

Introduction to Unix

GSND 5345Q, FDS

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Section 1

Introduction to Unix

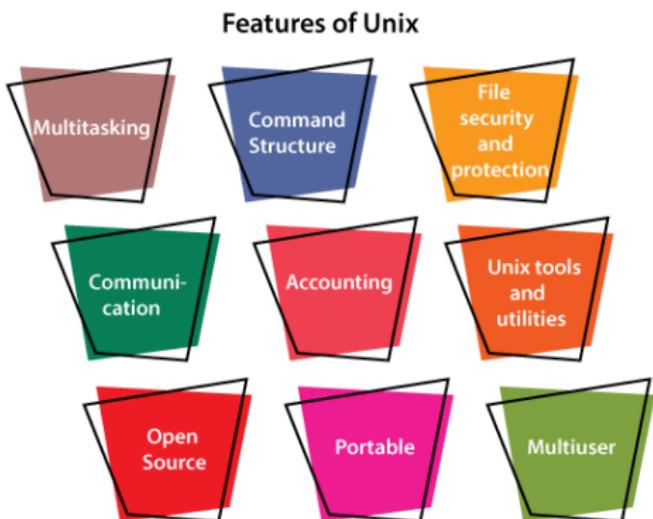
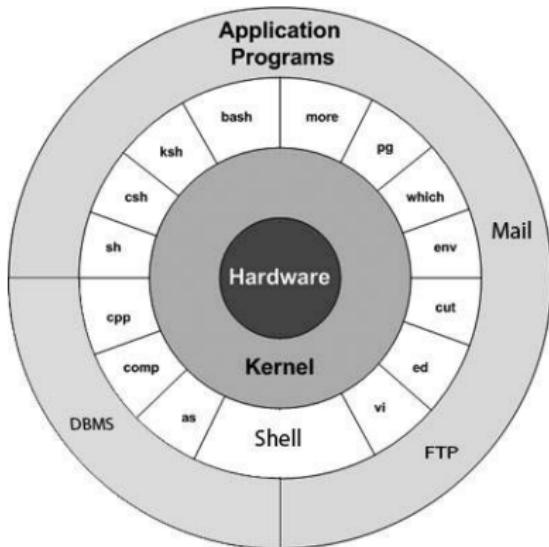
Unix Introduction

Unix is a family of multitasking, multiuser computer operating systems that derive from the original AT&T Unix. Originally developed in 1969 at Bell Labs. (Thanks Dennis Ritchie and Ken Thompson!)



Unix Introduction

The Unix operating system consists of many libraries and utilities along with the master control program, the kernel.



History of operating systems

Most operating systems can be grouped into two lineages:

- Microsoft's Windows NT-based operating systems
- “Unix-like” operating systems (e.g., Linux, Mac OS X, Android, iOS, Chrome OS, Orbis OS used on the PlayStation 4, firmware on your router)

UNIX

VS

Linux



Darwin



Unix and Data Science

Unix is the operating system of choice in data science.

We will introduce you to the Unix way of thinking using an example: how to keep a data analysis project organized, and later how to do things more efficiently.

We will learn some of the most commonly used commands along the way.

Section 2

Learning Unix

Naming conventions

Before you start, pick a name convention that you will use to systematically name your files and directories. The Smithsonian Data Management Best Practices has “five precepts of file naming and organization”:

- Have a distinctive, human-readable name that gives an indication of the content.
- Follow a consistent pattern that is machine-friendly.
- Organize files into directories (when necessary) that follow a consistent pattern.
- Avoid repetition of semantic elements among file and directory names.
- Have a file extension that matches the file format (no changing extensions!)

The Tidyverse Style Guide¹ is highly recommended!

¹<https://style.tidyverse.org/>

Section 3

The Terminal

Attention: Windows users

- **Git Bash** is a terminal for Windows that provides a Git command-line experience.
- It allows users to interact with their repositories and run shell commands.
- The following slides will guide you through the installation process.
- **Mac users:** nothing to see here! Move on!

Step 1: Download Git Bash

- Visit the official Git website: <https://git-scm.com/>
- Click on the “Download for Windows” button.

Step 2: Run the Installer

- ① Locate the downloaded .exe file in your downloads folder.
- ② Double-click to start the installer.
- ③ Follow the prompts in the setup wizard:
 - Choose default options unless you have specific requirements.
 - Ensure Git Bash is selected as a component.

Step 3: Complete Installation

- Once installed, launch Git Bash by searching for it in the Windows Start Menu.
- You're now ready to use Git Bash for your projects!

Mac Users

- Open the **Terminal** App on your Mac, or
- Use the terminal directly from RStudio

Basic Unix Commands

Instead of clicking, dragging, and dropping files and folders, we will be typing Unix commands into the terminal. (Similar typing commands into the R console!)

You will need access to a terminal. Once you have a terminal open, you can start typing into the *command line*, usually after a \$ or % symbol. Once you hit enter, Unix will try to execute this command. For example:

```
echo "hello world"
```

```
## hello world
```

Basic Unix Commands

The command echo is similar to cat in R. Executing this line should print out hello world, then return back to the command line.

Notice that you can't use the mouse to move around in the terminal. You have to use the keyboard. To go back to a previous command, you can use the up arrow.

Section 4

Files and directories

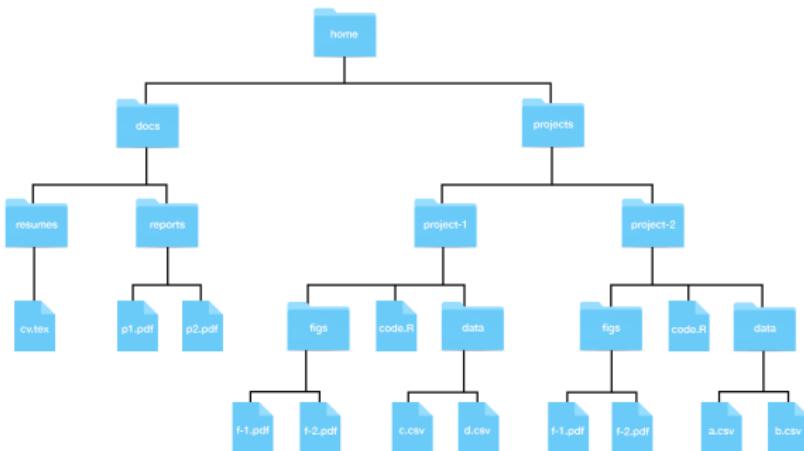
The filesystem

We refer to all the files, folders, and programs on your computer as the **filesystem**. Keep in mind that folders and programs are also files (for later discussion). We will focus on files and folders for now and discuss programs, or **executables**, in a later section.

The first concept top understand is how your filesystem is organized; a series of nested folders, each containing files, folders, and executables.

Directories and subdirectories

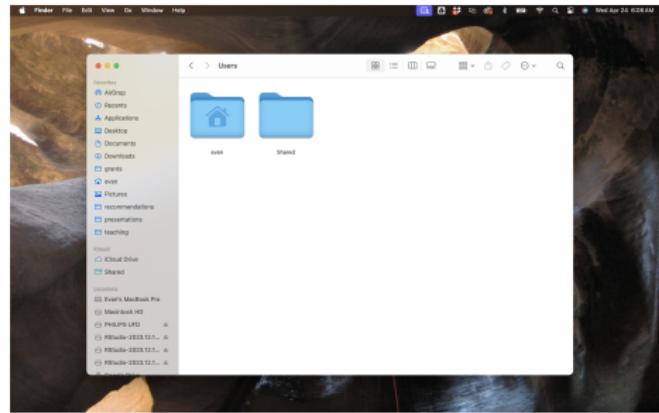
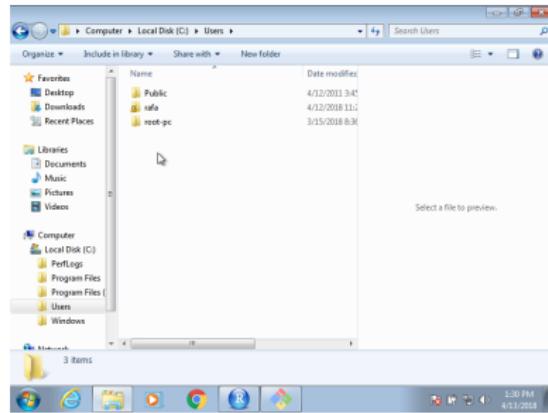
Here is a representation of the structure we are describing:



In Unix, we refer to folders as **directories**. Directories inside other directories referred to as **subdirectories**.

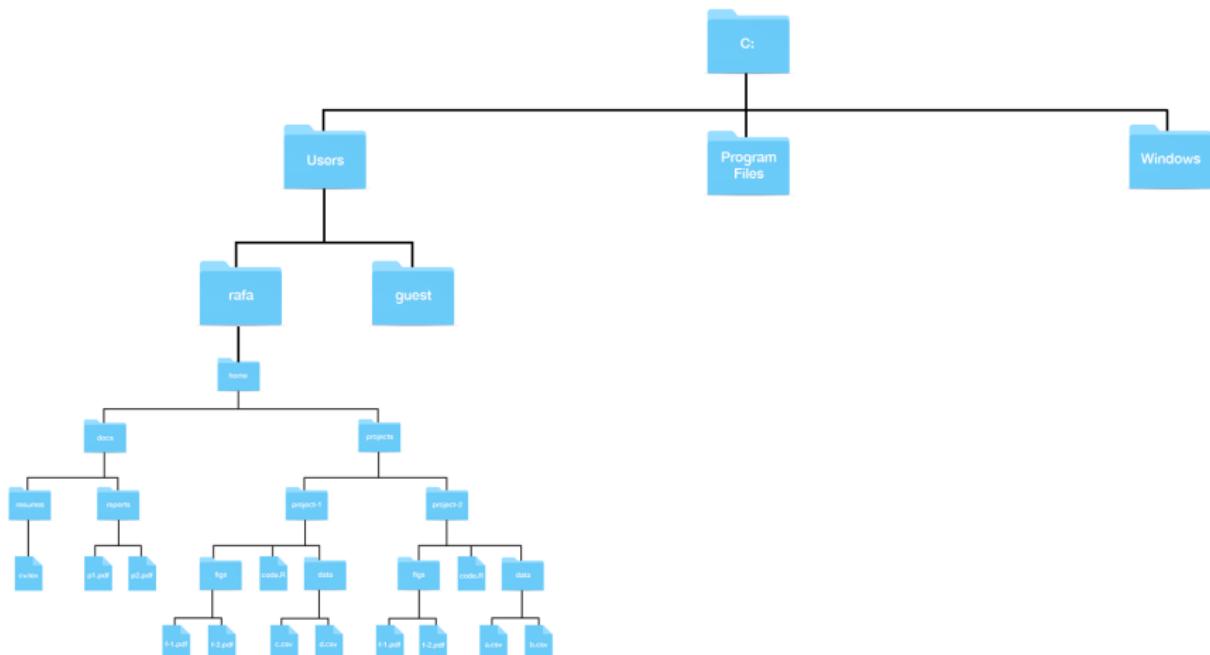
The home directory

The **home directory** is where your stuff is kept, as opposed to the system files, which are kept elsewhere. The name of your home directory is likely the same as your username. For example:



Windows filesystem structure

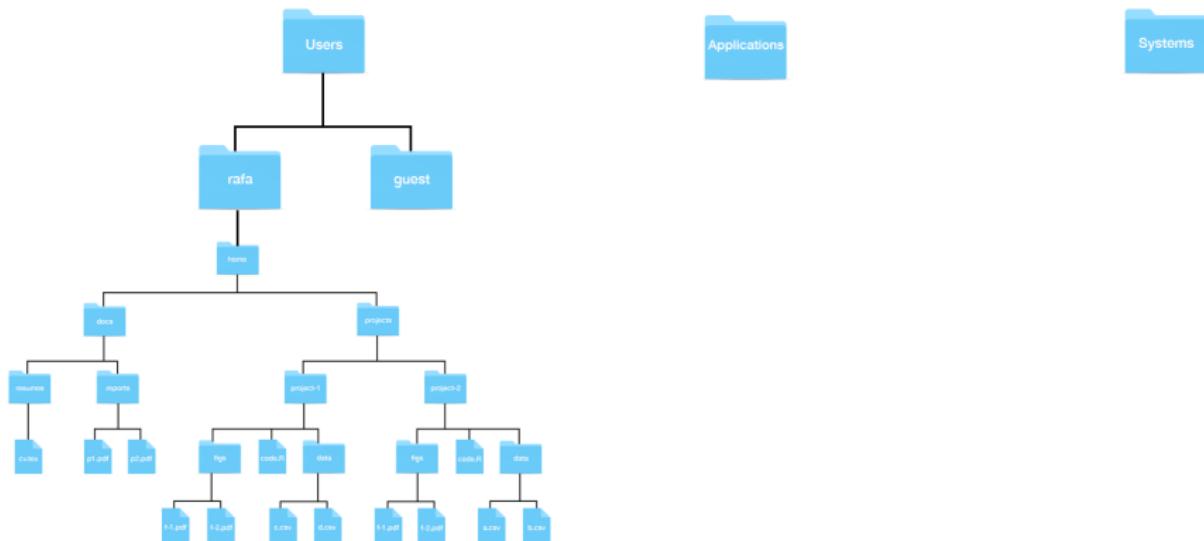
The Windows filesystem structure² looks like this:



²**Windows Users:** The typical R installation will make your Documents directory your

Mac filesystem structure

The Mac filesystem structure looks like this:



Working directory

In Unix, the concept of a current location is indispensable. We refer to this as the **working directory**. Each terminal window you have open has a working directory.

How do we know our working directory? We use the Unix command: `pwd`, which stands for *print working directory*:

```
pwd
```

Paths

The string returned by `pwd` is the **full path** of the working directory. Every directory has a full path. Later, we will learn about **relative paths**, which tell us how to get to a directory from the working directory.

In Unix, the shorthand `~` is a nickname for your home directory. So, for example, if `docs` is a directory in your home directory, the full path can be written `~/docs`.

Section 5

Basic Unix Commands

Some Basic Unix Commands

To see the content of your home directory, open a terminal and type:

```
ls
```

You can also add **options** ('-' and '--'), **arguments**, and **wild cards** (*) to change function behavior:

```
ls -l  
ls -a  
ls -t  
ls -r  
ls -lart  
ls -l *.txt
```

Some Basic Unix Commands

To create and remove directories, use the `mkdir` and `rmdir` functions, for example (use `ls` in between to see the directory come and go):

```
mkdir projects
mkdir junk
rmdir projects
```

Note: `rmdir` does not work if the directory is not empty.

Pro tip 1: The up arrow retrieves your previous commands.

Pro tip 2: You can auto-complete by hitting tab.

Some Basic Unix Commands

To change the working directory use the cd command, which stands for *change directory*. For example:

```
cd projects
```

To check that it worked, use pwd. Now try:

```
cd .
cd ..
cd ../..
cd /
cd ~
cd ~/projects
cd ../junk
```

Some Basic Unix Commands

In Unix, we move files from one directory using the `mv` command:

```
mv path-to-file path-to-destination-directory
```

Warning: `mv` will not ask “are you sure?” if your move results in overwriting a file. Some `mv` examples:

```
mkdir ~/junk ~/projects/resumes
touch ~/projects/resumes/cv.tex
mv ~/projects/resumes/cv.tex ../..
mv ~/cv.tex ~/mycv.tex
mv ~/projects/mycv.tex junk/
mv ~/junk/mycv.tex ../projects/resumes/
```

Some Basic Unix Commands

The command `cp` behaves similar to `mv` except instead of moving, we copy the file.

```
cp ~/projects/resumes/mycv.tex ~/mycv.tex
```

So in all the `mv` examples in the prior slide, you can switch `mv` to `cp` and they will copy instead of move. However to copy entire directories, add the recursive (`-r`) option:

```
cp -r ~/projects/resumes ~/junk/
```

Some Basic Unix Commands

In Unix, we remove files (and directories) with the `rm` command.

```
rm filename
```

Warning: Unlike throwing files into the trash or recycle bin, `rm` is permanent. Be careful! Note the following:

```
rm mycv.tex
```

```
rm junk/*.tex
```

```
rm -r projects junk
```

Some Basic Unix Commands

Unix uses an extreme version of abbreviations, which makes it hard to guess how to call commands. However, Unix includes complete help files or **man pages** (man is short for manual). In most systems, you can type `man` followed by the command name to get help. For example:

```
$ man ls
```

This command is not available in some of compact implementations of Unix (e.g., Git Bash). Alternatively, we can type the command followed by `-help`:

```
ls --help
```

Advanced Unix functions

Most Unix implementations include a large number of powerful tools and utilities. It will take time to become comfortable with Unix, but as you struggle, you will find yourself learning just by looking up solutions on the internet.

In your Homework, you will cover more advanced Unix functions such as chmod, less, vim, grep, ln, tar, ssh, and pipes. (and git!!!) Stay tuned!

Additional Unix Resources

Here are some resources more information:

- <https://www.codecademy.com/learn/learn-the-command-line>
- <https://www.edx.org/course/introduction-linux-linuxfoundationx-lfs101x-1>
- <https://www.coursera.org/learn/unix>

There are many reference books as well. Here are some particularly clear, succinct, and complete examples:

- <https://www.quora.com/Which-are-the-best-Unix-Linux-reference-books>
- <https://gumroad.com/l/bite-size-linux>
- <https://jvns.ca/blog/2018/08/05/new-zine--bite-size-command-line/>

Section 6

Next Lecture: Introduction to the Amarel HPC
Cluster

Next Lecture: HPC at Rutgers University

At Rutgers, the primary High Performance Computing (HPC) resources are governed by the Rutgers Office of Advanced Research and Computing (OARC). They provide significant online and synchronous (in person) resources for HPC, along with training in batch submission, programming languages, parallel programming, distributed systems, and HPC architectures.

Next Lecture: HPC at Rutgers

About Amarel

In July 2017, the [Office of Advanced Research Computing](#) (OARC) unveiled Amarel, a "condominium" style computing environment developed to serve the university's wide-ranging research needs. The Amarel cluster provides a shared platform that optimizes resources for the benefit of all users. Named in honor of **Dr. Saul Amarel**, one of the founders of the Rutgers Computer Science Department and contributor to advanced computing and artificial intelligence research and methodologies, Amarel is designed to suit many different research applications.

Through Aberdeen (late 2023):

- 560 compute nodes
 - 27,872 Intel Xeon cores
 - 224 GPUs
 - Open OnDemand servers
 - InfiniBand FDR & EDR fabric

More information:

- Community-contributed software repository
- Spans three Rutgers data centers (Piscataway, Newark, and Camden) producing a unified compute, data, and storage system
- Rolling node/phase retirement with new node replacement, beginning in spring 2021

[Click here for a short video about the Amarel cluster!](#)

Next Lecture: Getting Started with Amarel

If you are off campus, you will need access to VPN:

[Click Here for Rutgers VPN instructions for Windows Users](#)

[Click Here for Rutgers VPN instructions for Mac Users](#)

Next Lecture: Getting Started with Amarel

- ① **Request Access ([Click Here](#))**: OARC webpage to request access to Amarel
- ② **Training Workshops**: Attend training workshops offered by OARC to learn how to use Amarel effectively.
- ③ **Documentation and Support ([Click Here](#))**: Explore documentation and seek support from OARC staff and the user community.
- ④ **Start Small**: Begin with small-scale experiments and gradually scale up as needed.

Session info

```
sessionInfo()
```

```
## R version 4.5.1 (2025-06-13)
## Platform: aarch64-apple-darwin20
## Running under: macOS Tahoe 26.2
##
## Matrix products: default
## BLAS:    /Library/Frameworks/R.framework/Versions/4.5-arm64/Resources/lib/libRblas.0.dylib
## LAPACK:  /Library/Frameworks/R.framework/Versions/4.5-arm64/Resources/lib/libRlapack.dylib;  LAPACK version 3
##
## locale:
## [1] en_US.UTF-8/en_US.UTF-8/en_US.UTF-8/C/en_US.UTF-8/en_US.UTF-8
##
## time zone: America/Denver
## tzcode source: internal
##
## attached base packages:
## [1] stats      graphics   grDevices utils      datasets   methods    base
##
## loaded via a namespace (and not attached):
## [1] compiler_4.5.1    fastmap_1.2.0    cli_3.6.5       tools_4.5.1
## [5] htmltools_0.5.9   otel_0.2.0     rstudioapi_0.17.1 yaml_2.3.12
## [9] rmarkdown_2.30    knitr_1.51     xfun_0.55      digest_0.6.39
## [13] rlang_1.1.6      evaluate_1.0.5
```