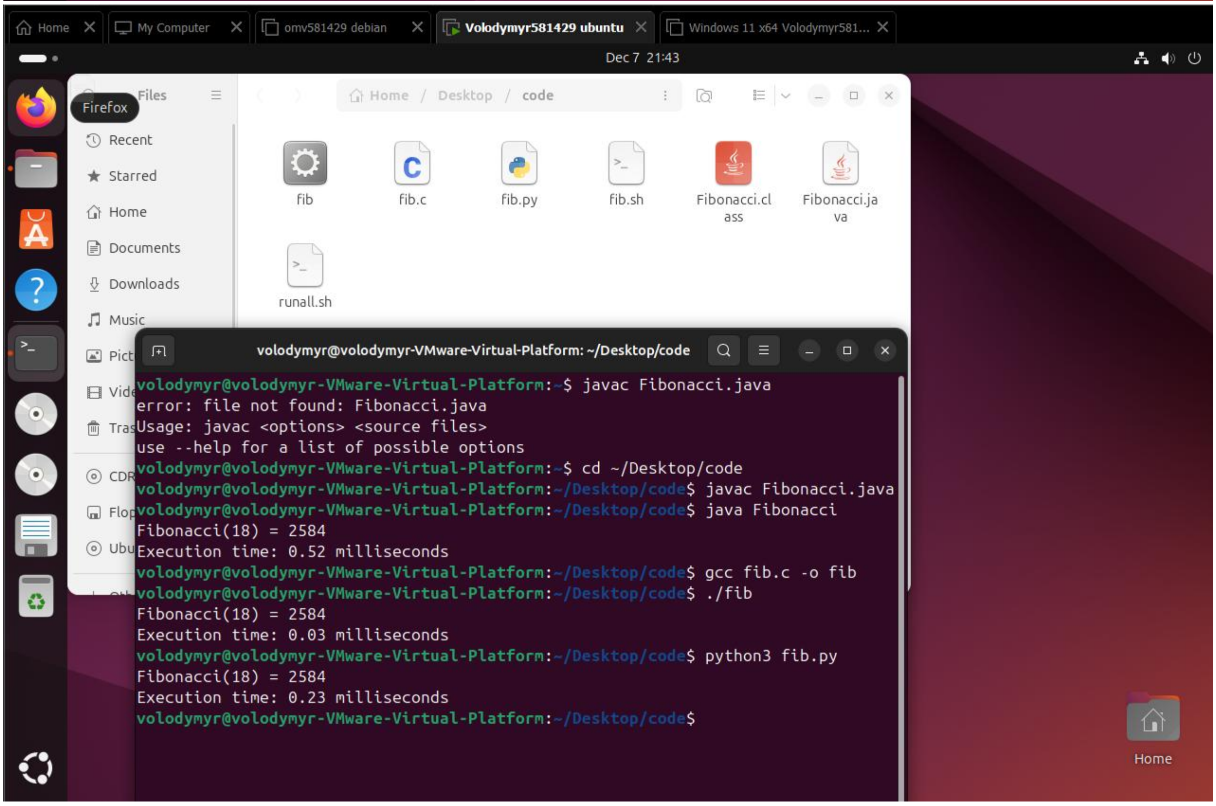
The Python and Bash files are not compiled, so no new file is created for those.

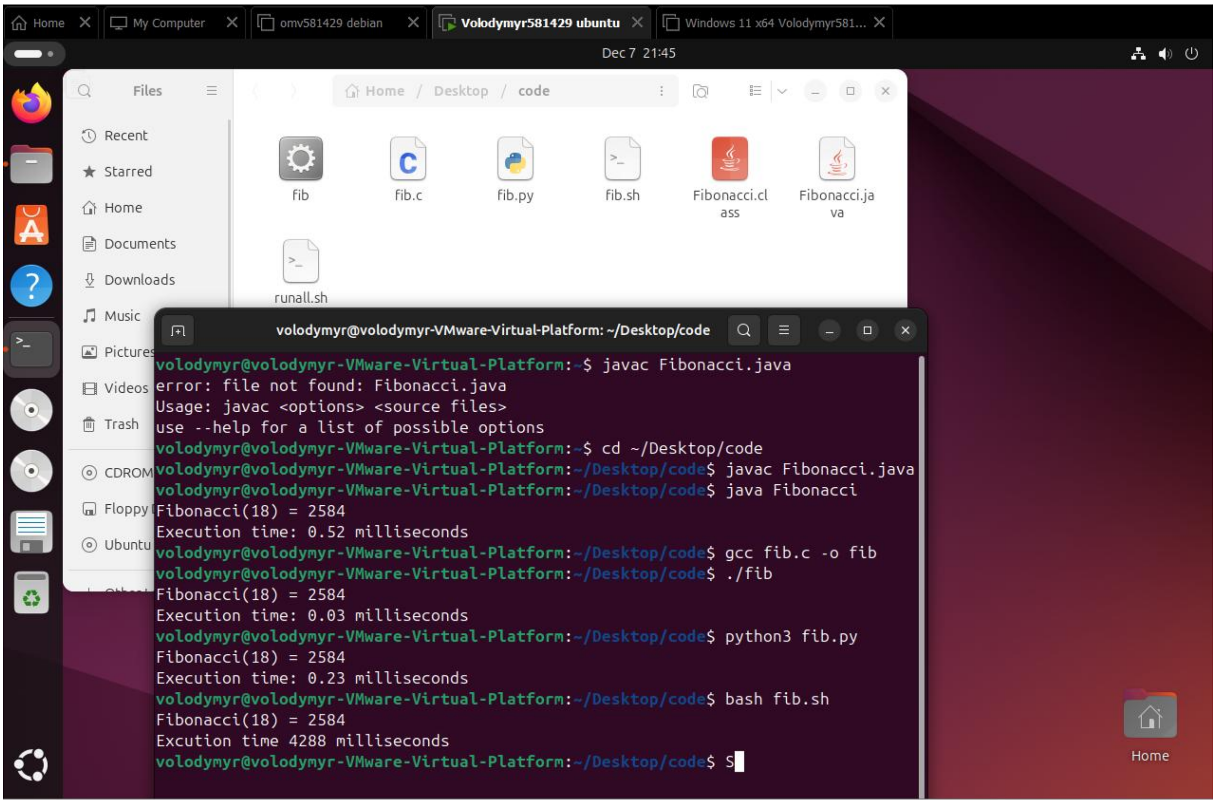
Take relevant screenshots of the following commands:

- Compile the source files where necessary
- Make them executable
- Run them
- Which (compiled) source code file performs the calculation the fastest?




Home
My Computer
omv581429 debian
Volodymyr581429 ubuntu
Windows 11 x64 Volodymyr581...
Dec 7 21:42
Files
Recent
Starred
Home
Home / Desktop / code
fib
fib.c
fib.py
fib.sh
Fibonacci.class
Fibonacci.java
volodymyr@volodymyr-VMware-Virtual-Platform: ~/Desktop/code
volodymyr@volodymyr-VMware-Virtual-Platform:~$ javac Fibonacci.java
error: file not found: Fibonacci.java
Usage: javac <options> <source files>
use --help for a list of possible options
volodymyr@volodymyr-VMware-Virtual-Platform:~$ cd ~/Desktop/code
volodymyr@volodymyr-VMware-Virtual-Platform:~/Desktop/code$ javac Fibonacci.java
volodymyr@volodymyr-VMware-Virtual-Platform:~/Desktop/code$ java Fibonacci
Fibonacci(18) = 2584
Execution time: 0.52 milliseconds
volodymyr@volodymyr-VMware-Virtual-Platform:~/Desktop/code$ gcc fib.c -o fib
volodymyr@volodymyr-VMware-Virtual-Platform:~/Desktop/code$ ./fib
Fibonacci(18) = 2584
Execution time: 0.03 milliseconds
volodymyr@volodymyr-VMware-Virtual-Platform:~/Desktop/code$
Home


Home
My Computer
omv581429 debian
Volodymyr581429 ubuntu
Windows 11 x64 Volodymyr581...
Dec 7 21:43
Firefox
Files
Recent
Starred
Home
Documents
Downloads
Music
Home / Desktop / code
fib
fib.c
fib.py
fib.sh
Fibonacci.class
Fibonacci.java
runall.sh
volodymyr@volodymyr-VMware-Virtual-Platform: ~/Desktop/code
volodymyr@volodymyr-VMware-Virtual-Platform:~$ javac Fibonacci.java
error: file not found: Fibonacci.java
Usage: javac <options> <source files>
use --help for a list of possible options
volodymyr@volodymyr-VMware-Virtual-Platform:~$ cd ~/Desktop/code
volodymyr@volodymyr-VMware-Virtual-Platform:~/Desktop/code$ javac Fibonacci.java
volodymyr@volodymyr-VMware-Virtual-Platform:~/Desktop/code$ java Fibonacci
Fibonacci(18) = 2584
Execution time: 0.52 milliseconds
volodymyr@volodymyr-VMware-Virtual-Platform:~/Desktop/code$ gcc fib.c -o fib
volodymyr@volodymyr-VMware-Virtual-Platform:~/Desktop/code$ ./fib
Fibonacci(18) = 2584
Execution time: 0.03 milliseconds
volodymyr@volodymyr-VMware-Virtual-Platform:~/Desktop/code$ python3 fib.py
Fibonacci(18) = 2584
Execution time: 0.23 milliseconds
volodymyr@volodymyr-VMware-Virtual-Platform:~/Desktop/code$
Home



As can be seen on these screenshots, the fib.c file performs the fastest.

Assignment 4.4: Optimize

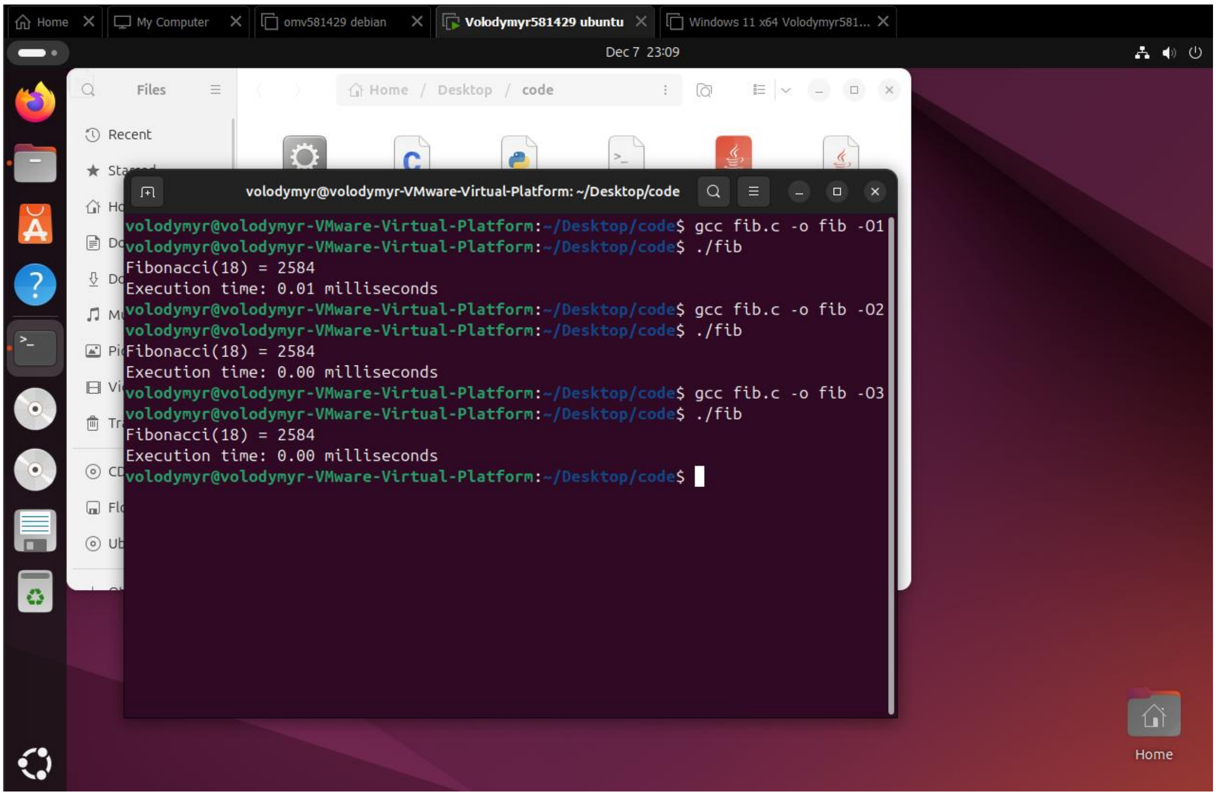
Take relevant screenshots of the following commands:

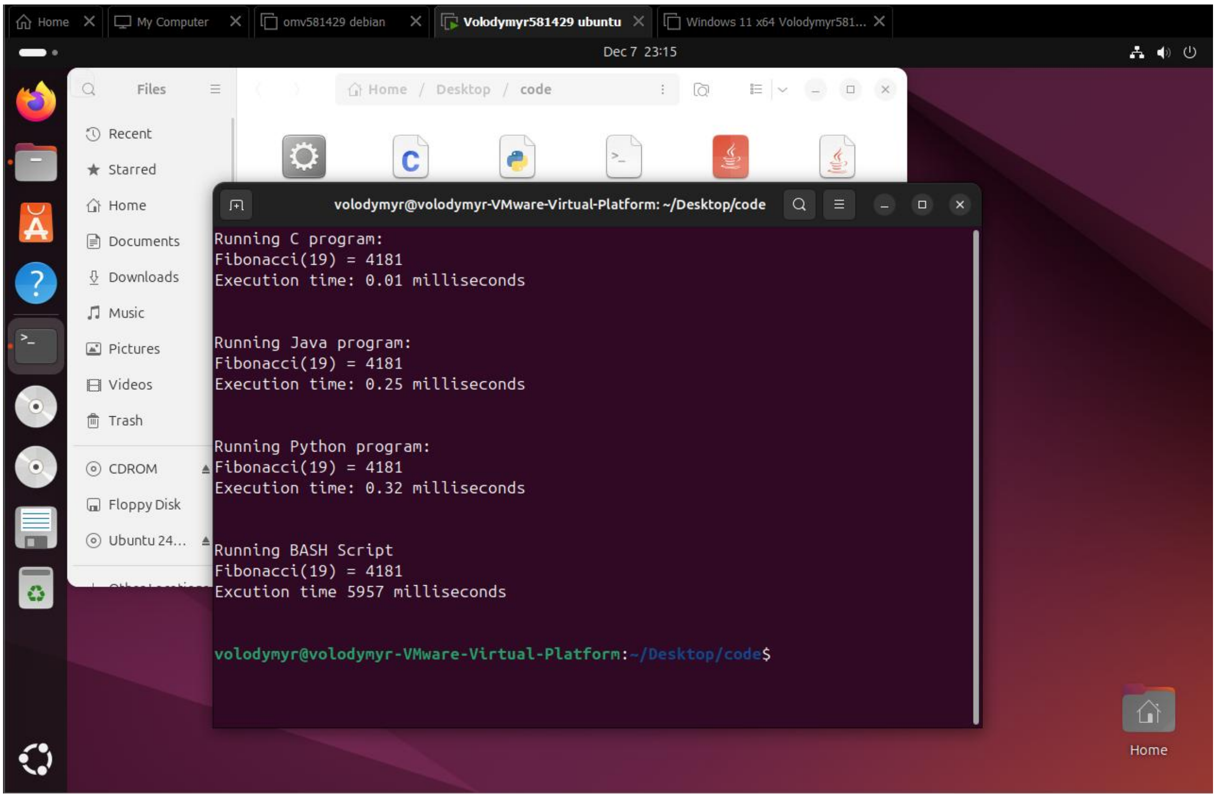
a) Figure out which parameters you need to pass to **the gcc** compiler so that the compiler performs a number of optimizations that will ensure that the compiled source code will run faster. **Tip!** The parameters are usually a letter followed by a number. Also read **page 191** of your book, but find 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?

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.





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.

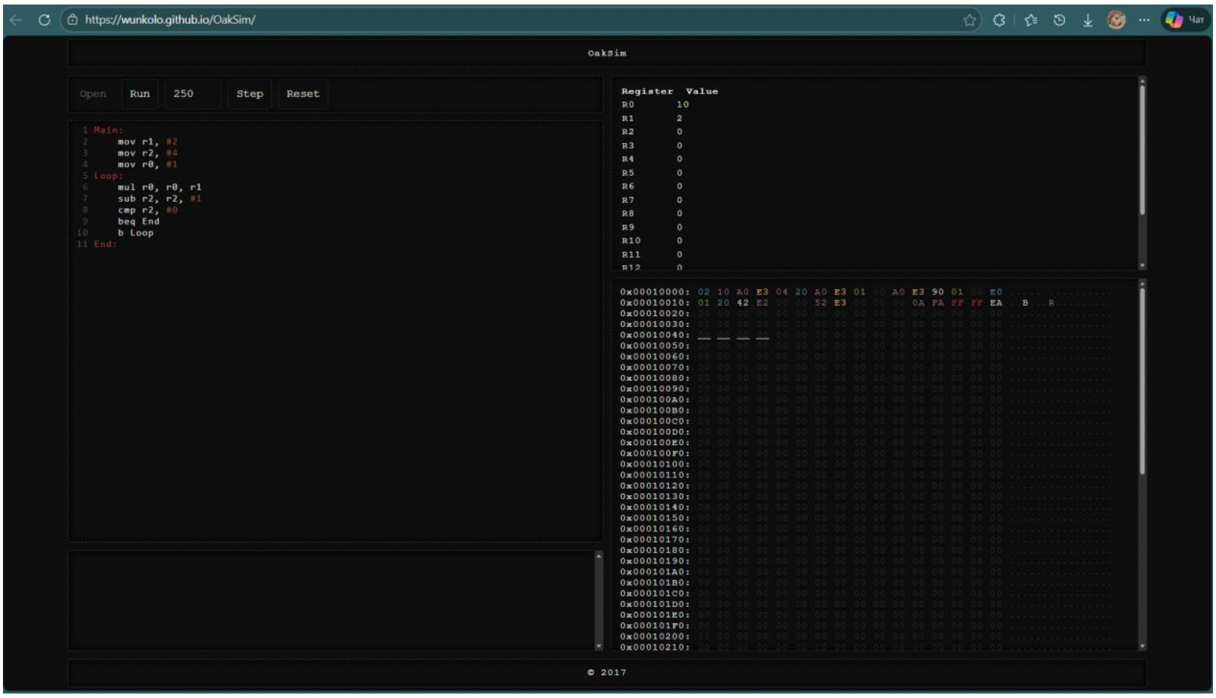
```
Main:
mov r1, #2
mov r2, #4


Loop:


End:
```

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

Screenshot of the completed code here.



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