

# Outline

- Introduction - history
- Command line basics – getting help
- File system
- Working with files and directories
- More file handling
- The shell revisited
- Monitoring resources

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# Outline detail

- Background info
- OS kernel shell
- Command Line Interface (CLI)

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## Some background

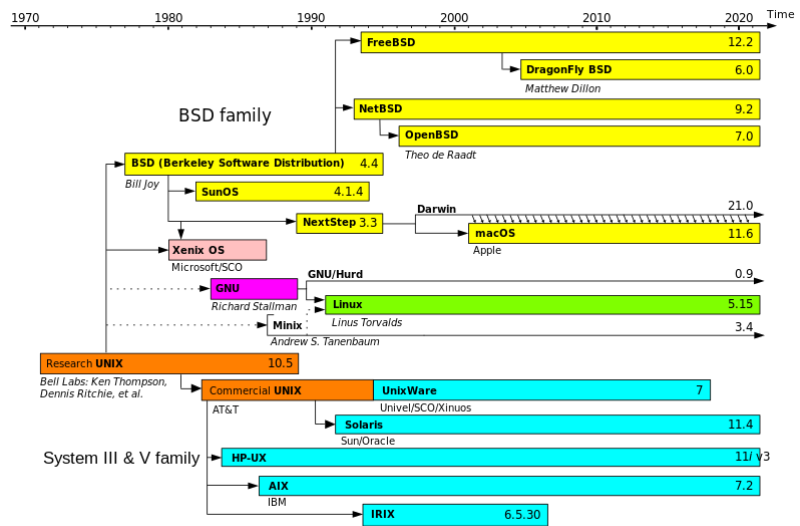
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## Operating system

- An operating system (OS) is system software that manages computer hardware, software resources, and provides common services for computer programs.  
([https://en.wikipedia.org/wiki/Operating\\_system](https://en.wikipedia.org/wiki/Operating_system))
  - Windows
    - Desktop systems
    - <https://gs.statcounter.com/os-market-share/desktop/worldwide/>
  - Linux
    - Server and supercomputing
  - MacOS
- Linux and Windows are based on foundations developed in the mid-1970s
- DOS, MacOS and UNIX are proprietary, i.e., the source code of their kernel is protected

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## \*nix time line



[https://en.m.wikipedia.org/wiki/File:Unix\\_timeline.en.svg](https://en.m.wikipedia.org/wiki/File:Unix_timeline.en.svg)

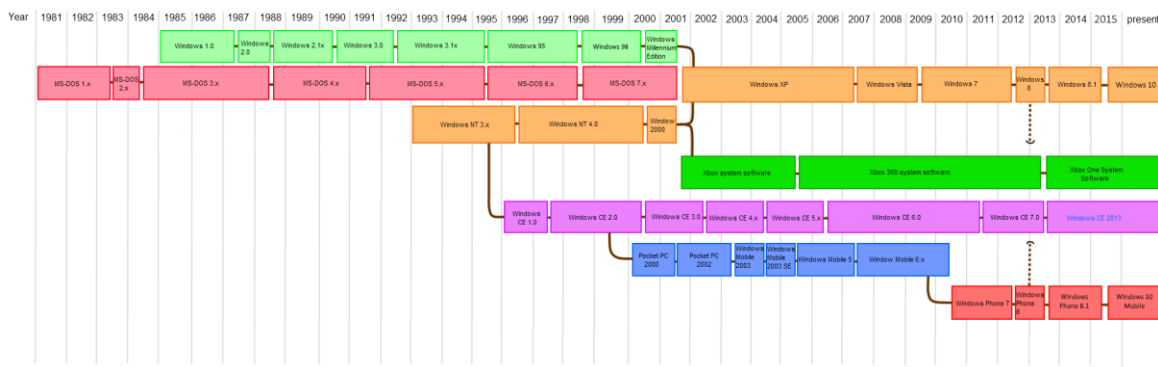
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## Some history

- 1970s: UNIX: roots in Bell Labs (AT&T) (<https://www.bell-labs.com/about/history/innovation-stories/50-years-unix/#gref>)
- 1985: Professor Andy Tanenbaum creates a UNIX like operating system based on System V Unix for the IBM PC & PC/AT computers: Minix.
- 1991: Linus Torvalds started developing Linux to create a system similar to Minix; released version 0.02
- Late 1980s: Richard Stallman and the Free Software Movement (FSF) made efforts to create an open-source UNIX-like operating system called GNU. In contrast to Linus Torvalds, Stallman started by creating utilities for the operating system first.
- These utilities were then added to the Linux kernel to create a complete system called GNU/Linux (or just Linux).

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# Windows time line



[https://en.wikipedia.org/wiki/List\\_of\\_Microsoft\\_operating\\_systems#/media/File:Microsoft\\_timeline\\_of\\_operating\\_systems\\_2.png](https://en.wikipedia.org/wiki/List_of_Microsoft_operating_systems#/media/File:Microsoft_timeline_of_operating_systems_2.png)

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OS, kernel, shell, etc.

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# Linux OS

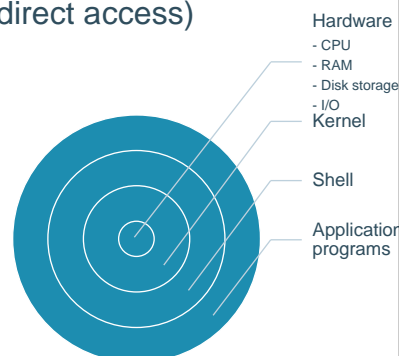
- Linux is not a single operating system, but rather a large family of free and open source operating systems based on the Linux kernel.
- Different variants within this family are referred to as **Linux Distributions** (<https://distrowatch.com/>) CentOS, Ubuntu, etc.
- There are two major components of Linux:
  - The **kernel** is the core of the Linux operating system:
    - Schedules processes and interfaces directly with the hardware.
    - It manages system and user I/O, processes, devices, files, and memory.
  - The **shell** is a text-only interface to the kernel.
    - Users input commands through the shell, and the kernel receives the tasks from the shell and performs them.
    - The shell works interactively (REPL- Read Evaluate Print Loop).
    - Users *do not* interact with the kernel directly, it is done through the shell or a desktop environment.

(<https://cvw.cac.cornell.edu/Linux/introduction>)

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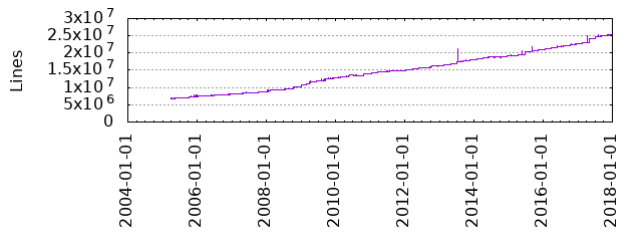
## Linux kernel

- aka: executive, system monitor.
- Provides a layer between the computer hardware and user applications.
- Provides an interface for software to use hardware (no direct access)
- Planning and assigning:
  - Memory, CPU, disk, etc.
  - Security aspects
  - Fulfill user requests (system calls).
  - Filesystem, networking, ...



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# Linux kernel



- Lines of code

([https://www.phoronix.com/scan.php?page=news\\_item&px=Linux-Kernel-Commits-2017](https://www.phoronix.com/scan.php?page=news_item&px=Linux-Kernel-Commits-2017))

- Linux in 2020: 27.8 million lines of code in the kernel

[https://www.theregister.co.uk/2020/01/06/linux\\_2020\\_kernel\\_systemd\\_code/](https://www.theregister.co.uk/2020/01/06/linux_2020_kernel_systemd_code/)

index : kernel/git/stable/linux.git

Linux kernel stable tree

primary refs log tree commit diff stats log msg

Commit message (Expand)

Linux 5.5-rc5 HEAD v5.5-rc5 master

Merge tag 'riscv-for-v5.5-rc5' of git://git.kernel.org/pub/scm/linux/kernel.g...

Documentation: riscv: add patch acceptance guidelines

riscv: prefix IRQ\_ macro names with an RV\_ namespace

clocksource: riscv: add notrace to riscv\_sched\_clock

Merge branch 'akpm' (patches from Andrew)

Merge tag 'apparmor-pr-2020-01-04' of git://git.kernel.org/pub/scm/linux/kern...

apparmor: fix aa\_xattrs\_match() may sleep while holding a RCU lock

Merge tag 'mips\_fixes\_5.5\_1' of git://git.kernel.org/pub/scm/linux/kernelgit...

hexagon: define ioremap\_uc

ocfs2: fix the crash due to call ocfs2\_get\_dlm\_debug once less

ocfs2: call journal flush to mark journal as empty after journal recovery whe...

mm/bug: defer freeing of huge pages if in non-task context

Author

- Linus Torvalds
- Linus Torvalds
- Paul Walmsley
- Zong Li
- Linus Torvalds
- Linus Torvalds
- John Johansen
- Linus Torvalds
- Nick Desaulniers
- Gang He
- Kai Li
- Waiman Long

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# Linux kernel

- File Management
  - Controls the creation, removal of files and provide directory maintenance
  - For a multiuser system, every user should have its own right to access files and directories
- Process Management
  - Multitask system: multiple programs can be executed simultaneously
  - When a program starts to execute, it becomes a *process*. The same program executing at 2 different times will become 2 different processes
  - Processes are managed by the kernel: creating, suspending, terminating
  - A process is protected from other processes and can communicate with the others

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## Linux kernel

- Memory management
  - Memory in a computer is divided into main memory (RAM) and secondary storage (usually refer to hard disk)
  - Memory is small in capacity but fast in speed, and hard disk is vice versa
  - Data that are not currently used should be saved to hard disk first, while data that are urgently needed should be retrieved and stored in RAM
- Device drivers
  - Interfaces between the kernel and the BIOS (*basic input/output system*)
  - Different device has different driver

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## Linux kernel

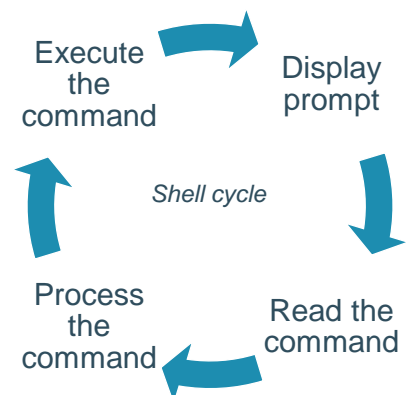
- Get the kernel version

```
uname -r
```
- `uname -a` provides the information in the order
  - KERNEL-NAME NODENAME KERNEL-RELEASE KERNEL-VERSION
  - MACHINE PROCESSOR HARDWARE-PLATFORM OPERATING-SYSTEM

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# Linux shell

- A shell is an interface for accessing the underlying commands of an operating system.
- When you sign in at the command line or launch a terminal window on Linux, the system launches the shell program.
- Is the command line interpreter: a program that accepts input from a user (e.g. a command) and performs the requested task. (REPL - *read-eval-print loop*)
- The shell's **prompt** identifies the type of shell being used



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# Most popular shells

- There are several types of shells for Linux.
- Check it with  
`$ echo $SHELL`
- Change the shell with  
`chsh`

File:check\_shell.sh

Shell	Prompt	Name	Note
sh	\$	Bourne Shell	Default on some Unix systems
bash	\$	Bourne Again Shell	Enhanced replacement for the Bourne shell Default on most Linux and Mac OS X systems
csh	%	C Shell	Default on many BSD systems
tcsh	>	TC Shell	Enhanced replacement for the C shell
ksh	\$	Korn Shell	Default on AIX systems

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# Shell

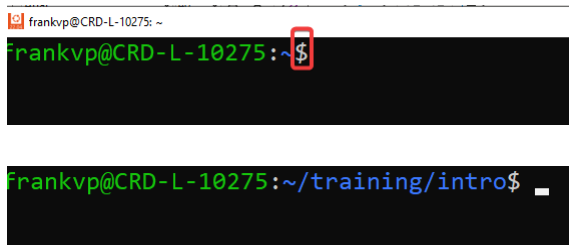
What does it?

- Command line editing and tools (auto complete)
- History
- Job control
- Configuration management (startup scripts)
- Automation / Scripting language

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## The prompt

- \$: prompt, which shows us that the shell is waiting for input
- The shell may use a different character as a prompt and likely adds information before the prompt.



```
frankvp@CRD-L-10275: ~  
frankvp@CRD-L-10275:~$  
frankvp@CRD-L-10275:~/training/intro$ -
```

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# CLI

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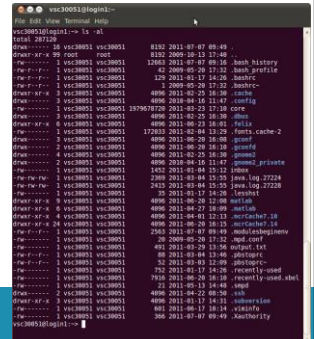
## Linux User Interface

- Traditional \*nux (Linux, Unix) systems use **command line interface** (cli or text-based interface)
- User needs to type lines of command to instruct the computer to work, similar to Windows DOS command window
- Advantages:
  - Fast: few resources required
  - Reliable: some of these commands have been around for years. Commands change less frequently than the GUI counterparts. GUI counterparts often use these same commands under the hood.
  - Productivity: use the keyboard instead of navigating through a bunch of menus and screens with the mouse and tabbing back and forth between different applications
- Disadvantages:
  - Memorize the commands
  - Typing a command can be error prone

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# Command Line Interface: Beware!

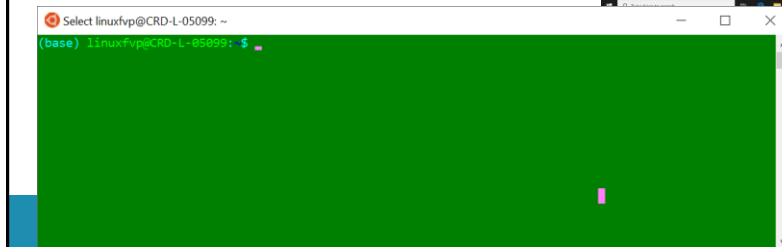
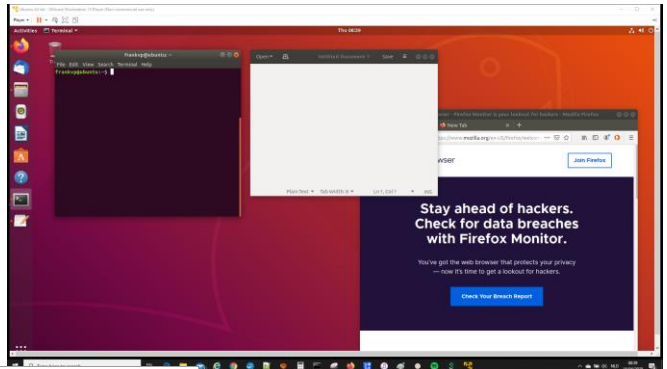
- Common use on servers and HPC system
- Implicitly assumes that you know what you are doing. Don't be scared!
- Often there are no warnings with commands, no *undo*
- No recycle bin!
- If anything goes wrong, you can stop the command with **ctrl+C**

A screenshot of a terminal window titled 'vic30051@logind:~'. The terminal shows the output of the 'cat /etc/passwd' command, displaying system user accounts like 'root', 'daemon', 'bin', 'sys', 'sync', 'games', 'man', 'lp', 'mail', 'news', 'uucp', 'proxy', 'at', 'atd', 'nobody', 'sshd', 'gnome', 'gdm', 'pam', 'plasma', 'kde', 'kdm', 'lightdm', 'polkit', 'avahi', 'cups', 'cups-filters', 'cups-browsed', 'cups-pk-helper', 'cups-pk-helper2', 'cups-pk-helper3', 'cups-pk-helper4', 'cups-pk-helper5', 'cups-pk-helper6', 'cups-pk-helper7', 'cups-pk-helper8', 'cups-pk-helper9', 'cups-pk-helper10', 'cups-pk-helper11', 'cups-pk-helper12', 'cups-pk-helper13', 'cups-pk-helper14', 'cups-pk-helper15', 'cups-pk-helper16', 'cups-pk-helper17', 'cups-pk-helper18', 'cups-pk-helper19', 'cups-pk-helper20', 'cups-pk-helper21', 'cups-pk-helper22', 'cups-pk-helper23', 'cups-pk-helper24', 'cups-pk-helper25', 'cups-pk-helper26', 'cups-pk-helper27', 'cups-pk-helper28', 'cups-pk-helper29', 'cups-pk-helper30', 'cups-pk-helper31', 'cups-pk-helper32', 'cups-pk-helper33', 'cups-pk-helper34', 'cups-pk-helper35', 'cups-pk-helper36', 'cups-pk-helper37', 'cups-pk-helper38', 'cups-pk-helper39', 'cups-pk-helper40', 'cups-pk-helper41', 'cups-pk-helper42', 'cups-pk-helper43', 'cups-pk-helper44', 'cups-pk-helper45', 'cups-pk-helper46', 'cups-pk-helper47', 'cups-pk-helper48', 'cups-pk-helper49', 'cups-pk-helper50', 'cups-pk-helper51', 'cups-pk-helper52', 'cups-pk-helper53', 'cups-pk-helper54', 'cups-pk-helper55', 'cups-pk-helper56', 'cups-pk-helper57', 'cups-pk-helper58', 'cups-pk-helper59', 'cups-pk-helper60', 'cups-pk-helper61', 'cups-pk-helper62', 'cups-pk-helper63', 'cups-pk-helper64', 'cups-pk-helper65', 'cups-pk-helper66', 'cups-pk-helper67', 'cups-pk-helper68', 'cups-pk-helper69', 'cups-pk-helper70', 'cups-pk-helper71', 'cups-pk-helper72', 'cups-pk-helper73', 'cups-pk-helper74', 'cups-pk-helper75', 'cups-pk-helper76', 'cups-pk-helper77', 'cups-pk-helper78', 'cups-pk-helper79', 'cups-pk-helper80', 'cups-pk-helper81', 'cups-pk-helper82', 'cups-pk-helper83', 'cups-pk-helper84', 'cups-pk-helper85', 'cups-pk-helper86', 'cups-pk-helper87', 'cups-pk-helper88', 'cups-pk-helper89', 'cups-pk-helper90', 'cups-pk-helper91', 'cups-pk-helper92', 'cups-pk-helper93', 'cups-pk-helper94', 'cups-pk-helper95', 'cups-pk-helper96', 'cups-pk-helper97', 'cups-pk-helper98', 'cups-pk-helper99', 'cups-pk-helper100'. The terminal also shows the output of the 'cat /etc/group' command, displaying system groups like 'root', 'daemon', 'bin', 'sys', 'sync', 'games', 'man', 'lp', 'mail', 'news', 'uucp', 'proxy', 'at', 'atd', 'nobody', 'sshd', 'gnome', 'gdm', 'pam', 'plasma', 'kde', 'kdm', 'lightdm', 'polkit', 'avahi', 'cups', 'cups-filters', 'cups-browsed', 'cups-pk-helper', 'cups-pk-helper2', 'cups-pk-helper3', 'cups-pk-helper4', 'cups-pk-helper5', 'cups-pk-helper6', 'cups-pk-helper7', 'cups-pk-helper8', 'cups-pk-helper9', 'cups-pk-helper10', 'cups-pk-helper11', 'cups-pk-helper12', 'cups-pk-helper13', 'cups-pk-helper14', 'cups-pk-helper15', 'cups-pk-helper16', 'cups-pk-helper17', 'cups-pk-helper18', 'cups-pk-helper19', 'cups-pk-helper20', 'cups-pk-helper21', 'cups-pk-helper22', 'cups-pk-helper23', 'cups-pk-helper24', 'cups-pk-helper25', 'cups-pk-helper26', 'cups-pk-helper27', 'cups-pk-helper28', 'cups-pk-helper29', 'cups-pk-helper30', 'cups-pk-helper31', 'cups-pk-helper32', 'cups-pk-helper33', 'cups-pk-helper34', 'cups-pk-helper35', 'cups-pk-helper36', 'cups-pk-helper37', 'cups-pk-helper38', 'cups-pk-helper39', 'cups-pk-helper40', 'cups-pk-helper41', 'cups-pk-helper42', 'cups-pk-helper43', 'cups-pk-helper44', 'cups-pk-helper45', 'cups-pk-helper46', 'cups-pk-helper47', 'cups-pk-helper48', 'cups-pk-helper49', 'cups-pk-helper50', 'cups-pk-helper51', 'cups-pk-helper52', 'cups-pk-helper53', 'cups-pk-helper54', 'cups-pk-helper55', 'cups-pk-helper56', 'cups-pk-helper57', 'cups-pk-helper58', 'cups-pk-helper59', 'cups-pk-helper60', 'cups-pk-helper61', 'cups-pk-helper62', 'cups-pk-helper63', 'cups-pk-helper64', 'cups-pk-helper65', 'cups-pk-helper66', 'cups-pk-helper67', 'cups-pk-helper68', 'cups-pk-helper69', 'cups-pk-helper70', 'cups-pk-helper71', 'cups-pk-helper72', 'cups-pk-helper73', 'cups-pk-helper74', 'cups-pk-helper75', 'cups-pk-helper76', 'cups-pk-helper77', 'cups-pk-helper78', 'cups-pk-helper79', 'cups-pk-helper80', 'cups-pk-helper81', 'cups-pk-helper82', 'cups-pk-helper83', 'cups-pk-helper84', 'cups-pk-helper85', 'cups-pk-helper86', 'cups-pk-helper87', 'cups-pk-helper88', 'cups-pk-helper89', 'cups-pk-helper90', 'cups-pk-helper91', 'cups-pk-helper92', 'cups-pk-helper93', 'cups-pk-helper94', 'cups-pk-helper95', 'cups-pk-helper96', 'cups-pk-helper97', 'cups-pk-helper98', 'cups-pk-helper99', 'cups-pk-helper100'.

# Linux User Interface

- By adopting the X-Window technology, graphical user interface (GUI) is available for Linux.
- Uses pointing devices (e.g. mouse) to control the system, similar to Microsoft's Windows
- Provide menu-driven and/or icon-driven interfaces
  - menu-driven: user is provided with a menu of choices. Each choice refers to a particular task
  - icon-driven: tasks are represented by pictures (icon) and shown to user. Click on an icon invokes one task
- Advantages:
  - No need to memorize commands. Always select task from menus or icons
- Disadvantages:
  - Slow and requires resources for its implementation
  - Suitable for general users and systems, such as PC use

# Linux User Interface



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## Someone is doing something somewhere

- Linux is a multiuser OS
  - Allows multiple users to use the resource of a computer at the same time
  - Before you can do anything, you have to log in.
    - This can be either a graphical or a nongraphical prompt.
      - Linux desktop: you are likely to see a graphical environment.
      - A server: you'll just see a shell login prompt.
- Check who you are on the computer: `whoami`
- List the users logged on with: `who`
- What is the machine you are working on: `hostname`

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## Useful commands

- What is the directory you are working in: `pwd`
- What date/time is it: `date`
- Clear the contents of the current screen  
`$ clear`
- `$ logout`
  - The `logout` command logs your account out of the system (in a text mode).
  - This will end the terminal session and return to the login screen.
  - Some systems may have a file called `.logout` or `.bash_logout` in each user's home directory.
- `$ exit`
  - Exit the current shell. The `exit` command is similar to the `logout` command with the exception that it does not run the logout script located in the user's home directory.

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## Hands-on

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