Template Week 4 – Software

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Assignment 4.1: ARM assembly

Screenshot of working assembly code of factorial calculation:

```
1  Main:
2      mov r0, #1
3      mov r2, #5
4
5  Loop:
6      mul r0, r0, r2
7      sub r2, r2, #1
8      cmp r2, #0
9      bne Loop
10
11 End:
12     mov r1, r0
13
```

Register	Value
R0	78
R1	78
R2	0
R3	0
R4	0
R5	0

Assignment 4.2: Programming languages

Take screenshots that the following commands work:

java –version

```
jos@jos-VMware-Virtual-Platform:~$ java --version
openjdk 21.0.9 2025-10-21
OpenJDK Runtime Environment (build 21.0.9+10-Ubuntu-124.04)
OpenJDK 64-Bit Server VM (build 21.0.9+10-Ubuntu-124.04, mixed mode, sharing)
jos@jos-VMware-Virtual-Platform:~$
```

gcc –version

```
jos@jos-VMware-Virtual-Platform:~$ gcc --version
gcc (Ubuntu 13.3.0-6ubuntu2~24.04) 13.3.0
Copyright (C) 2023 Free Software Foundation, Inc.
This is free software; see the source for copying conditions.  There is NO
warranty; not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.
```

python3 –version

```
jos@jos-VMware-Virtual-Platform:~$ python3 --version
Python 3.12.3
```

bash --version

```
jos@jos-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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```

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?

How do I run a Java program?

Eerst java bestand compilen met javac Fibonacci.java en dan kan je hem runnen met java Fibonacci

How do I run a Python program?

python3 fib.py

How do I run a C program?

Eerst gcc fib.c -o fib om het bestand te compilen en dan ./fib om hem te runnen

How do I run a Bash script?

bash fib.sh

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

Bij C word het bestand fib gemaakt

Bij java word het bestand Fibonacci.class gemaakt

Take relevant screenshots of the following commands:

- Compile the source files where necessary

```
jos@jos-VMware-Virtual-Platform:~/Desktop/code./code$ javac Fibonacci.java
```

```
jos@jos-VMware-Virtual-Platform:~/Desktop/code./code$ gcc fib.c -o fib
```

- Make them executable
-
```
jos@jos-VMware-Virtual-Platform:~/Desktop/code./code$ chmod +x fib.py fib.sh runall.sh
```
- Run them
-
```
Running C program:
Fibonacci(19) = 4181
Execution time: 0.02 milliseconds


Running Java program:
Fibonacci(19) = 4181
Execution time: 0.21 milliseconds


Running Python program:
Fibonacci(19) = 4181
Execution time: 0.35 milliseconds


Running BASH Script
Fibonacci(19) = 4181
Excution time 8923 milliseconds
```
- Which (compiled) source code file performs the calculation the fastest?
  C

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

```
jos@jos-VMware-Virtual-Platform:~/Desktop/code./code$ gcc -O3 fib.c -o fib
```

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

Yes

```
Running C program:
Fibonacci(19) = 4181
Execution time: 0.01 milliseconds
```

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.

```
1  Main:
2  mov r1, #2
3  mov r2, #4
4
5  mov r4, #0 ; Loop counter
6  mov r0, #1
7  Loop:
8  add r4, r4, #1
9  mul r0, r1, r0
10 cmp r4, r2
11 beq End
12 b Loop
13
14 End:
15
```

Register	Value
R0	10
R1	2
R2	4
R3	0
R4	4
R5	0
R6	0
R7	0
R8	0
R9	0
R10	0
R11	0
R12	0
SP	10000

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