

Installation

CSC100 Introduction to programming in C/C++

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1 What are you going to learn?

- Why we don't just get coding
- Setting up infrastructure
- Install a C compiler
- Install the Emacs editor and IDE
- Customize the IDE
- Understand and learn to use GitHub
- Summary of concepts/code
- What's next

2 Why we don't just get coding

There are two BIG reasons - one is philosophical, the other is technical.

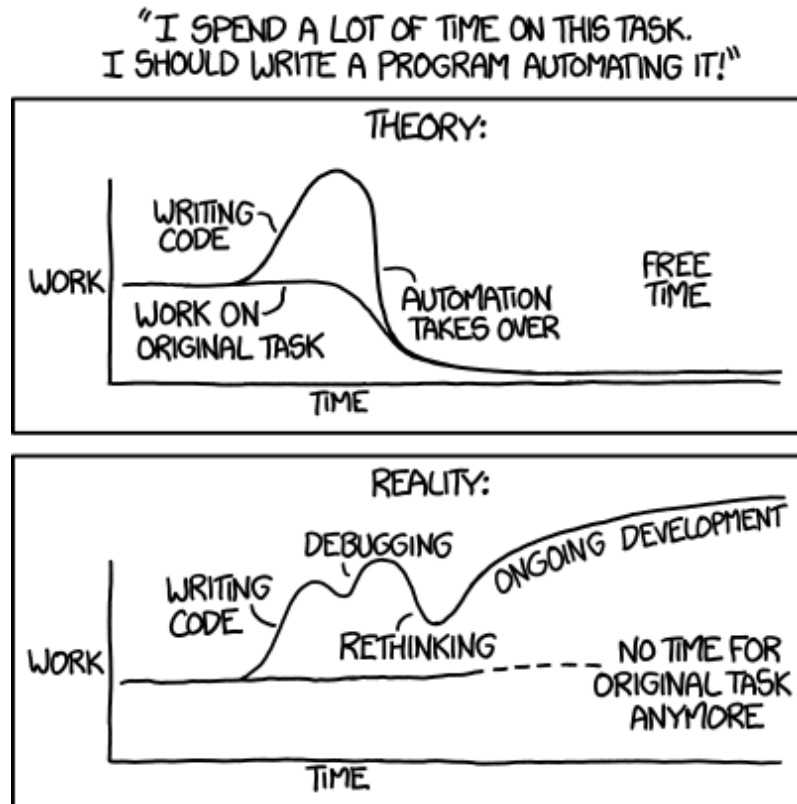


Figure 1: Automation by xkcd.

3 Philosophy

"Understanding underlying technologies helps you develop a sense of what can go wrong. Knowing just high-level tools makes it easy to ask the wrong questions. It's worth learning to use a hammer before graduating to a nail gun. Learning underlying systems and tools gives you the power to build new tools, which is important because there will always be a need for tool builders, even if tool users are more common. Learning about computers

so that the behavior of programs isn't a mystery enables you to craft better code." (Steinhart, 2019)

- Understanding technologies makes them safer
- Knowing low-level tools helps asking the right questions
- Learning low-level tools helps you build new tools
- Learning about computers enables you to craft better code

4 Technology

The other reason has to do with C itself:

TASK	PROGRAM	EXAMPLE
C source code is written and edited	editor	GNU Emacs
C source code is compiled, linked, debugged	compiler	GNU CC
C object code is run	shell	GNU bash

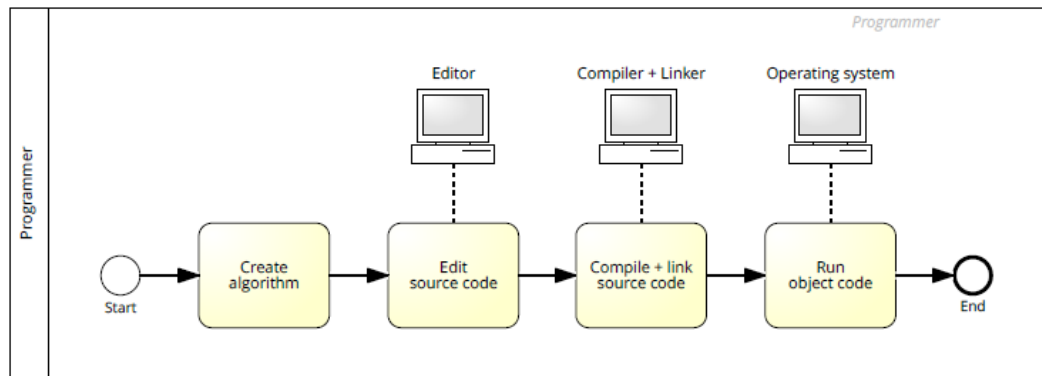


Figure 2: C programming workflow (BPMN model)

There are different routes to get C running on your computer, depending on your operating system (Linux, MacOS or Windows)¹.

The problem with most IDEs is that they're clunky. They take some time getting used to, have many functions that you'll never need, and any time spent on learning the IDE is wasted unless you keep working with it. IDEs do not teach you transferable skills.

¹Provided the block has been formatted correctly.

5 Infrastructure Setup

The sections below cover most of the infrastructure used in my courses. They are also available as FAQs on GitHub.

If you look at this at GitHub, look at `*.org` files for syntax highlighting. The Markdown (`*.md`) files do not have it (instead they have inline links, which the Org-files don't have).

PLATFORM	SOFTWARE	PURPOSE
GitHub	Git	Hosting
MinGW	GCC	Compiler
GNU	Emacs	Editor

6 GitHub - What is it?

- Largest software development platform (2023: 100 mio developers)
- Built around the version control system Git by Linus Torvalds
- Bought by Microsoft in 2018
- AI support (e.g. GitHub Copilot)

Watch: "What is GitHub?" (GitHub, 2016)

`../img/2_github.gif`

7 GitHub - Why are we using it?

Image: Org-mode file in GitHub

- It's free
- To host course materials
- Upload assignments (esp. Org-files)
- Discussion
- Wiki for collaboration
- Complements the learning management system²

²This is why we changed the Windows `PATH` variable during the installation of the programs `R` and `GNU gcc` (here).

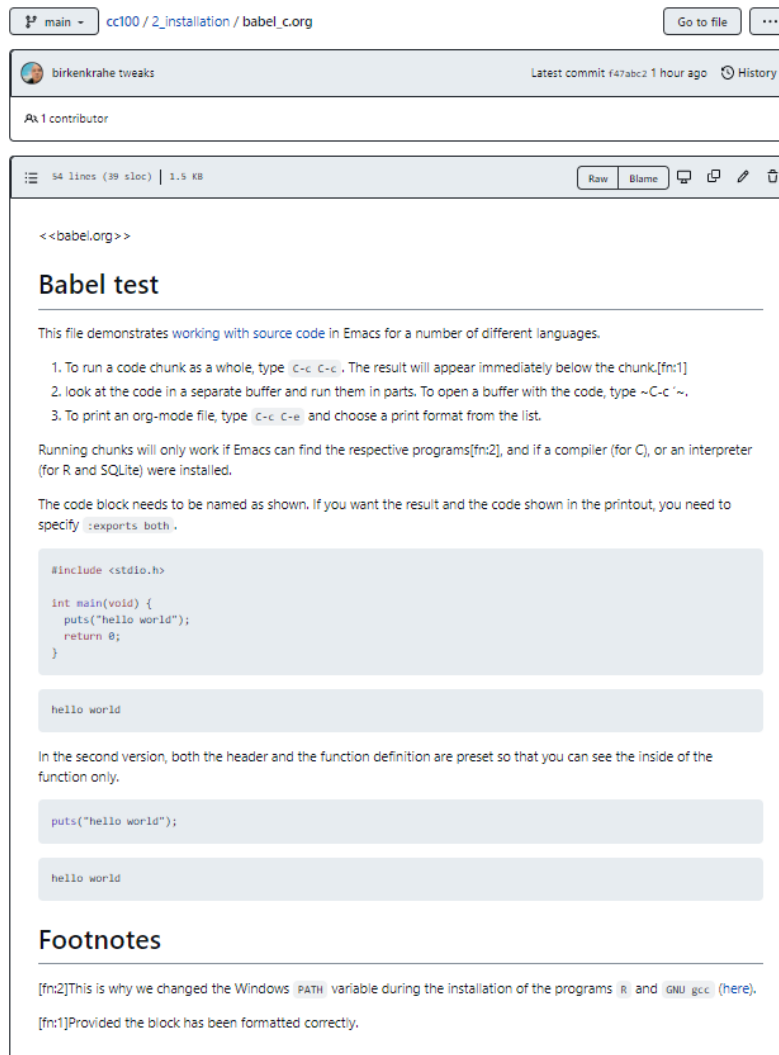


Figure 3: Screenshot of an Org-file rendered in GitHub

8 GitHub - What will you have to do?

- Optional: Sign up with GitHub - use Lyon Email
- Pick an available username **using your own first and last name**, e.g. `MarcusBirkenkrahe`, or `DonaldTrump`
- Optional: Complete the "Hello World" exercise (FAQ)

If you do have a GitHub account already, do the exercise anyway using your existing account (it takes 10 min)!

9 GitHub - What else can you do?

- You can fork the cc repository
- You can watch the cc repository - and set Notifications to **Participating and @mentions** so that you see my comments (see image below). *Image: Notifications settings when watching a repository*
 - You can submit issues from the repository (e.g. if you notice mistakes or if you want extra information, or to share a link)
 - You can participate in discussions (sometimes I will make you)
 - You can add to the wiki (e.g. comments and links to interesting resources)
 - You can install the mobile app on your smartphone³
 - You can use it as a platform for projects or coding
 - You can download the desktop client to manage repos on your PC (see image below).

10 Install GNU CC

- Compiler & linker are usually bundled
- GCC ("GNU cc") is a popular C/C++ compiler
- MinGW ("Minimalist GNU for Windows") is a port of GNU gcc to Windows

³Only Markdown (`.md`) files are rendering in the mobile app. Org-mode files (`.org`) do not. Since you have Emacs, feel free to add a Markdown version of an Org file if you want one because you use the mobile version a lot.

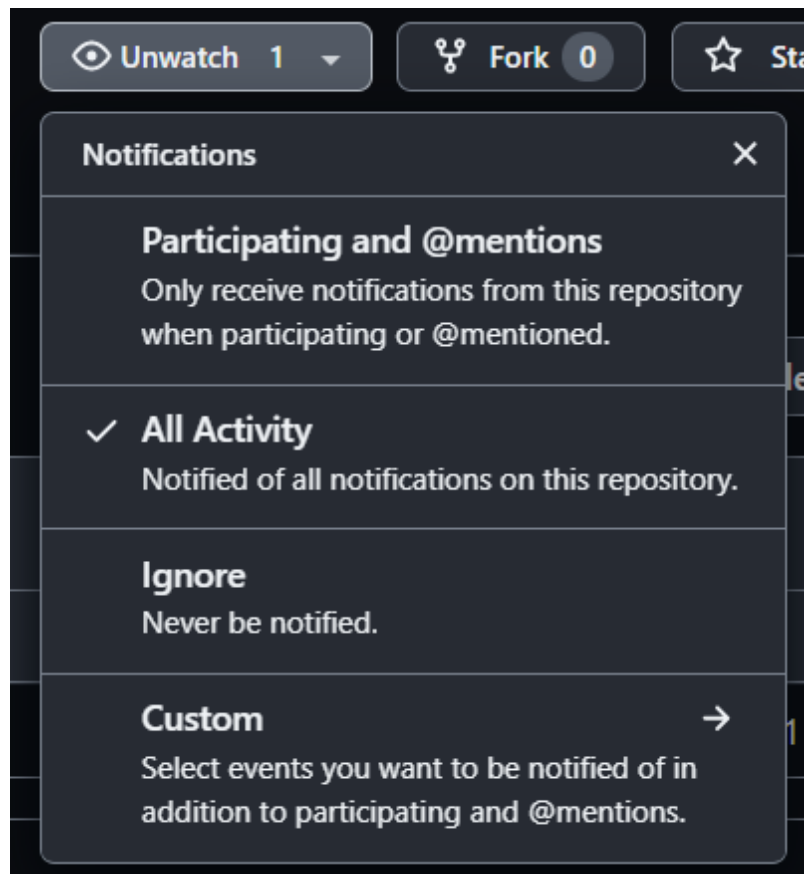


Figure 4: GitHub notifications setting

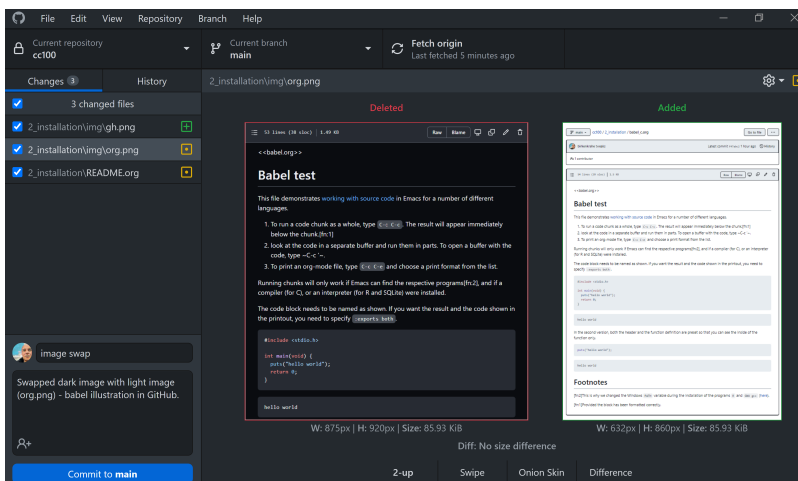


Figure 5: GitHub desktop client commit



Figure 6: Shameless plug for the Free Software Foundation - fsf.org

11 Install GCC on Windows

1. Download the 64bit installer from strawberryperl.com: `strawberry-perl-5.32.1.1-64bit.ms`.
2. Run the installer - accept all presets. This program will automatically update the `PATH` to `gcc`.
3. Open a command line terminal and check that installation is complete with `gcc --version`

12 Install Clang on MacOS

Apple no longer allows GNU tools - instead, you can install the free Clang compiler as part of the Xcode development suite.

- Check if you already have a C compiler: open a terminal (search for `terminal` app) and enter `cc -v`.
- If no compiler is found, download it by entering `xcode-select --install`
- Test it by typing `cc -v`.



```
carlyebirkenkrahe — -bash — 80x24
|$ cc -v
Apple clang version 12.0.0 (clang-1200.0.32.29)
Target: x86_64-apple-darwin19.6.0
Thread model: posix
InstalledDir: /Library/Developer/CommandLineTools/usr/bin
$
```

Figure 7: Checking Clang compiler exists on a Mac

13 Install GCC on Linux

Under Linux, the installation of a binary (executable) for that distribution and computer architecture, is done with a simple command from the command line, usually using the package manager, e.g. `apt` for Ubuntu 20.04: `sudo apt install build-essential`. This will install `gcc`, `g++`, and the powerful GNU `make` program.

14 Emacs for C programming

With the Emacs editor + Org-mode, you can almost program interactively (live code) with C - akin to Python or R. Org-mode inside Emacs works like a REPL (Read-Evaluate-Print-Loop).

A resource to look at, and use (for free, at first) that uses the REPL concept, is repl.it. See image below for the "hello world" program in C.

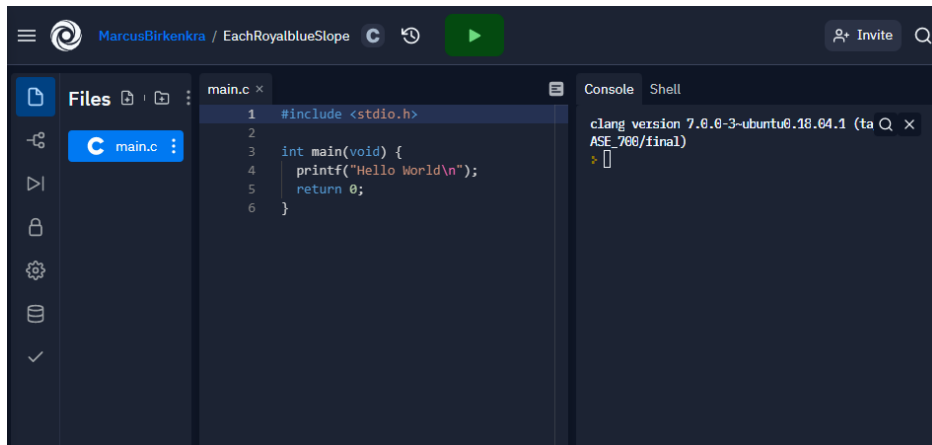


Figure 8: Replit.com C template

15 What is Emacs ?

PROPERTY	WHAT THIS MEANS
Extensible editor	You can adapt it to your needs ⁴
Written in C with Emacs Lisp	It's fast and smart (via Lisp ⁵)
Ancient software	Written 1976, released in 1985 ⁶
Ca. 1.5M lines of code	By comparison: Windows ca. 50M; Linux kernel ca. 30M

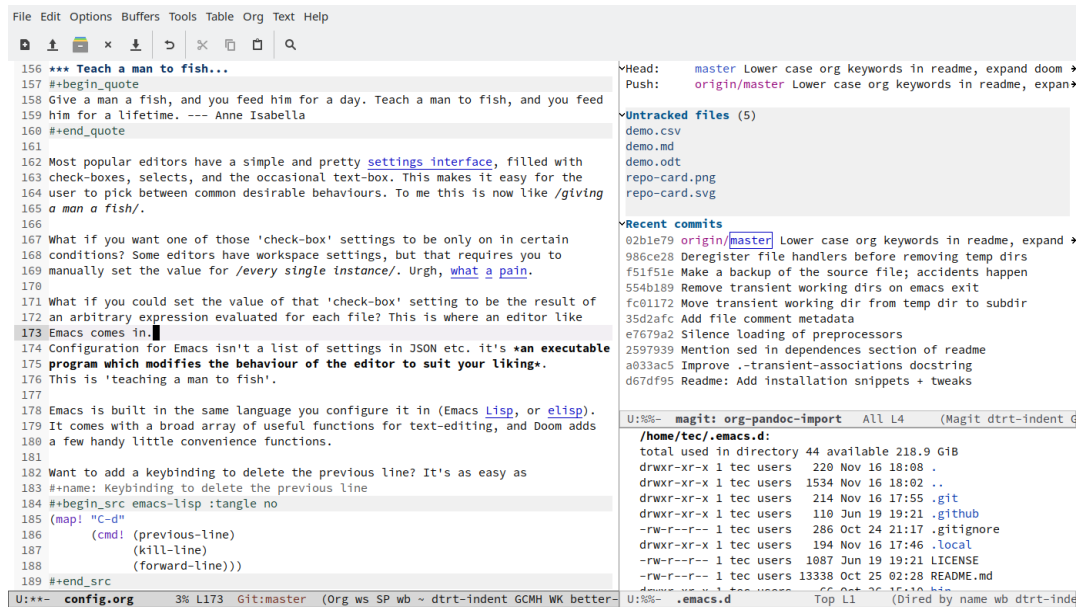


Figure 9: Emacs 27.1 showing Org, Magit and Dired

Challenge: which Emacs properties can you deduce from this image alone?⁷

⁴Here is an example from my `/.emacs` file: I defined the function `iwb` to indent a whole buffer according to the buffer's mode - something that can also be done with the key sequence `C-x h C-M-\` (`mark-whole-buffer + indent-region`).

```
;; re-indenting of whole buffer according to mode
(defun iwb ()
  "indent whole buffer"
  (interactive)
  (delete-trailing-whitespace)
  (indent-region (point-min) (point-max) nil)
  (untabify (point-min) (point-max)))
```

⁵Emacs Lisp is a Lisp dialect. Lisp was one of the first languages used for Artificial Intelligence research (cp. SHRDLU, an early natural language processing system).

⁶Written in 1976 by Richard Stallman, who then tinkered with it for ten years before releasing it. Emacs is also one of the two contenders, along with `vi`, of the famous editor wars of the UNIX culture. UNIX is the "mother" of all operating systems, the systems that make computer run and do stuff.

⁷(1) Emacs has versions (at the time the screenshot was taken: 27.1); (2) Emacs has named "buffers", and you can open several simultaneously [the names correspond to Emacs plugins or packages for organization (org), Git (magit) and file management (dired)]; (3) Emacs has layout themes with title and borders. (4) Each buffer is accompanied by a status line at the bottom [modeline].

16 How do you use Emacs?

See FAQ. I use Emacs for most of my computing needs:

- Writing (teaching, research)
- Planning (Calendar, ToDo)
- Organizing (Files)

See also the article "Getting started with Emacs" (Kenlon, 2020), and the video "The Absolute Beginner's Guide to Emacs" (System Crafters, 2020) with my notes.



Figure 10: DESY APE research group (1994). Can you find me?

Other uses:

- As window manager (only under Linux)
- As email client
- Remote access (with GNU Tramp)



Figure 11: Neal Stephenson

17 How will we use Emacs?

We'll use it as:

- EDITOR to write source code,
- NOTEBOOK to write literate programs, and
- SHELL to build and run code.

"Emacs outshines all other editing software in approximately the same way that the noonday sun does the stars. It is not just bigger and brighter; it simply makes everything else vanish." – Neal Stephenson, *In the Beginning was the Command Line* (1998)⁸

We will not use Emacs as a substitute for religion even though there is a "Church of Emacs" (EmacsWiki)! Huh?! What?!

⁸Neal Stephenson is a sci-fi author who also coined the term "cyberspace", and developed a spacecraft and launch system for Bezos' Blue Origin.



Figure 12: The real Church: Notre Dame de Paris. Source: Wikipedia.

18 Does it really have to be Emacs?



You'll handle it. Keep calm and carry on coding.

If you look around, you'll see a lot of discussion on different source code editors and IDEs. Currently Microsoft's Visual Studio (VS) Code seems to

be the most popular contender. However, as one developer said:

"One thing that cannot be replaced by any extension in VS code, VIM or any other editor: Emacs' Org mode. Org mode is for sure one of the most amazing pieces of software I have ever seen or worked with. It does things that no other text-based word processor can do, even if you are writing complex scientific reports. VS code has an extension which brings less than 5% of Org mode functionality, tops and that is mostly the code highlighting." (Timachi, 2019)

19 What about Emacs' famously "steep learning curve" ?

"Emacs can be a challenge if you are used to using mouse pointer. One should be willing to leave the mouse and stick with the keyboard." (Timachi, 2019)

Using the keyboard for everything is much faster (than mouse-only, or mouse + keyboard) but takes getting used to. During the writing of this paragraph, I used the following keystrokes (with the command behind the keys, which your fingers will learn):

KEY	COMMAND
<q RET	org-self-insert-command
C-M-\	indent-region
M-q	org-fill-paragraph
C-a	org-beginning of line
C-e	org-end-of-line
C-x C-s	save-buffer

Computer science, and IT, are largely about mastering, and creating new tools. Therefore, almost any effort is justified that goes into improving your **meta skills**⁹ in this area.

⁹"Meta skills" are transferable skills that you learn, or improve, while you learn something specific (like Emacs or Org-mode). While the special skills might become obsolete or less important to you over time (because of a change of job, interest, or the market), meta skills stay important and fresh forever, because you can use them for every new special skill learning project.

20 Install GNU Emacs



Figure 13: GNU Emacs creator, Richard M Stallman (MIT)

21 Emacs download and Installation for Windows

- Download GNU Emacs + ESS as a modified version for Windows.
- Run the installer - accept all presets.
- Once you're done, you can open Emacs from the desktop with a shortcut. If you also want to open it in the command line terminal as `emacs -nw`, you need to update the `PATH` variable for Windows:
 1. Find the `bin` directory for Emacs in the File explorer - if you followed the standard instructions, it is in `c:\Program Files\Emacs\emacs-28.2\bin` - copy this address as text
 2. search for `PATH` in the Windows search bar
 3. in `System Properties`, select `Environment Variables`

4. in **Environment Variables**, select the lower screen, **System variables**, then select the line with **PATH** on it, and select **Edit...**
 5. In **Edit environment variable**, select **New**
 6. Paste the address as text on a new line
 7. Select **OK** three times until all screen dialogues are gone.
 8. Open a Windows command line terminal
 9. Enter **emacs -nw** on the terminal
 10. If successful, leave Emacs with **C-x C-c**
- Check out my new tutorial at GitHub (with videos)

22 Emacs download and Installation for MacOS

- Download Emacs for MacOS from here (currently version 28.2)
- Run the installer - accept all presets.
- Drag the Emacs icon into your Applications icon
- Ignore the warning
- In a terminal, type **emacs --version** to see if it worked, and start emacs with **emacs**.

23 Customize GNU Emacs

- GNU Emacs is much more than a text editor and an IDE. It's more like an operating system inside your operating system. Among the many things that Emacs is capable of, we only need one for this class: the ability to create and run interactive notebooks.
- This will give you the power of Jupyter notebooks or Colaboratory on your computer, without language limitations, and you can share notebooks with anyone, who has Emacs (or Markdown, for reading only).
- The central package for many day to day tasks is **Org-mode**. Here is a set of Org-mode tutorials (with videos) covering many interesting applications. Org-mode is especially popular among scientists, and among these, physicists (my original tribe), who developed it.

- And here is an excellent video tutorial by someone who is also getting started with Emacs for the first time like you: The Absolute Beginner's Guide to Emacs (System Crafters, 2021) - 1hr11min long - time well invested (I made some notes).

24 Create Emacs configuration file (.emacs)

- To create interactive computing notebooks in Emacs, we use the Org-mode and Babel packages. Both are already installed in your version of Emacs, but you have to tell Babel, which languages you want to work with.
- Customization like this is done with a configuration file `.emacs`, which is placed in your home directory (`$HOME`). Where this folder is actually located on your computer depends on your operating system¹⁰.
- Download the configuration file from GitHub and copy and paste it into a `.emacs` file or save it as `emacs.txt` and rename it to `.emacs`.
- Once you've created the `.emacs` file, you can start Emacs and code away "literarily". The customizations below are optional. But even just by using Emacs as your editor for assignments, you'll become quite an expert, almost a "hacker" (Wulff, 2021).

25 Create sample notebook for C

- To create a notebook using Org-mode, create an `.org` file. Then type `C-c C-`, and select your chunk from the list. You can also abbreviate this by entering `<s` on any line.
- You can work with source code in Emacs for a number of different languages:
 1. To run a code chunk as a whole, type `C-c C-c`. The result will appear immediately below the chunk.¹
 2. look at the code in a separate buffer and run them in parts. To open a buffer with the code, type `C-c '`.

¹⁰On my Windows machine, `$HOME` is `C:\Users\birkenkrahe\`. On my Linux box, it is `/home/marcus/`.

3. To print an org-mode file, type `C-c C-e` and choose a print format from the list.

- Running chunks will only work if Emacs can find the respective programs², and if a compiler (for C), or an interpreter (for R and SQLite) were installed.
- The code block needs to be named as shown. If you want the result and the code shown in the printout, you need to specify `:exports both`.

```
#include <stdio.h>

int main(void) {
    puts("hello world");
    return 0;
}

hello world
```

In the second version, both the header and the function definition are preset so that you can see the inside of the function only.

```
puts("hello world");

hello world
```

26 Summary

- To program in C, we need a computer, a compiler, and an editor
- You'll have to download the compiler for Windows or MacOS
- You can download and install Emacs (ready for data science)
- Emacs is a highly customizable editor (using Emacs Lisp)
- Org-mode is a literate programming environment

27 Jargon

CONCEPT	EXPLANATION
Source code	Human-readable program
Compiling	Translating source
Linking	Linking compiled program to libraries
Library	Bundle of reusable macros or functions
Object code	Code ready for execution by a machine
Execution	Running object code on a machine
Interpreter	Machine that interprets and executes source code
Script	Source code for an interpreter
Emacs	Extensible text editor (via Emacs Lisp)
Literate Program	Readable code - expands into doc + executable
GNU	"GNU's not UNIX"
GNU/Linux	Free, open source operating system
Richard Stallman	Creator of the GNU project and Emacs
Org-mode	Emacs package for literate programming (and more)

28 References

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