

# 1 - ROS2 - Démarrage

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# Installation PC ROS2

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ROS est un Middleware Open Source pour développer des applications robotiques. Originellement développé sous Linux (Ubuntu), il est maintenant disponible sur plusieurs systèmes d'exploitation dont Debian et Windows.

## Installation des prérequis et liens importants

Pour des raisons de stabilité et légèreté du système, il y a tout à penser que les déploiements de ROS dans des milieux industriels se font (robotique autonome et mobile) et se feront à l'avenir sur Ubuntu et de plus en plus Debian. L'industrie des serveurs a déjà largement adopté Debian pour sa stabilité et sa modularité. C'est pourquoi plutôt que d'apprendre la ligne de commande Windows, nous recommandons d'apprendre la ligne de commande Bash, utilisée dans Ubuntu/Debian. Pour cela, il faut installer un système (noyau) Linux, plusieurs options s'offrent à nous:

- Machine virtuelle
  - Windows subsystem for Linux (WSL2)
  - Machine virtuelle Linux, par exemple via VirtualBox
- Machine physique
  - dual-boot Windows-Ubuntu
  - PC sous Ubuntu 22.04

Notes importantes pour les installations virtuelles (deux premières options d'installation) :

- Ces installations sont suffisantes pour effectuer des simulations et du développement tant qu'il n'y a pas de Hardware à tester.
- L'accélération graphique n'est pas supportée par la carte graphique (GPU) mais par le processeur (CPU) (voir [ce bug](#))
- un PC avec 32Go de RAM est recommandé si des composants imposants de ROS doivent être compilés, par exemple pour utiliser la version de développement [MoveIt 2 Rolling](#). En effet Windows consomme à lui seul près de 4-8Go, Ubuntu >2Go et la compilation >4Go, on peut vite atteindre la saturation. 16Go peuvent suffire mais il faudra compiler sans parallélisation, et fermer des applications lourdes dans Windows comme Firefox.

# Ubuntu via Windows SubSystem for Linux (WSL2)

WSL2 installe une machine virtuelle avec le noyau Linux complet, supporté et managé par Microsoft Windows. **Il n'y a pas besoin de droits administrateur car le logiciel est disponible dans le store Windows.**

## Prérequis :

- Depuis le menu démarrer Windows, rechercher "A propos de", "Spécifications de Windows"
  - Version >22H2
  - Build >19041 (testé avec 19045.2486)
  - Si votre version est inférieure, demandez à votre administrateur de màj vers 22H2 et Build 19045.2486
  - Si vous ne pouvez màj, optez pour l'option d'installation d'Ubuntu via VirtualBox
- Exécuter Windows PowerShell en mode administrateur (connectez-vous avec un compte administrateur si vous n'avez pas les droits)
- Lancer `wsl --install` (si ça ne fonctionne pas, votre Windows n'est probablement pas à la bonne version)
- `wsl --update`
- Redémarrer l'ordinateur

## Installation de Ubuntu 22 :

- Ouvrir Windows Store
- Rechercher et installer `Ubuntu` (c'est la version LTS actuelle qui sera installée, en ce moment 22.04.X)
- Depuis le menu démarrer Windows, Lancer l'application `Ubuntu`. Une Terminal s'ouvre (ligne de commande Linux Bash)
- Définir l'utilisateur principal, par exemple `ros2` et un mot de passe (8 caractères mini, majuscule, minuscule, chiffre, caractère spécial).
- Mettre à jour Ubuntu

```
sudo apt update
sudo apt upgrade
```

Depuis Windows, pour éteindre les Machines Virtuelles Ubuntu et ainsi libérer la mémoire RAM affectée :

- Lancer l'application `Windows PowerShell`
- `wsl --shutdown` Autres commandes WSL depuis `Windows PowerShell` :
- `wsl --status` : devrait retourner `Distribution par défaut : Ubuntu`, `Version par défaut : 2` (WSL2)

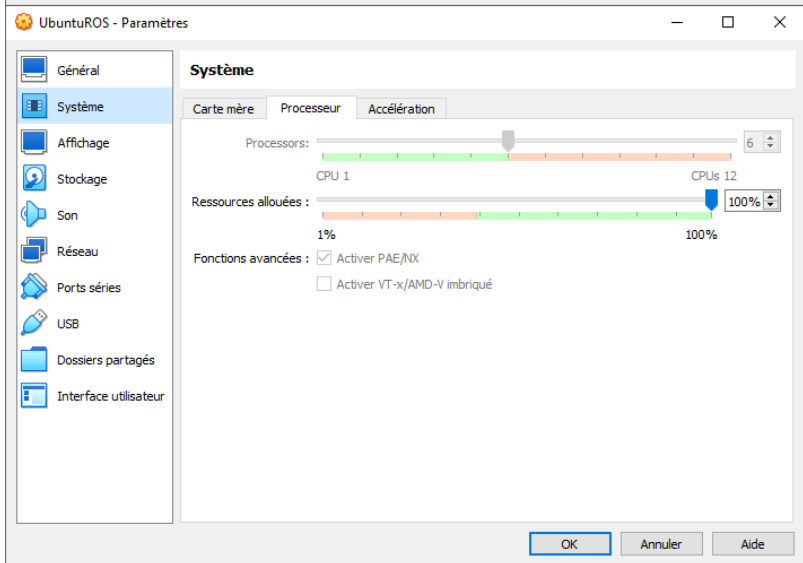
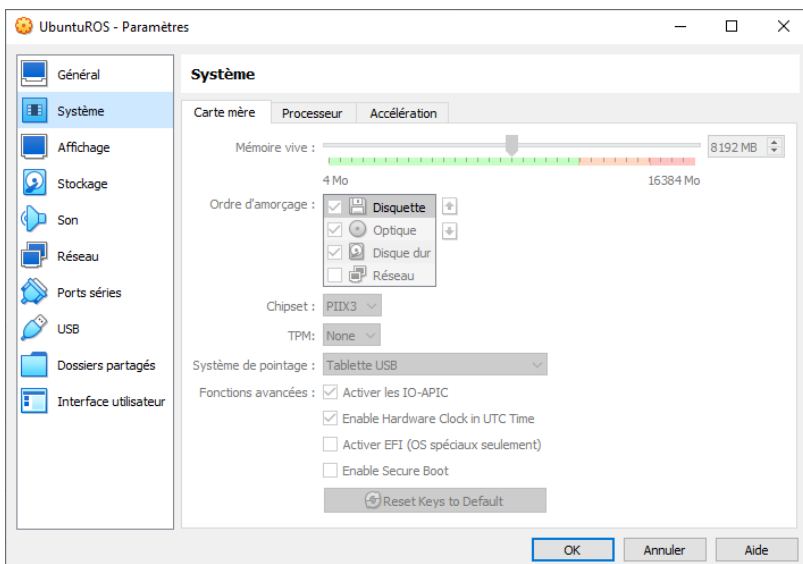
- `wsl --list` (ou `wsl -l -v`) : liste les Machines Virtuelles Linux installées via WSL (et la version WSL utilisée)

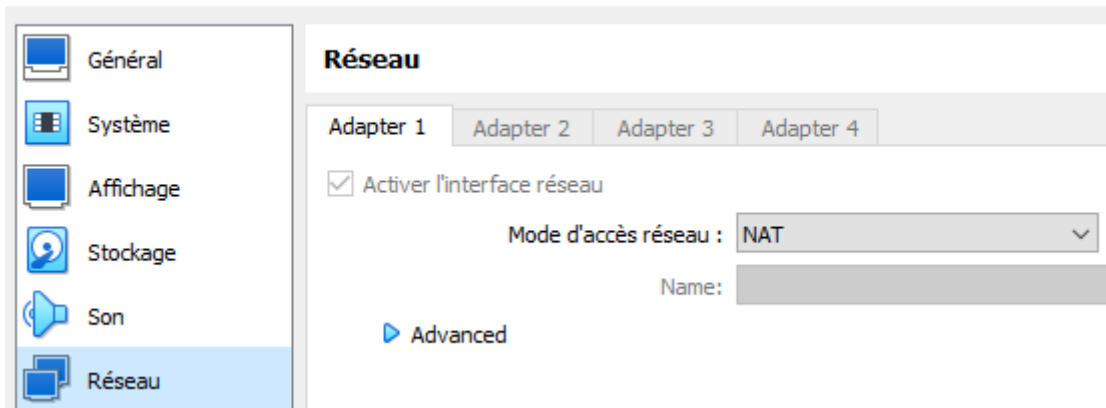
# Ubuntu via VirtualBox

Télécharger et installer VirtualBox pour Windows :

<https://www.oracle.com/virtualization/technologies/vm/downloads/virtualbox-downloads.html>

- Télécharger la VM depuis seafile (\Seafile\IHA-IDF\Smart\_Prod\Formation\_ROS2\UbuntuROS.ova)
  - [Lien public de téléchargement](#)
- Lancer VirtualBox
- Importer la VM : Outils -> Importer -> Rechercher le fichier UbuntuROS.ova
- Vérifier et adapter la configuration de la VM en ressources RAM, CPU, GPU et Réseau selon la configuration de votre PC





- Démarrer la VM
- Ignorer l'erreur sur le dossier partagé Linux-Windows

## Windows 10/11

Une installation native sous Windows 10 avec Visual Studio 2019 (Version Community gratuite) est possible :

- [ROS 1](#)
- [ROS 2](#)

## Installation de ROS2 Humble

Les distributions stables publiées (pré-compilées) de ROS2 sont nommées par ordre alphabétique.

Début 2023, on va **installer ROS 2 Humble** :

```
sudo apt update && sudo apt install locales
sudo locale-gen en_US en_US.UTF-8
sudo update-locale LC_ALL=en_US.UTF-8 LANG=en_US.UTF-8
export LANG=en_US.UTF-8
sudo apt install software-properties-common
sudo add-apt-repository universe
sudo apt update && sudo apt install curl
sudo curl -sSL https://raw.githubusercontent.com/ros/rosdistro/master/ros.key -o
/usr/share/keyrings/ros-archive-keyring.gpg
echo "deb [arch=$(dpkg --print-architecture) signed-by=/usr/share/keyrings/ros-archive-
keyring.gpg] http://packages.ros.org/ros2/ubuntu $(. /etc/os-release && echo $UBUNTU_CODENAME)
main" | sudo tee /etc/apt/sources.list.d/ros2.list > /dev/null
```

```
sudo apt update && sudo apt upgrade
sudo apt install ros-humble-desktop-full
source /opt/ros/humble/setup.bash
echo 'source /opt/ros/humble/setup.bash' >> ~/.bashrc
```

## Tester l'installation

<https://docs.ros.org/en/humble/Installation/Ubuntu-Install-Debians.html#try-some-examples>

- Ouvrir un premier Terminal : `ros2 run demo_nodes_cpp talker`
- Ouvrir un second Terminal : `ros2 run demo_nodes_cpp listener`

## Installation d'autres versions de ROS2

Pour avoir accès à toutes les dernières fonctionnalités en cours de développement (partiellement publiées), il faut **installer ROS2 Rolling**, qui est une distribution en développement continu "**rolling release**". Par exemple en Avril 2023, l'**API Python de MoveIt2 et son tutoriel** ne sont disponibles que sous rolling.

On peut installer plusieurs versions de ros en parallèle. Chaque version sera installée dans `/opt/ros/version`. Pour faire cohabiter les deux versions, il faut "sourcer" le bon répertoire avant de lancer un programme `ros2 launch ...` ou de compiler un workspace `colcon build ...`. Deux options s'offrent à nous :

- Si on bascule souvent de version : commenter les lignes `source /opt/ros/humble/setup.bash` en bas du fichier `~/.bashrc`
  - Il faudra alors lancer la commande `source /opt/ros/humble/setup.bash` **à chaque nouvelle ouverture de Terminal Bash.**
- Si on travaille principalement avec une version : commenter la ligne correspondant à la version principale `source /opt/ros/humble/setup.bash` en bas du fichier `~/.bashrc` lorsqu'on veut utiliser la version secondaire.

## Outils utiles

### Terminal multi-fenêtres Terminator

- Installer Terminator : c'est un logiciel de Ligne de commande pratique pour programmer avec ROS
  - Depuis Windows Store : Rechercher et installer `Terminator (Ubuntu)`

- Depuis la ligne de commande Linux : `sudo apt install terminator`
- Depuis le menu démarrer Windows, Lancer `Terminator (Ubuntu)`

# Visual Studio Codium

Pour éviter d'alourdir la VM avec de la télémétrie Microsoft, on installe la version sans tracker de Visual Studio Code depuis [un dépôt debian](#) :

- Lancer la VM VirtualBox ou WSL (`Terminator (Ubuntu)`)
- Dans Terminator, lancer les commandes suivantes :

```
wget https://gitlab.com/paulcarroty/vscodium-deb-rpm-repo/raw/master/pub.gpg
sudo mv pub.gpg /usr/share/keyrings/vscodium-archive-keyring.asc
echo 'deb [ signed-by=/usr/share/keyrings/vscodium-archive-keyring.asc ]
https://paulcarroty.gitlab.io/vscodium-deb-rpm-repo/debs vscodium main' \
| sudo tee /etc/apt/sources.list.d/vscodium.list
sudo apt update
sudo apt install codium
```

- Lancer VSCodium dans la VM VirtualBox ou directement depuis Windows, lancer `VSCodium (Ubuntu)`
- Ouvrir le **dossier contenant le code source** `/src` du projet dont vous voulez étudier/modifier le code : `File --> Open Folder --> ~/ws_moveit/src`

# Installer Firefox dans WSL

<https://askubuntu.com/questions/1444962/how-do-i-install-firefox-in-wsl-when-it-requires-snap-but-snap-doesnt-work>

```
sudo snap remove firefox
sudo apt remove firefox
sudo add-apt-repository ppa:mozillateam/ppa

# Create a new file, it should be empty as it opens:
sudo gedit /etc/apt/preferences.d/mozillateamppa

# Insert these lines, then save and exit
Package: firefox*
Pin: release o=LP-PPA-mozillateam
Pin-Priority: 501
```

```
# after saving, do  
sudo apt update  
sudo apt install firefox-esr
```

# Sources

- [Installation de Movelt2 Humble sur Ubuntu 22.04](#)
- [Tutoriels débutant](#)

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Auteur: [Gauthier Hentz](#), sur le [wiki de l'innovation de l'IUT de Haguenau](#)

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# Tutoriels de base

Pour comprendre les concepts de ROS2 par la pratique, il existe des tutoriels pour débutant. Ils reposent sur la simulation d'un robot mobile à deux roues principales développé par les développeurs de ROS en 2010 : [Turtlebot](#). Le [TurtleBot 3 est vendue par Robotis](#) et peut être couplé à un bras manipulateur 5 axes [OpenMANIPULATOR-X](#). Il est possible de [simuler des applications de manipulation mobile avec Gazebo](#).

Pour réaliser les tutoriels de base, il nous faut un environnement de développement, deux options :

- Une machine virtuelle (VM) [VirtualBox](#), ou disponible au téléchargement ici
  - Le plus simple et rapide pour démarrer
  - Si on n'a pas de Hardware ou qu'on ne souhaite travailler qu'en simulation
- Une installation simple ou dual-boot sur un PC
  - Il faut alors installer de zéro
  - Indispensable si on veut travailler avec du Hardware

Supposons que vous avez [installé et testé votre environnement comme celui de la VM](#).

Connexion à la VM

- nom : ubuntu22ros2
- utilisateur :
- mdp : département de l'IUT

Nous pouvons directement passer aux tutoriels sur les outils ROS 2 en ligne de commande :

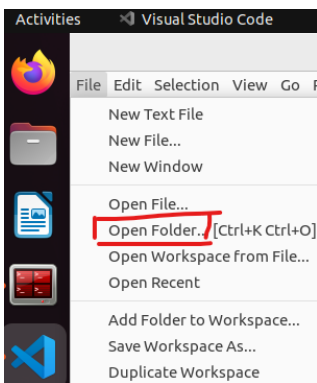
- [Configuring environment](#)
- [Using  , and](#)
- [Understanding nodes](#)
- [Understanding topics](#)
- [Understanding services](#)
- [Understanding parameters](#)

Ces premiers tutoriels ne nécessitent qu'une installation basique de ROS 2, on n'y regarde pas le code source.

Ensuite on passe aux tutoriels sur les bibliothèques clientes de ROS 2 en C++ et Python :

- Using `colcon` to build packages
- Creating a workspace
- Creating a package
- Writing a simple publisher and subscriber (C++) --> Correction
- Writing a simple publisher and subscriber (Python)
- Writing a simple service and client (C++)
- Writing a simple service and client (Python)
- Creating custom msg and srv files

Ces tutoriels vous engagent à copier et analyser du code source en C++ et Python. Les fichiers créés sont placés dans le dossier de travail (workspace) `/home/etudiant/ros2_ws/src`, à ouvrir avec Visual Studio Code :



Vous trouverez des fichiers de correction commentés dans `ros2_ws/src/cpp_pubsub/src/`, en particulier :

- `publisher_member_function.cpp`
- `subscriber_member_function.cpp`

Pour les tester il faut lancer :

```
cd ~/ros2_ws
colcon build --packages-select cpp_pubsub
source install/setup.bash
ros2 run cpp_pubsub talker
```

Le noeud se met à publier/parler :

```
[INFO] [minimal_publisher]: Publishing: "Hello World: 0"
[INFO] [minimal_publisher]: Publishing: "Hello World: 1"
[INFO] [minimal_publisher]: Publishing: "Hello World: 2"
[INFO] [minimal_publisher]: Publishing: "Hello World: 3"
[INFO] [minimal_publisher]: Publishing: "Hello World: 4"
```

Puis dans un second Terminal :

```
ros2 run cpp_pubsub listener
```

Le noeud se met à écouter :

```
[INFO] [minimal_subscriber]: I heard: "Hello World: 10"  
[INFO] [minimal_subscriber]: I heard: "Hello World: 11"  
[INFO] [minimal_subscriber]: I heard: "Hello World: 12"  
[INFO] [minimal_subscriber]: I heard: "Hello World: 13"  
[INFO] [minimal_subscriber]: I heard: "Hello World: 14"
```

Tapez `Ctrl+C` dans chaque Terminal pour arrêter les noeuds ("stop spinning").

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# Découverte d'Ubuntu Linux et son Terminal Bash

## Navigating the Ubuntu GUI

In this exercise, we will familiarize ourselves with the graphical user interface (GUI) of the Ubuntu operating system.

### Task 1: Familiarize Yourself with the Ubuntu Desktop

At the log-in screen, click in the password input box, enter `rosindustrial` for the password, and hit enter. The screen should look like the image below when you log in:

images/ubuntu\_desktop.png

There are several things you will notice on the desktop:

images/ubuntu\_desktop\_details.png

1. The gear icon on the top right of the screen brings up a menu which allows the user to log out, shut down the computer, access system settings, etc...
2. The bar on the left side shows running and “favorite” applications, connected thumb drives, etc.
3. The top icon is used to access all applications and files. We will look at this in more detail later.
4. The next icons are either applications which are currently running or have been “pinned” (again, more on pinning later)
5. Any removable drives, like thumb drives, are found after the application icons.
6. If the launcher bar gets “too full”, clicking and dragging up/down allows you to see the applications that are hidden.

7. To reorganize the icons on the launcher, click and hold the icon until it “pops out”, then move it to the desired location.

## Task 2: Open and Inspect an Application

Click on the filing-cabinet icon in the launcher. A window should show up, and your desktop should look like something below:

images/ubuntu\_folder\_browser.png

Things to notice:

1. The close, minimize, and maximize buttons typically found on the right-hand side of the window title bar are found on the left-hand side.
2. The menu for windows are found on the menu bar at the top of the screen, much in the same way Macs do. The menus, however, only show up when you hover the mouse over the menu bar.
3. Notice that there are menu highlights of the folder icon. The dots on the left show how many windows of this application are open. Clicking on these icons when the applications are open does one of two things:
  - If there is only one window open, this window gets focus.
  - If more than one are open, clicking a second time causes all of the windows to show up in the foreground, so that you can choose which window to go to (see below):

images/ubuntu\_inspect.png

## Task 3: Start an Application & Pin it to the Launcher Bar

Click on the launcher button (top left) and type gedit in the search box. The “Text Editor” application (this is actually gedit) should show up (see below):

images/ubuntu\_start\_application.png

Click on the application. The text editor window should show up on the screen, and the text editor icon should show up on the launcher bar on the left-hand side (see below):

images/ubuntu\_application\_pin.png

1. Right-click on the text editor launch icon, and select “Lock to Launcher”.
2. Close the gedit window. The launcher icon should remain after the window closes.
3. Click on the gedit launcher icon. You should see a new gedit window appear.

# Le Terminal Linux

In this exercise, we will familiarize ourselves with the Linux terminal.

## Starting the Terminal

1. Pour ouvrir le Terminal, recherchez le programme "terminator" ou cliquez sur l'icône:



2. Create a second terminal window, either by:
  - Right-clicking on the terminal and selecting the “Open Terminal” or
  - Selecting “Open Terminal” from the “File” menu
3. Create a second terminal within the same window by pressing “Ctrl+Shift+T” while the terminal window is selected.
4. Close the 2nd terminal tab, either by:
  - clicking the small ‘x’ in the terminal tab (not the main terminal window)
  - typing `exit` and hitting enter.
5. The window will have a single line, which looks like this:  
`ros-industrial@ros-i-humble-vm: ~$`
6. This is called the prompt, where you enter commands. The prompt, by default, provides three pieces of information:
  1. *ros-industrial* is the login name of the user you are running as.
  2. *ros-i-humble-vm* is the host name of the computer.
  3. `~` is the directory in which the terminal is currently in. (More on this later).
7. Close the terminal window by typing `exit` or clicking on the red ‘x’ in the window’s titlebar.

## Navigating Directories and Listing Files

### Prepare your environment

1. Open your home folder in the file browser.
2. Double-click on the `ex0.3` folder we created in the previous step.
  - *We'll use this to illustrate various file operations in the terminal.*

3. Right click in the main file-browser window and select “Open in Terminal” to create a terminal window at that location.
4. In the terminal window, type the following command to create some sample files that we can study later:
  - `cp -a ~/industrial_training/exercises/0.3/. .`

## ls Command

1. Enter `ls` into the terminal.
  - You should see `test.txt`, and `new` listed. (If you don't see 'new', go back and complete the [previous exercise](#)).
  - Directories, like `new`, are colored in blue.
  - The file `sample_job` is in green; this indicates it has its “execute” bit set, which means it can be executed as a command.
2. Type `ls *.txt`. Only the file `test.txt` will be displayed.
3. Enter `ls -l` into the terminal.
  - Adding the `-l` option shows one entry per line, with additional information about each entry in the directory.
  - The first 10 characters indicate the file type and permissions
  - The first character is `d` if the entry is a directory.
  - The next 9 characters are the permissions bits for the file
  - The third and fourth fields are the owning user and group, respectively.
  - The second-to-last field is the time the file was last modified.
  - If the file is a symbolic link, the link's target file is listed after the link's file name.
4. Enter `ls -a` in the terminal.
  - You will now see one additional file, which is hidden.
5. Enter `ls -a -l` (or `ls -al`) in the command.
  - You'll now see that the file `hidden_link.txt` points to `hidden_text_file.txt`.

## pwd and cd Commands

1. Enter `pwd` into the terminal.
  - This will show you the full path of the directory you are working in.
2. Enter `cd new` into the terminal.
  - The prompt should change to `ros-industrial@ros-i-humble-vm: ~/ex0.3/new$`.
  - Typing `pwd` will show you now in the directory `/home/ros-industrial/ex0.3/new`.
3. Enter `cd ..` into the terminal. \* In the [previous exercise](#), we noted that `..` is the parent folder. \* The prompt should therefore indicate that the current working directory is `/home/ros-industrial/ex0.3`.
4. Enter `cd /bin`, followed by `ls`.
  - This folder contains a list of the most basic Linux commands.  
*Note that `pwd` and `ls` are both in this folder.*
5. Enter `cd ~/ex0.3` to return to our working directory.
  - Linux uses the `~` character as a shorthand representation for your home directory.

- It's a convenient way to reference files and paths in command-line commands.
- You'll be typing it a lot in this class... remember it!

If you want a full list of options available for any of the commands given in this section, type `man <command>` (where `<command>` is the command you want information on) in the command line. This will provide you with built-in documentation for the command. Use the arrow and page up/down keys to scroll, and `q` to exit.

# Altering Files

## mv Command

1. Type `mv test.txt test2.txt`, followed by `ls`.
  - You will notice that the file has been renamed to `test2.txt`.  
*This step shows how `mv` can rename files.*
2. Type `mv test2.txt new`, then `ls`.
  - The file will no longer be present in the folder.
3. Type `cd new`, then `ls`.
  - You will see `test2.txt` in the folder.  
*These steps show how `mv` can move files.*
4. Type `mv test2.txt ../test.txt`, then `ls`.
  - `test2.txt` will no longer be there.
5. Type `cd ..`, then `ls`.
  - You will notice that `test.txt` is present again.  
*This shows how `mv` can move and rename files in one step.*

## cp Command

1. Type `cp test.txt new/test2.txt`, then `ls new`.
  - You will see `test2.txt` is now in the `new` folder.
2. Type `cp test.txt "test copy.txt"`, then `ls -l`.
  - You will see that `test.txt` has been copied to `test copy.txt`.  
*Note that the quotation marks are necessary when spaces or other special characters are included in the file name.*

## rm Command

1. Type `rm "test copy.txt"`, then `ls -l`.
  - You will notice that `test copy.txt` is no longer there.

## mkdir Command



1. Type `mkdir new2`, then `ls`.
  - You will see there is a new folder `new2`.

## touch Command

1. Type `touch ~/Templates/"Untitled Document"`.
  - This will create a new Document named **"Untitled Document"**

You can use the `-i` flag with `cp`, `mv`, and `rm` commands to prompt you when a file will be overwritten or removed.

## Editing Text (and Other GUI Commands)

1. Type `gedit test.txt`.
  - You will notice that a new text editor window will open, and `test.txt` will be loaded.
  - The terminal will not come back with a prompt until the window is closed.
2. There are two ways around this limitation. Try both...
3. **Starting the program and immediately returning a prompt:**
  1. Type `gedit test.txt &`.
    - The `&` character tells the terminal to run this command in "the background", meaning the prompt will return immediately.
  2. Close the window, then type `ls`.
    - In addition to showing the files, the terminal will notify you that `gedit` has finished.
4. **Moving an already running program into the background:**
  1. Type `gedit test.txt`.
    - The window should open, and the terminal should not have a prompt waiting.
  2. In the terminal window, press `Ctrl+Z`.
    - The terminal will indicate that `gedit` has stopped, and a prompt will appear.
  3. Try to use the `gedit` window.
    - Because it is paused, the window will not run.
  4. Type `bg` in the terminal.
    - The `gedit` window can now run.
  5. Close the `gedit` window, and type `ls` in the terminal window.
    - As before, the terminal window will indicate that `gedit` is finished.

## Running Commands as Root

1. In a terminal, type `ls -a /root`.
  - The terminal will indicate that you cannot read the folder `/root`.
  - Many times you will need to run a command that cannot be done as an ordinary user, and must be done as the "super user"
2. To run the previous command as root, add `sudo` to the beginning of the command.

- In this instance, type `sudo ls -a /root` instead.
- The terminal will request your password (in this case, `rosindustrial`) in order to proceed.
- Once you enter the password, you should see the contents of the `/root` directory.

**Warning:** `sudo` is a powerful tool which doesn't provide any sanity checks on what you ask it to do, so be **VERY** careful in using it

[https://industrial-training-master.readthedocs.io/en/humble/\\_source/prerequisites/Navigating-the-Ubuntu-GUI.html](https://industrial-training-master.readthedocs.io/en/humble/_source/prerequisites/Navigating-the-Ubuntu-GUI.html)

# Usage avancé du bash Linux

## Job management

### Stopping Jobs

1. Type `./sample_job`.
  - The program will start running.
2. Press Control+C.
  - The program should exit.
3. Type `./sample_job sigterm`.
  - The program will start running.
4. Press Control+C.
  - This time the program will not die.

### Stopping “Out of Control” Jobs

1. Open a new terminal window.
2. Type `ps ax`.
3. Scroll up until you find `python ./sample_job sigterm`.
  - This is the job that is running in the first window.
  - The first field in the table is the ID of the process (use `man ps` to learn more about the other fields).
4. Type `ps ax | grep sample`.
  - You will notice that only a few lines are returned.
  - This is useful if you want to find a particular process
  - *Note: this is an advanced technique called “piping”, where the output of one program is passed into the input of the next. This is beyond the scope of this class, but is useful to learn if you intend to use the terminal extensively.*
5. Type `kill <id>`, where `<id>` is the job number you found with the `ps ax`.
6. In the first window, type `./sample_job sigterm sigkill`.
  - The program will start running.
7. In the second window, type `ps ax | grep sample` to get the id of the process.
8. Type `kill <id>`.
  - This time, the process will not die.
9. Type `kill -SIGKILL <id>`.
  - This time the process will exit.

### Showing Process and Memory usage

1. In a terminal, type `top`.
  - A table will be shown, updated once per second, showing all of the processes on the system, as well as the overall CPU and memory usage.
2. Press the Shift+P key.
  - This will sort processes by CPU utilization.  
*This can be used to determine which processes are using too much CPU time.*
3. Press the Shift+M key.
  - This will sort processes by memory utilization  
*This can be used to determine which processes are using too much memory.*
4. Press q or Ctrl+C to exit the program.