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System Software

Introduction to course

Jarno Tuominen, Spring 2024

Course Practises

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- Schedule
- Exercises
- Grading

Schedule

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Lectures mainly on Fridays (a few Wednesdays as well)

1 hour theory part (lecture)

2 hours demo/exercise session

- Occasionally teacher may (or may not) show some demonstration
- Mainly you will be working with the exercises, while teacher is supporting you on a need basis

Presence is mandatory - no online/ recorded lectures
Communications over Teams - feel free to ask help!

Exercises

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Two systems in use

- Ville for automatically graded exercises
- Virtual machine-based development environment on your own PC
- Git for submitting your work

Note: ItsLearning not in use. All the material in Git. Follow also Teams.

Grading

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Based on:

- Completion rate of exercises
- Git activity
- A short exam testing basic concepts

Weighting to be decided (later on)

Questions?

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System Software
Basics of C Language

Sanna Määttä

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C Language

C Language

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Originally C was designed for UNIX operating system.

C was created from ALGOL, BCPL and B programming languages and was first published in 1972.

Latest C standard is from 2018, ISO/IEC 9899:2018 (C17 is the informal name).

- The ISO/IEC standard is not free.
- You can find a final draft version of the *2011* standard here: http://www.open-std.org/jtc1/sc22/wg14/www/docs/n1570.pdf

C Language

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C is a general purpose and procedural programming language.

C has a static type system.

- This is different compared to e.g. Python, where you do not always need to define the type of a variable.

Where Is C Language Used?

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Embedded Systems, IoT applications

In System Software (operating system kernels, device drivers, Bootloader, BIOS/UEFI, system applications…)

Most operating systems (at least their kernels) are written in C (UNIX, Linux, Windows, MacOS, iOS, Android, Windows Phone).

Most databases (Oracle DB, MySQL, PostgreSQL, MS SQL Server) are written in C/C++.

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First Program in C

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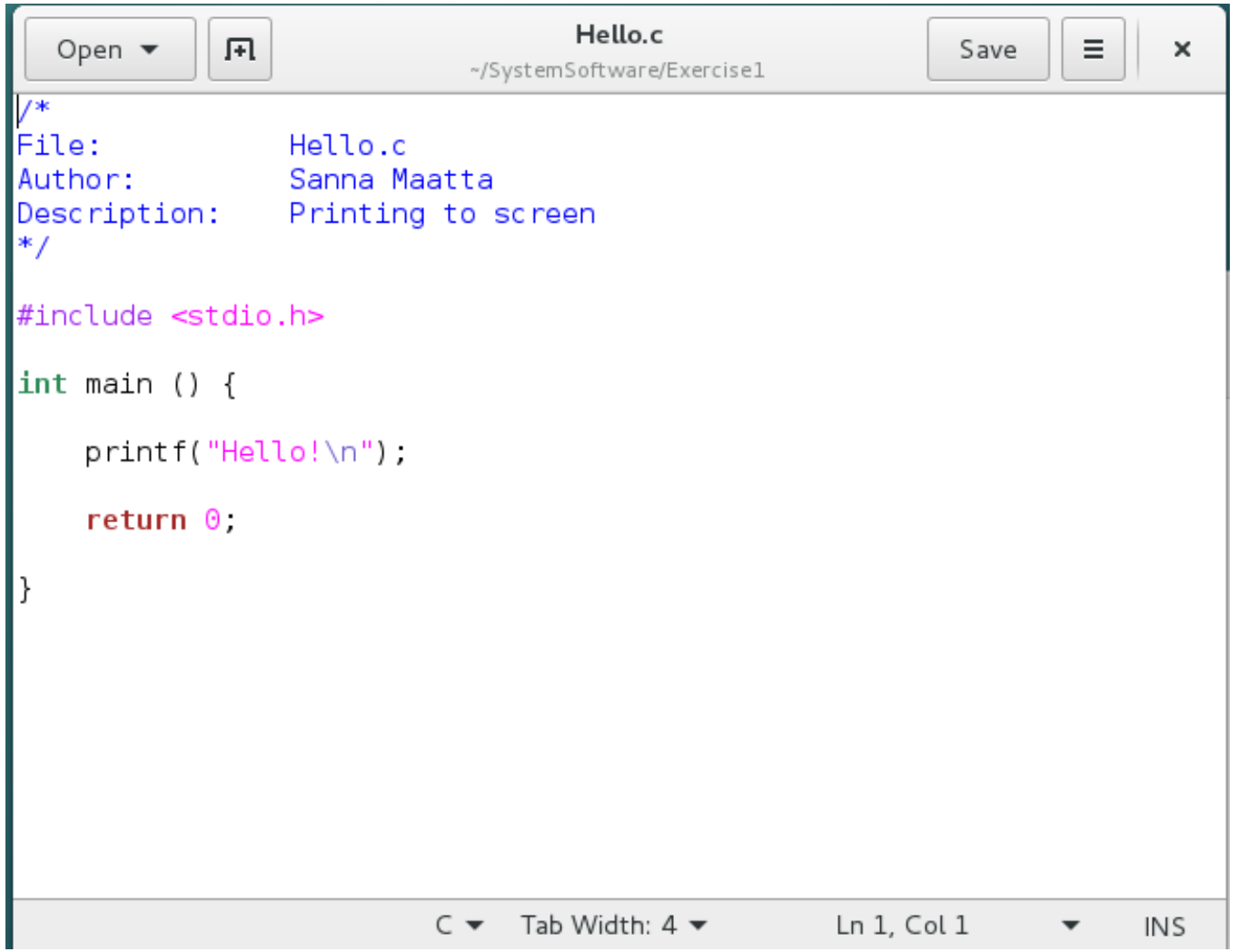
How to Start Writing Code



Write the “Hello World” program first.

Then compile and run your code, this way you know your development environment is working properly!

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Open | Hello.c ~/SystemSoftware/Exercise1 | Save

```c
/*
File:           Hello.c
Author:         Sanna Maatta
Description:    Printing to screen
*/

#include <stdio.h>

int main () {

    printf("Hello!\n");

    return 0;

}
```

C | Tab Width: 4 | Ln 1, Col 1 | INS

For comparison, same in Python.

```python
# File: main.py
# Author: Sanna Maatta
# Printing to screen

print("Hello")
```

First Program in C

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Open | Hello.c ~/SystemSoftware/Exercise1 | Save

```
/*
File:           Hello.c
Author:         Sanna Maatta
Description:    Printing to screen
*/

#include <stdio.h>

int main () {

    printf("Hello!\n");

    return 0;

}
```

File header (style guide rule 2)

C | Tab Width: 4 | Ln 1, Col 1 | INS

First Program in C

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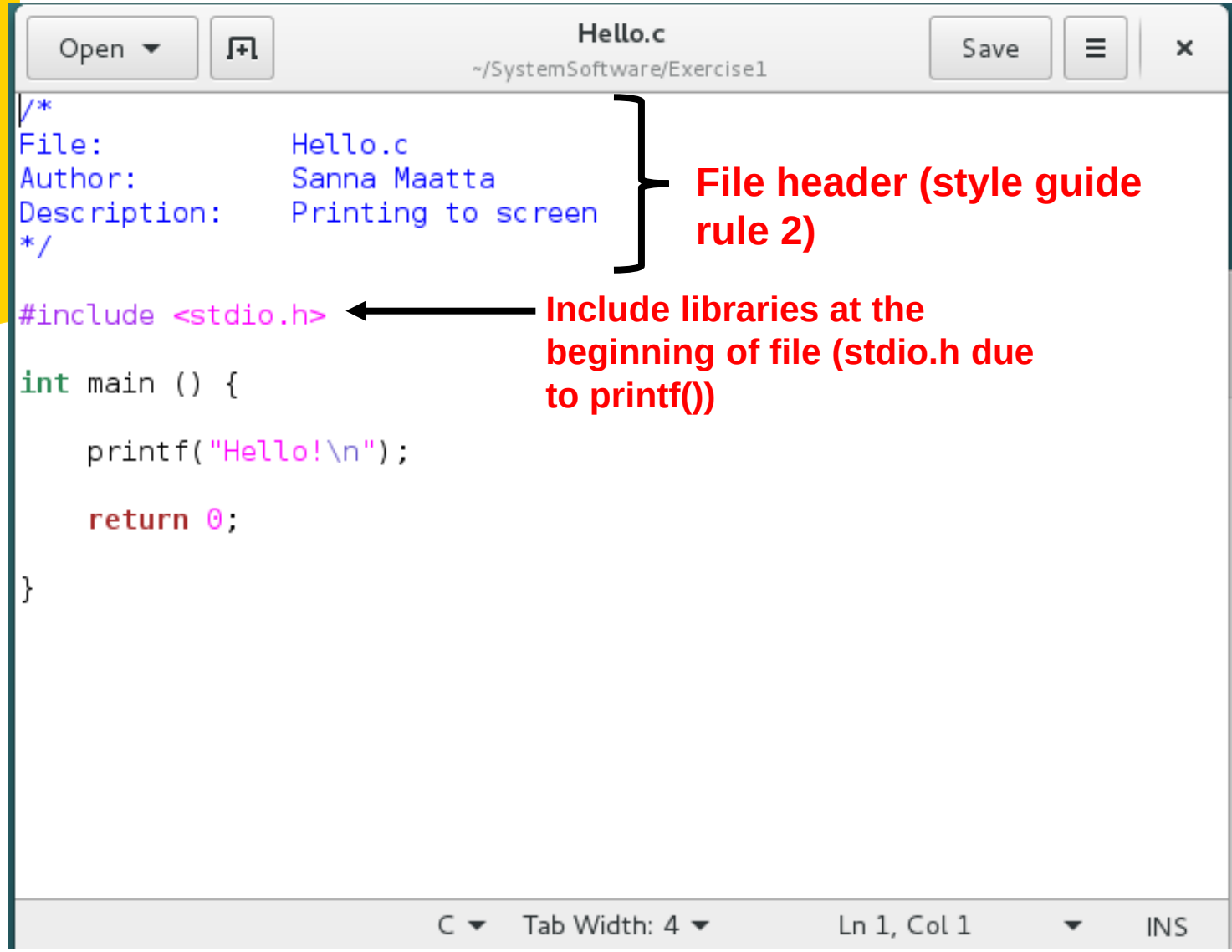

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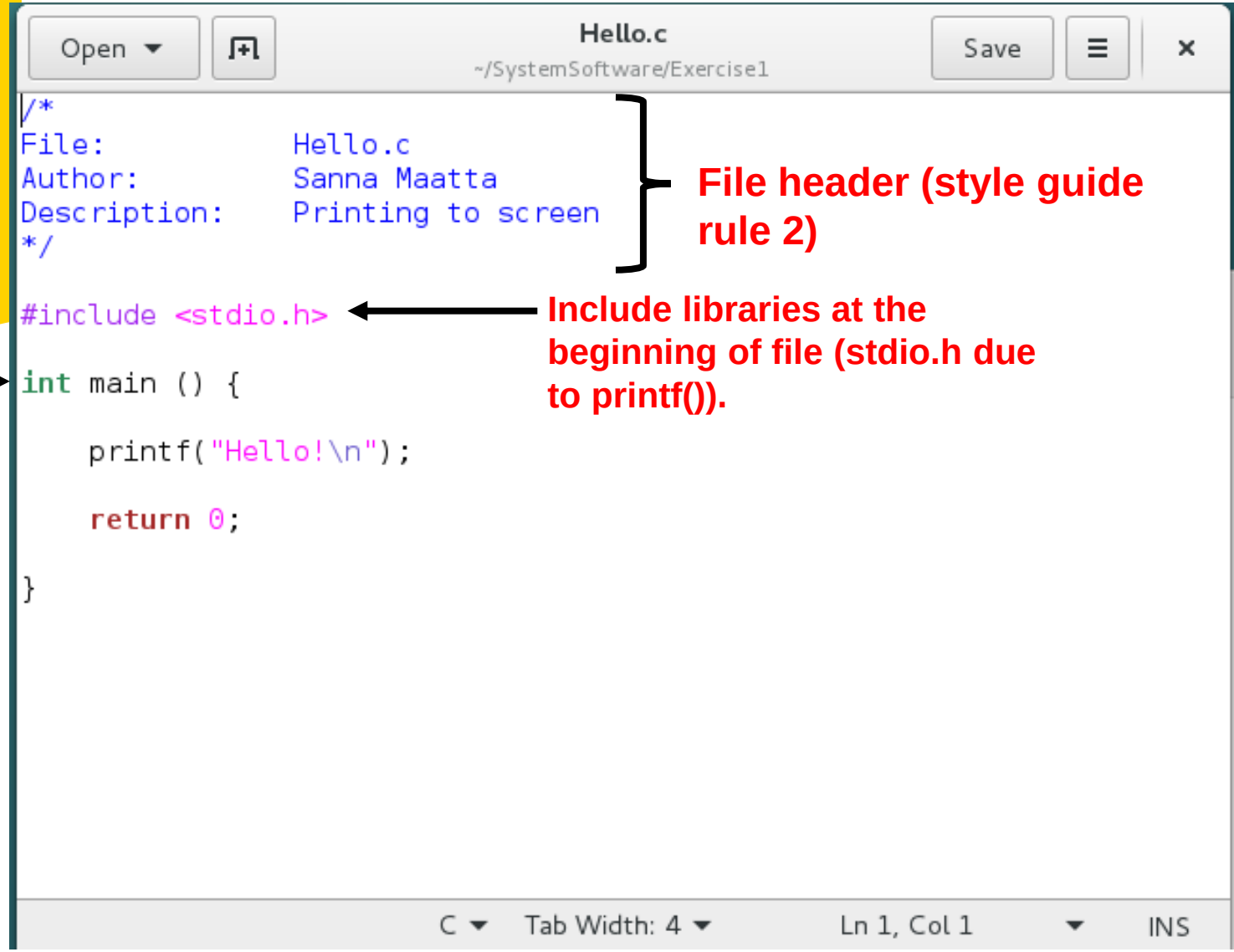
First Program in C

Main function
Each C program shall have 1 main function.



File header (style guide rule 2)

Include libraries at the beginning of file (stdio.h due to printf()).

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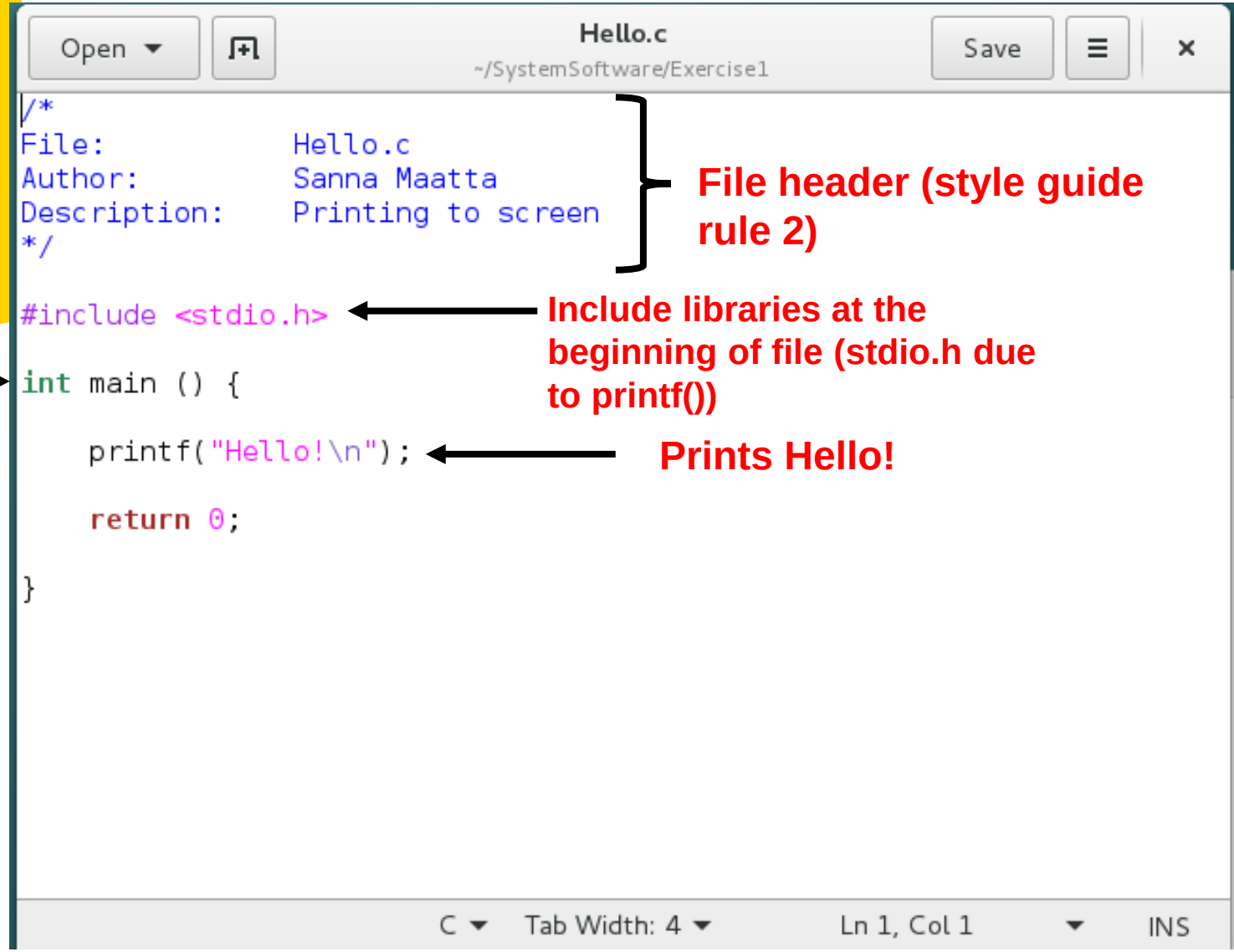
First Program in C

Main function
Each C program shall have 1 main function



File header (style guide rule 2)

Include libraries at the beginning of file (stdio.h due to printf())

Prints Hello!

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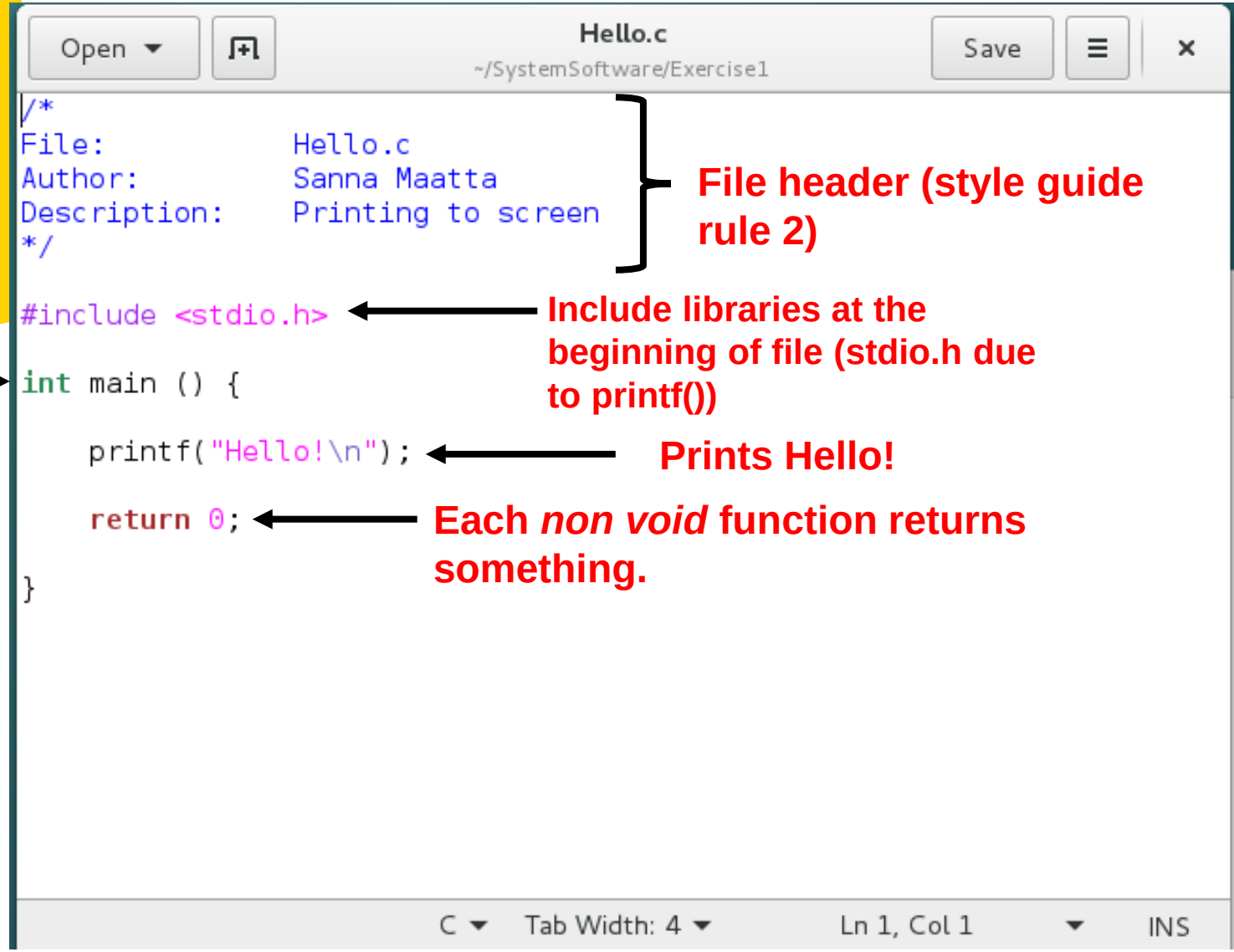
First Program in C

Main function
Each C program shall have 1 main function



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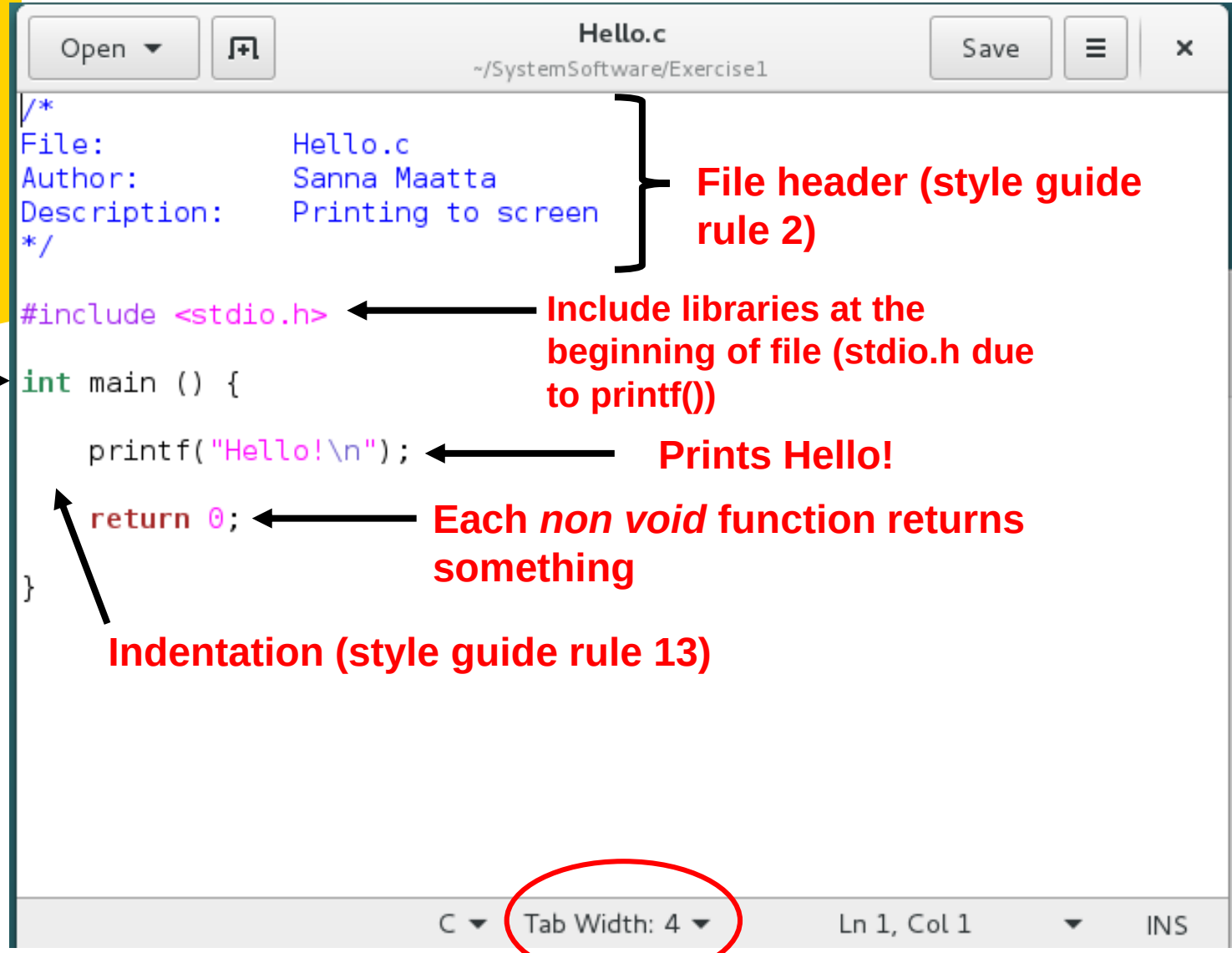
First Program in C

Main function
Each C program shall have 1 main function



First Program in C

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File naming (style guide rule 5)

Open | Hello.c ~/SystemSoftware/Exercise1 | Save

```
/*
File:           Hello.c
Author:         Sanna Maatta
Description:    Printing to screen
*/

#include <stdio.h>

int main () {

    printf("Hello!\n");

    return 0;

}
```

File header (style guide rule 2)

Include libraries at the beginning of file (stdio.h due to printf())

Main function
Each C program shall have 1 main function

Prints Hello!

Each *non void* function returns something

Indentation (style guide rule 13)

C | Tab Width: 4 | Ln 1, Col 1 | INS

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First Program in C

Open | Hello.c ~/SystemSoftware/Exercise1 | Save

```
/*
File:           Hello.c
Author:         Sanna Maatta
Description:    Printing to screen
*/

#include <stdio.h>

int main () {

    printf("Hello!\n");

    return 0;

}
```

Functions' statements are enclosed in curly brackets { }

Semicolon ; finishes each sentence

C | Tab Width: 4 | Ln 1, Col 1 | INS

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First Program in C

Open | Hello.c ~/SystemSoftware/Exercise1 | Save

```
/*
File:           Hello.c
Author:         Sanna Maatta
Description:    Printing to screen
*/

#include <stdio.h>

int main () {

    printf("Hello!\n");

    return 0;

}
```

Pre-processor commands start with #

C | Tab Width: 4 | Ln 1, Col 1 | INS

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How to Compile and Run C Code on Linux

Compiling and Running on Linux

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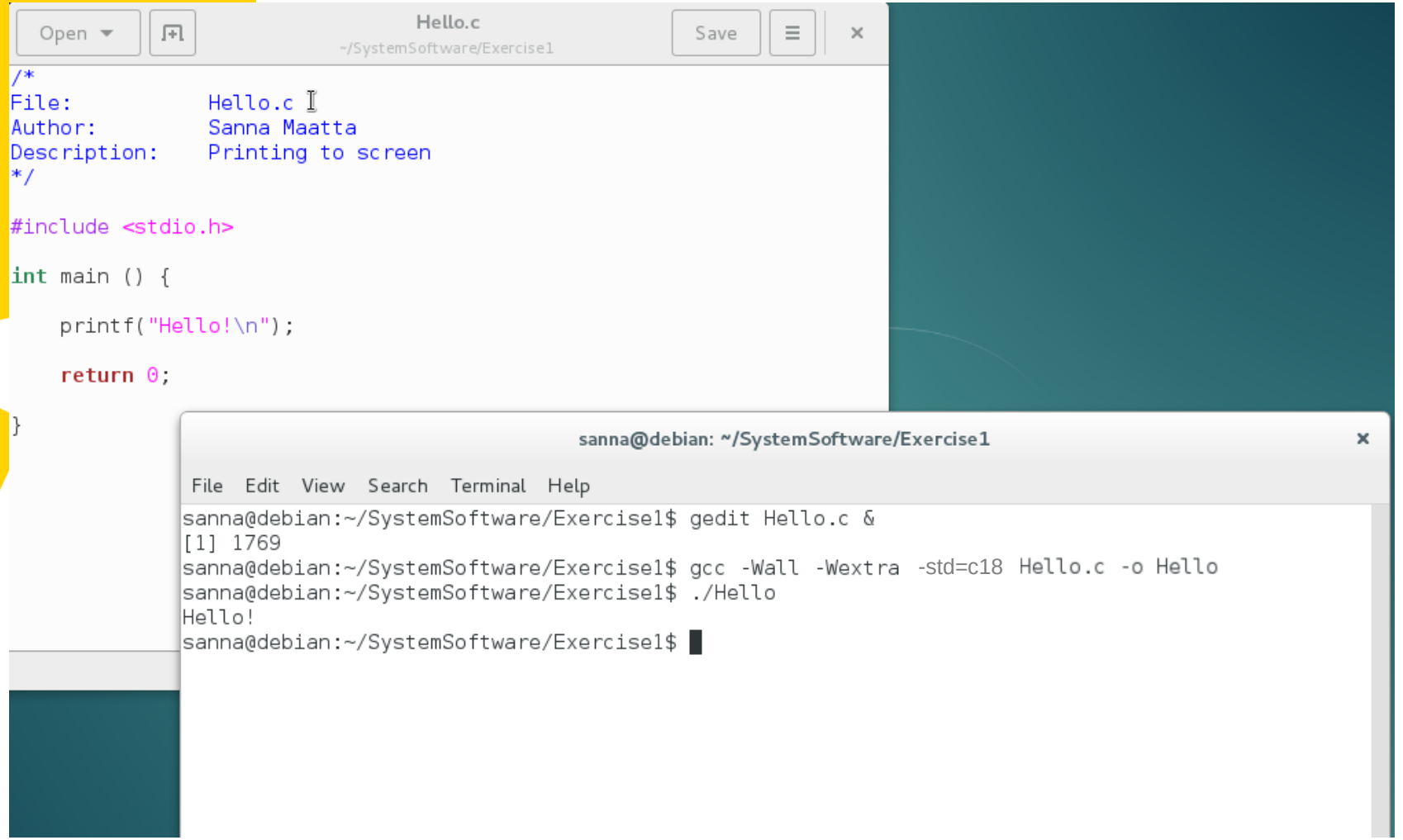

Compiling and Running on Linux

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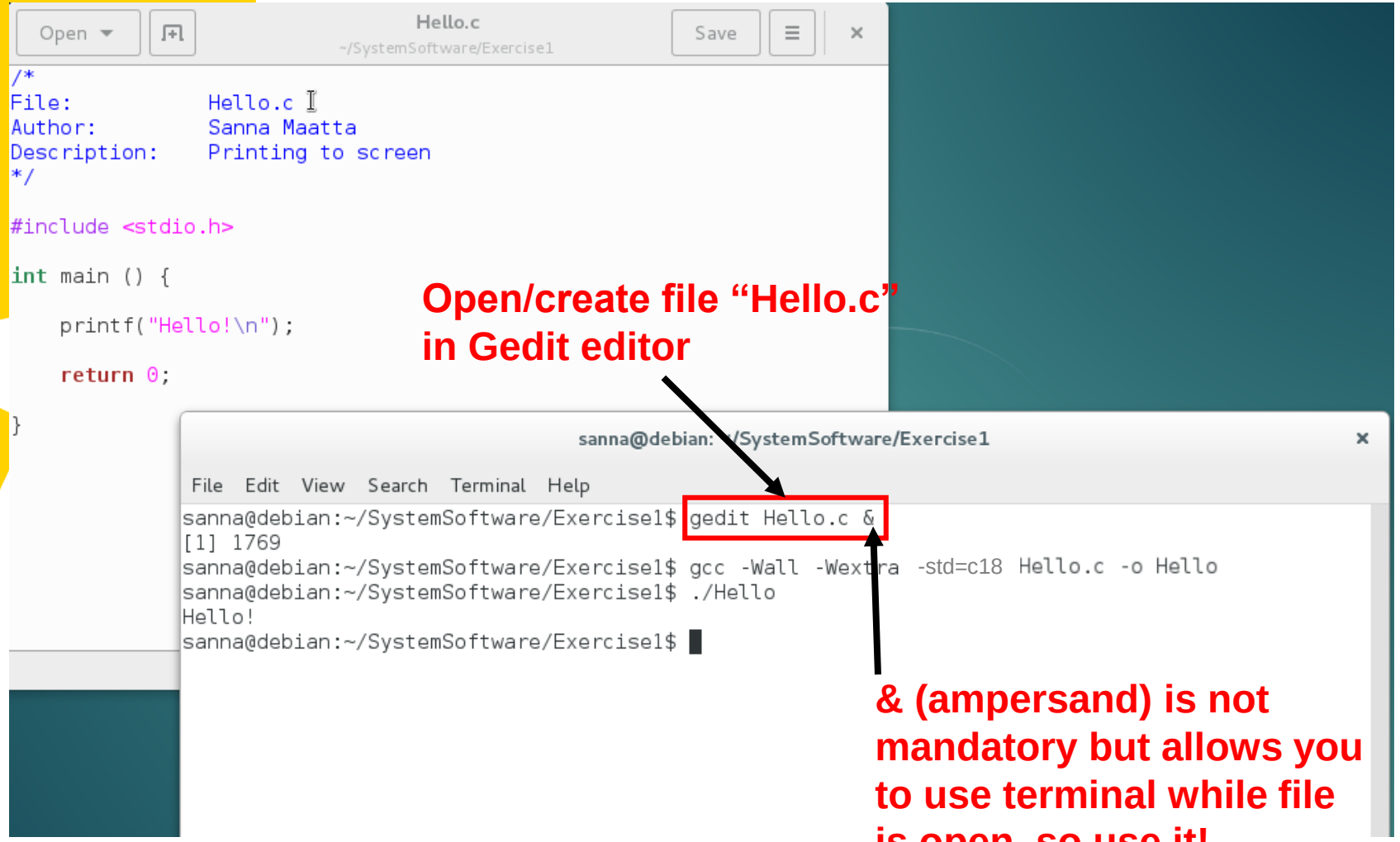
Open/create file “Hello.c” in Gedit editor

& (ampersand) is not mandatory but allows you to use terminal while file is open, so use it!



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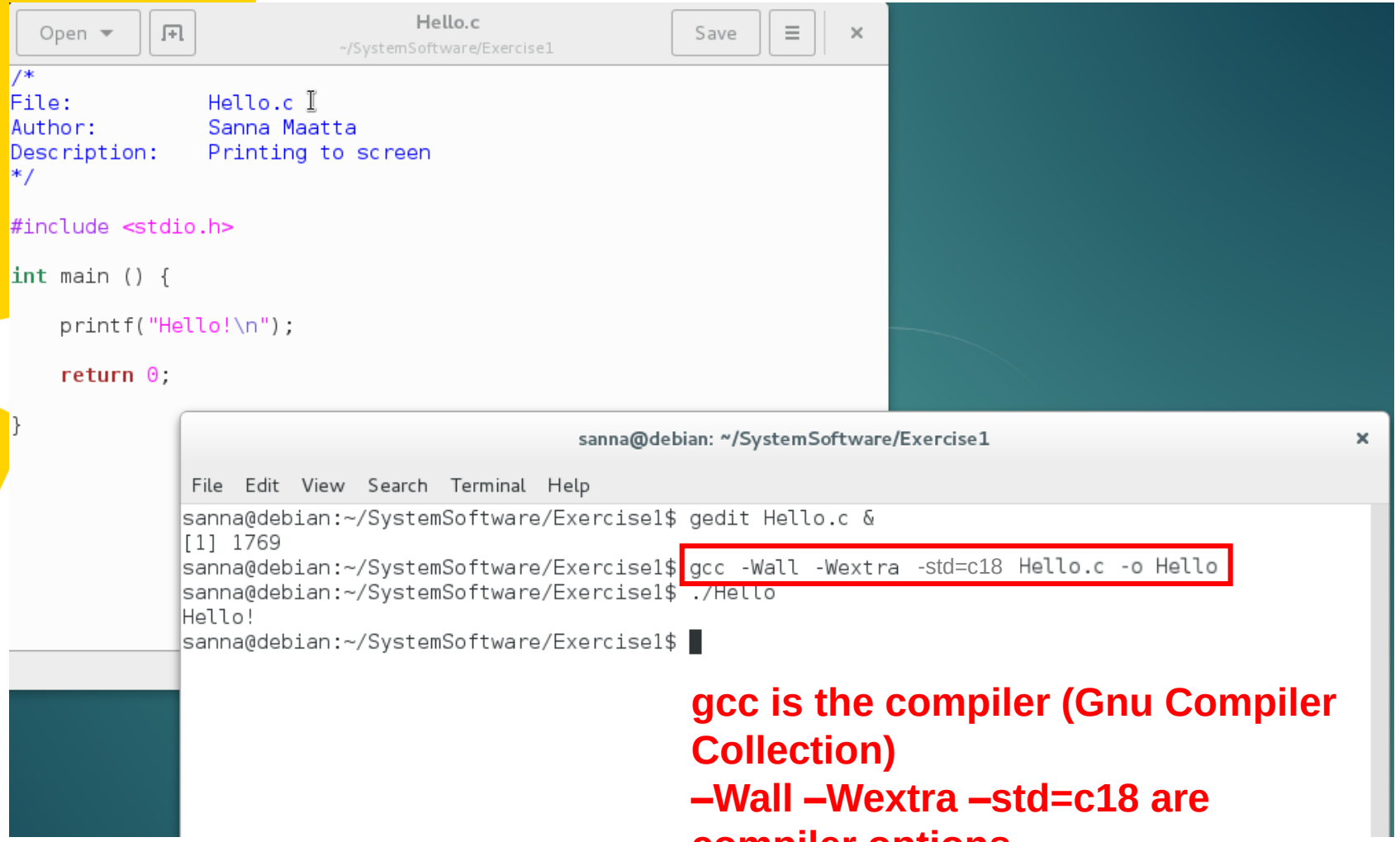
Compiling and Running on Linux



gcc is the compiler (Gnu Compiler Collection)
–Wall –Wextra –std=c18 are compiler options

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Compiling and Running on Linux

Hello.c
~/SystemSoftware/Exercise1

```
/*
File:           Hello.c
Author:         Sanna Maatta
Description:    Printing to screen
*/

#include <stdio.h>

int main () {

    printf("Hello!\n");

    return 0;

}
```

```
sanna@debian: ~/SystemSoftware/Exercise1
File  Edit  View  Search  Terminal  Help
sanna@debian:~/SystemSoftware/Exercise1$ gedit Hello.c &
[1] 1769
sanna@debian:~/SystemSoftware/Exercise1$ gcc -Wall -Wextra -std=c18 Hello.c -o Hello
sanna@debian:~/SystemSoftware/Exercise1$ ./Hello
Hello!
sanna@debian:~/SystemSoftware/Exercise1$
```

-o makes an executable “Hello” from Hello.c

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Compiling and Running on Linux

Hello.c
~/SystemSoftware/Exercise1

```
/*
File:           Hello.c
Author:         Sanna Maatta
Description:    Printing to screen
*/

#include <stdio.h>

int main () {

    printf("Hello!\n");

    return 0;

}
```

```
sanna@debian: ~/SystemSoftware/Exercise1
File  Edit  View  Search  Terminal  Help
sanna@debian:~/SystemSoftware/Exercise1$ gedit Hello.c &
[1] 1769
sanna@debian:~/SystemSoftware/Exercise1$ gcc -Wall -Wextra -std=c18 Hello.c -o Hello
sanna@debian:~/SystemSoftware/Exercise1$ ./Hello
Hello!
sanna@debian:~/SystemSoftware/Exercise1$
```

Running the executable program

Notice, there is no file extension .c any more in the executable's name

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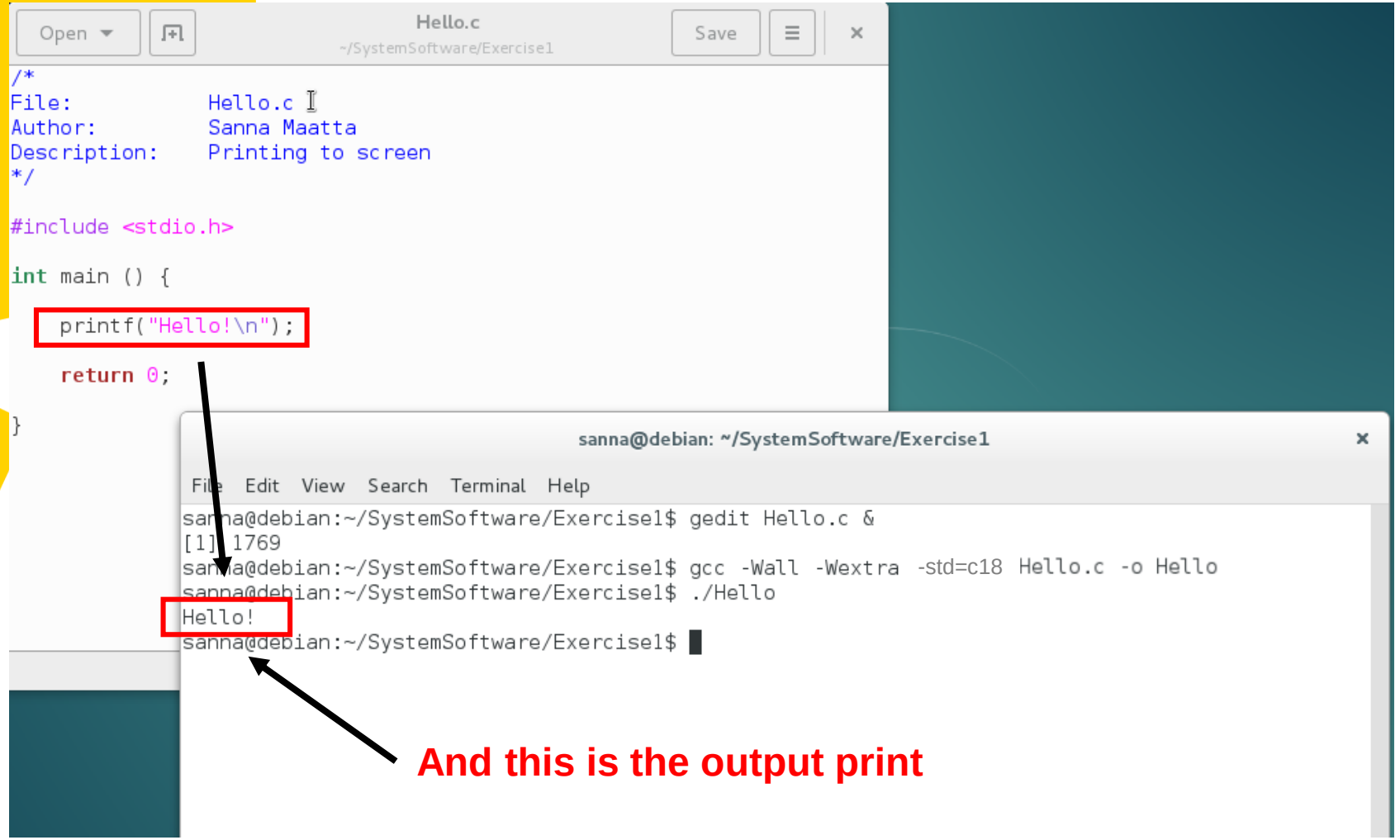
Compiling and Running on Linux



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Output Formatting in C

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Output Formatting Example 1

Output.c
~/SystemSoftware

```
/*
File:           Output.c
Author:         Sanna Maatta
Description:    Output formatting example
*/

#include <stdio.h>

int main () {

    printf("Hello \t\tWorld!\n");

    return 0;

}
```

sanna@debian: ~/SystemSoftware

File Edit View Search Terminal Help

```
sanna@debian:~/SystemSoftware$ ./Output
Hello           World!
sanna@debian:~/SystemSoftware$
```

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Output Formatting Example 1

Output.c
~/SystemSoftware

```
/*
File:           Output.c
Author:         Sanna Maatta
Description:    Output formatting example
*/

#include <stdio.h>

int main () {

    printf("Hello \t\tWorld!\n");

    return 0;

}
```

\t for tabulator
\t\t for two tabulators

```
sanna@debian: ~/SystemSoftware
File  Edit  View  Search  Terminal  Help
sanna@debian:~/SystemSoftware$ ./Output
Hello         World!
sanna@debian:~/SystemSoftware$
```

Notice the extra space (two tabs) here

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Output Formatting Example 1

Output.c
~/SystemSoftware

```
/*
File:           Output.c
Author:         Sanna Maatta
Description:    Output formatting example
*/

#include <stdio.h>

int main () {

    printf("Hello \t\tWorld!\n");

    return 0;

}
```

\n for newline

```
sanna@debian: ~/SystemSoftware
File  Edit  View  Search  Terminal  Help
sanna@debian:~/SystemSoftware$ ./Output
Hello           World!
sanna@debian:~/SystemSoftware$
```

- \n (newline)
- \t (tab)
- \v (vertical tab)
- \f (new page)
- \b (backspace)
- \r (carriage return)

Output Formatting Example 2

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Output.c
~/SystemSoftware

```
/*
File:           Output.c
Author:         Sanna Maatta
Description:    Output formatting example
*/

#include <stdio.h>

int main () {

    int testVariable = 5;

    printf("Hello \t\tWorld!\n");

    printf("Variable value: %d\n", testVariable);

    return 0;

}
```

Notice the syntax when printing out variable values.

```
sanna@debian:~/SystemSoftware$ ./Output
Hello           World!
Variable value: 5
sanna@debian:~/SystemSoftware$
```

Output Formatting Example 2

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Open | Output.c ~/SystemSoftware | Save

```
/*
File:           Output.c
Author:         Sanna Maatta
Description:    Output formatting example
*/

#include <stdio.h>

int main () {

    int testVariable = 5;

    printf("Hello \t\tWorld!\n");

    printf("Variable value: %d\n", testVariable);

    return 0;

}
```

%d: integer
%c: character
%f: float and double
%x: hexadecimal

Notice the syntax when printing out variable values.

C | Tab Width

sanna@debian: ~/SystemSoftware

File Edit View Search Terminal Help

```
sanna@debian:~/SystemSoftware$ ./Output
Hello           World!
Variable value: 5
sanna@debian:~/SystemSoftware$
```

Output Formatting Example 2

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Open | Output.c ~/SystemSoftware | Save

```
/*
File:           Output.c
Author:         Sanna Maatta
Description:    Output formatting example
*/

#include <stdio.h>

int main () {

   int testVariable = 5;

   printf("Hello \t\tWorld!\n");

   printf("Variable value: %d\n", testVariable);

   return 0;

}
```

Always initialize variables (style guide rule 6).

C | Tab Width

sanna@debian: ~/SystemSoftware

File Edit View Search Terminal Help

```
sanna@debian:~/SystemSoftware$ ./Output
Hello           World!
Variable value: 5
sanna@debian:~/SystemSoftware$
```

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Output Formatting Example 2

Output.c
~/SystemSoftware

```
/*
File:           Output.c
Author:         Sanna Maatta
Description:    Output formatting example
*/

#include <stdio.h>

int main () {

    int testVariable = 5;

    printf("Hello \t\tWorld!\n");

    printf("Variable value: %d\n", testVariable);

    return 0;

}
```

Always initialize variables (style guide rule 6).

```
sanna@debian:~/SystemSoftware$ ./Output
Hello           World!
Variable value: 5
sanna@debian:~/SystemSoftware$
```

int number; // Un-initialized variable. Do not use!

int number = 0; // Initialized variable.

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Output Formatting Example 3

Output.c
~/SystemSoftware

```
/*
File:           Output.c
Author:         Sanna Maatta
Description:    Output formatting example
*/

#include <stdio.h>

int main () {

    int testVariable = 5;
    float secondVariable = 8.0;

    printf("Hello \t\tWorld!\n");

    printf("Variable value: %d %.3f \n", testVariable, secondVariable);

    return 0;

}
```

```
sanna@debian: ~/SystemSoftware
File  Edit  View  Search  Terminal  Help
sanna@debian:~/SystemSoftware$ ./Output
Hello           World!
Variable value: 5 8.000
sanna@debian:~/SystemSoftware$
```

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Output Formatting Example 3

Output.c
~/SystemSoftware

```
/*
File:           Output.c
Author:         Sanna Maatta
Description:    Output formatting example
*/

#include <stdio.h>

int main () {

    int testVariable = 5;
    float secondVariable = 8.0;

    printf("Hello \t\tWorld!\n");

    printf("Variable value: %d %.3f \n", testVariable, secondVariable);

    return 0;

}
```

Three decimal precision

```
sanna@debian: ~/SystemSoftware
File  Edit  View  Search  Terminal  Help
sanna@debian:~/SystemSoftware$ ./Output
Hello           World!
Variable value: 5 8.000
sanna@debian:~/SystemSoftware$
```

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Questions?