

1 Installing a Virtual Machine

1.1 Downloads

If you have already done this at home then,

- Windows users can download either VMWare Workstation Player or VirtualBox. Links to the current versions are on the MyClasses page for this class.
- Mac users should download VirtualBox. Links to the current versions are on the MyClasses page for this class.
- Download at least the 32 bit version of Linux Mint. You can download both the 32 and 64 bit versions but depending on how some of your computers are configured you may not be able to install the 64 bit version.

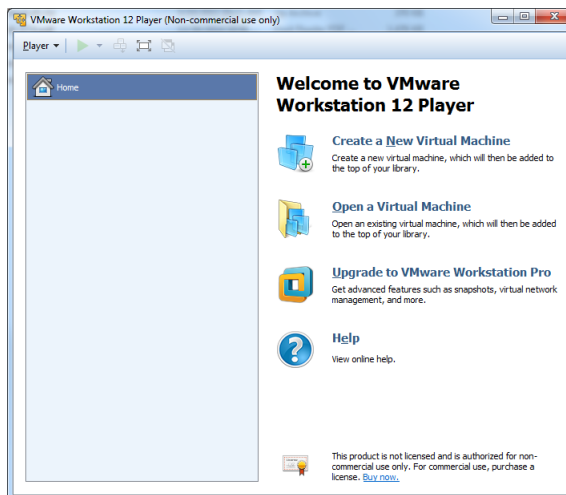
Note that you will need around 15 GB minimum to install Linux Mint as a virtual machine.

1.2 Install the Virtual Machine Software

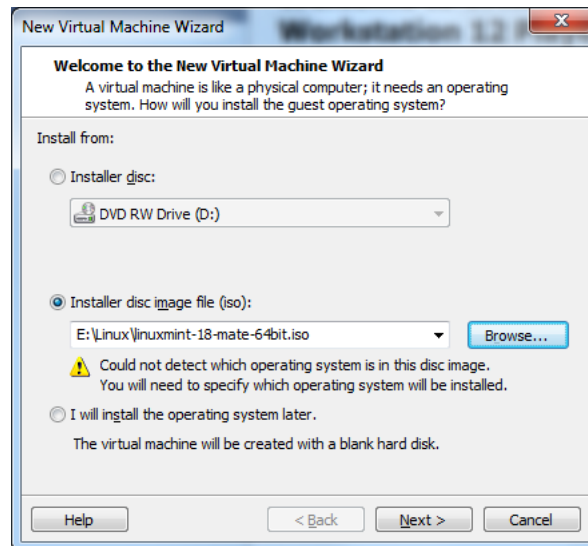
Install either the VMWare Workstation Player or VirtualBox on your computer. These are standard installation packages and should install without difficulties. One note is that VMWare Workstation Player is distributed for both individual use (which is free) and corporate use (which needs a license). So at one point you will be asked to put in a license number, simply leave that blank and proceed with the installation.

1.3 Setting Up VMWare for Linux Mint

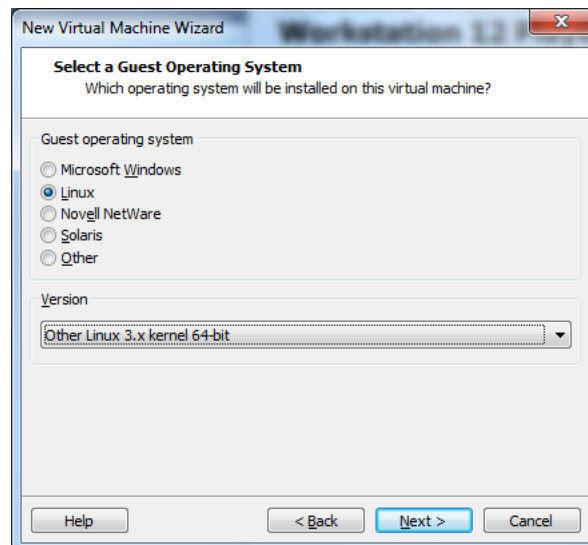
1. Start VMWare Workstation Player you will see the home screen, below.



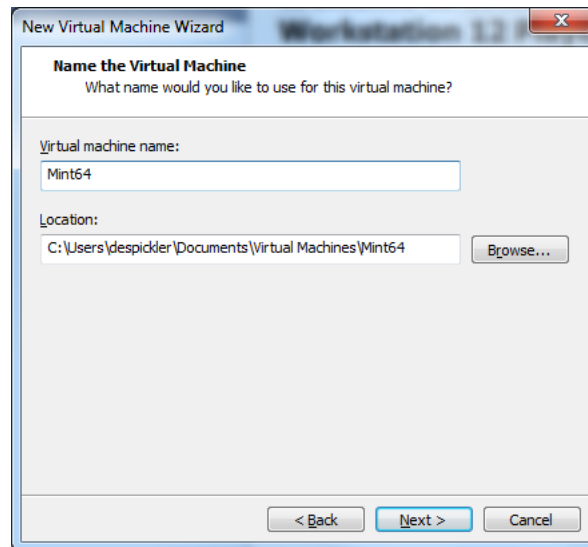
2. Click on the *Create a New Virtual Machine* link. The following dialog will appear. Select the *Installer disc image file (iso)* radio button. Click the Browse button and select the Mint iso file you downloaded. then click Next.



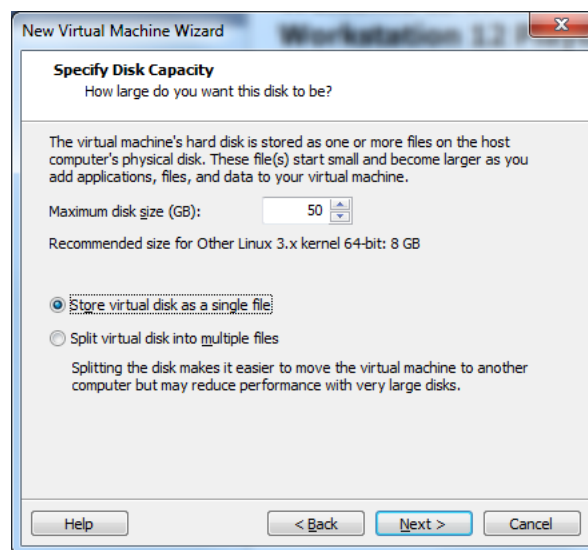
3. Select Linux and since Mint is not listed in the version drop-down box, select *Other Linux 3.x kernel 64-bit* if you are installing the 64 bit image and select the *Other Linux 3.x kernel* option if you are installing the 32 bit version. Click Next.



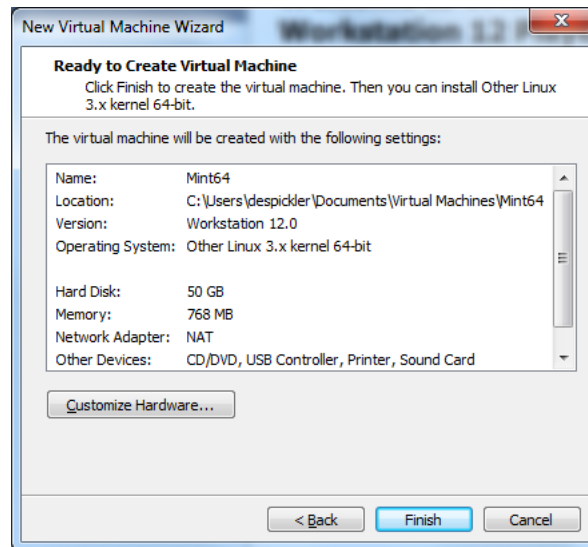
4. Give a name to the virtual machine, this name will appear in the virtual machine listing on the program's home screen. VMWare will select an automatic location for the virtual machine, you may change this if you would like. Click Next.



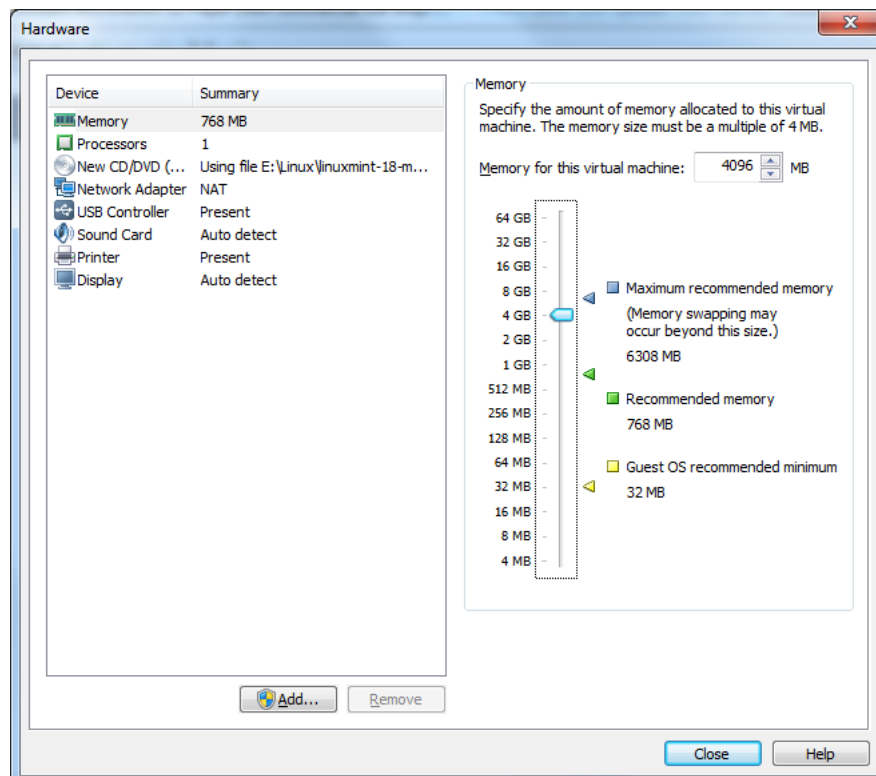
5. Set the size of the virtual hard drive for the machine. The default will be too small. VMWare will allow the virtual machine to use up to this amount of hard drive space, but no more. Also, the machine will not use all this space, it will only use what is needed. For Mint, 15 GB should be sufficient but I usually make this 50–100 GB. Remember that it will only use what it needs. I also select to store the virtual disk as a single file, this should not matter either way. Click Next.



6. Now you will see a list of options that have been selected for the virtual machine creation. We will make one change to this. The default amount of memory that VMWare chooses is a little small for my taste. Click on *Customize Hardware...*, you will see the dialog below.

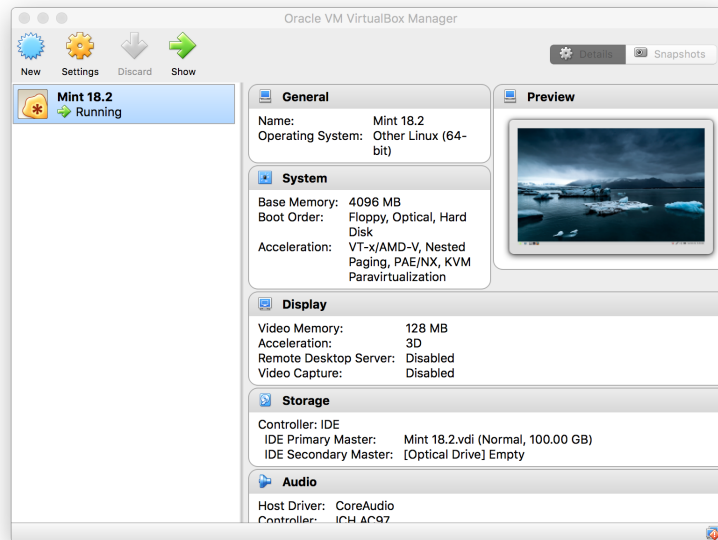


7. Select Memory from the Device list and increase the allocation to something between 2 and 4 GB, but do not go over the Maximum recommended memory. A virtual machine is a virtualization of the computer hardware. So it is software that simulated hardware, hence it will be slower than running Linux directly on the computer hardware. So giving it more memory to work with is a good way to speed it up. As a rule of thumb, I do not give the virtual machine more than half my computer's memory. When you are done, click Close then click Finish from the other dialog box.



1.4 Setting Up VirtualBox for Linux Mint

1. Start VirtualBox, you will see the home screen that looks something like the image below. Note that the left panel will be blank for you since in the image below I already have a Mint virtual machine installed.



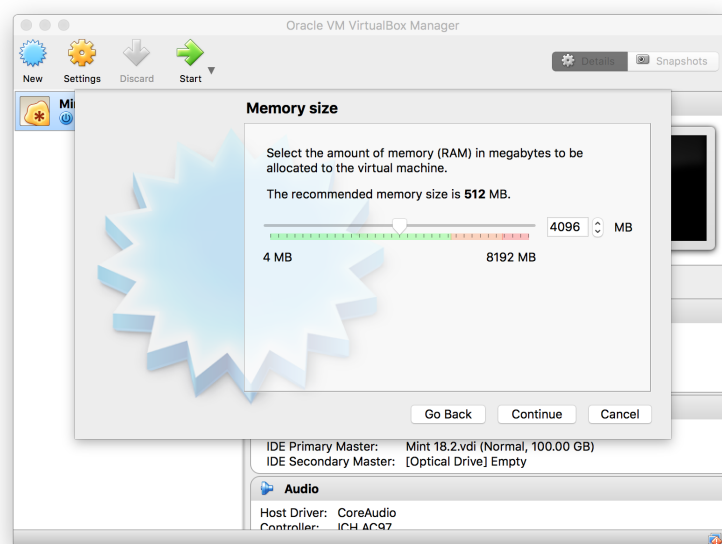
2. Click on the *New* toolbar button. The following dialog will appear. Give the virtual machine a name (such as Linux Mint 18.2), make sure that the type is set to Linux, and the version is set to Other Linux (32-bit) or Other Linux (64-bit), depending on what you will be installing.



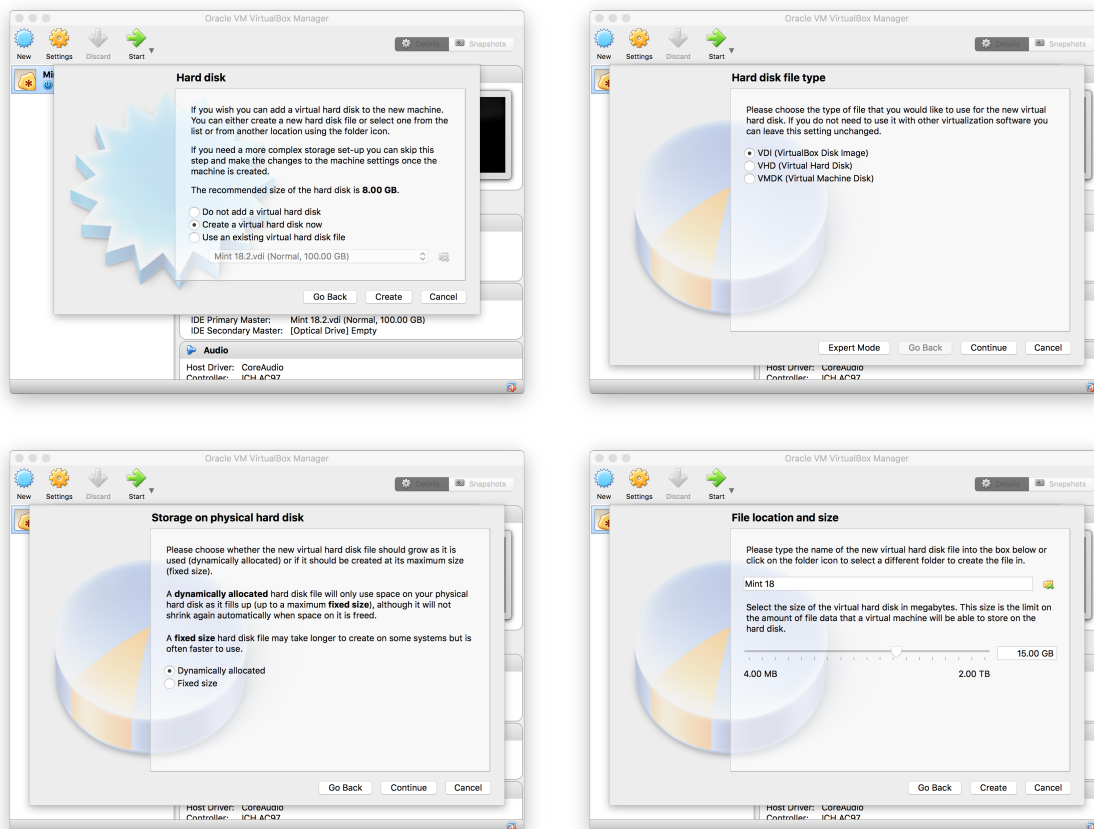
Once that is done click on the Continue button.



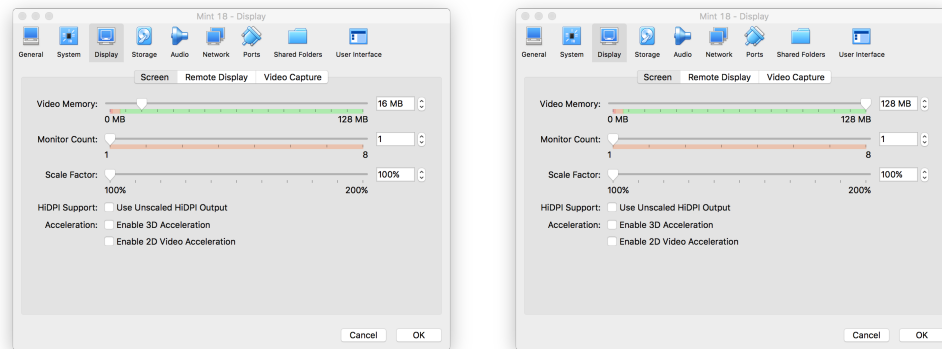
3. The next dialog will ask you for the amount of memory to dedicate to the virtual machine. Select something between 2 and 4 GB, but do not go over the Maximum recommended memory. A virtual machine is a virtualization of the computer hardware. So it is software that simulated hardware, hence it will be slower than running Linux directly on the computer hardware. Giving it more memory to work with is a good way to speed it up. As a rule of thumb, I do not give the virtual machine more than half my computer's memory. When you are done, click Continue.



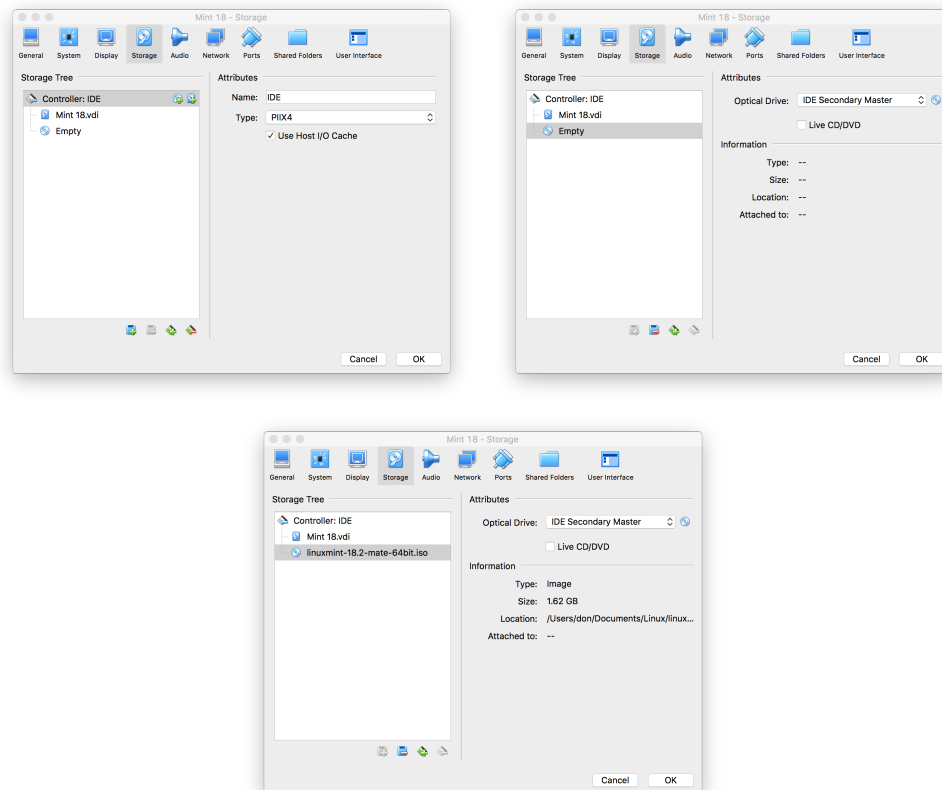
4. The next series of dialog boxes are options on the virtual hard drive, this is really just a file on your computer's hard drive, like a Word document, just much larger.
- (a) The first dialog will ask if you want to create the disk now, select Create a virtual hard disk now, and click Continue.
 - (b) The second is on what type of image you want, leave it as VDI and click Continue.
 - (c) The third will ask if you want it to be a fixed size or dynamically allocated, select Dynamically allocated and click Continue.
 - (d) The fourth will ask you the size of the disk, which is the maximum size the virtual machine will allow. The default of 8 GB is a bit too small, change this to at least 15 GB. If you are interested in testing out Linux beyond what we do in this class then you might want to make this larger, say 50–100 GB.



5. At this point you should be taken back to the home screen and your new virtual machine should show up in the list in the left panel. This does not mean that Linux is ready to go, this just means that we are ready to install the operating system. Before we install the operating system we will make one more change that will help increase the speed of the virtual machine. On the right, click on Display. The following dialog will open, slide the Video Memory slider to 128 MB and click OK.



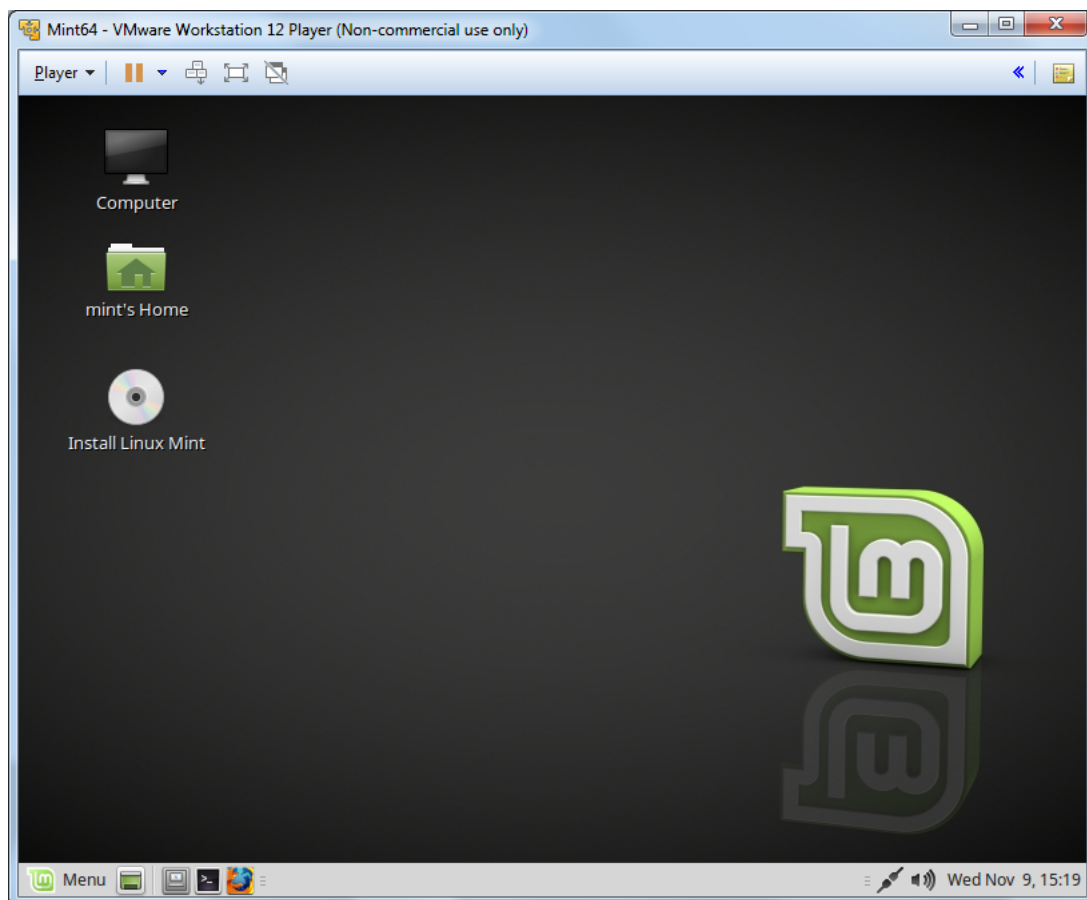
6. Before we install Mint we need to insert the virtual CD into the virtual CD player, sounds silly but that's what we are doing. Click on Storage and the following dialog will appear. Select the CD drive on the left, under Attributes, click on the CD icon on the far right, then Choose Virtual Optical Disk File... Navigate to the iso image of Linux Mint you downloaded and select it. The "disk" information should now appear in the area below. Click OK.



2 Installing Mint

Now that we have our virtual computer created we are ready to install the virtual operating system. In general I prefer to dedicate a machine to a single operating system, or do some type of multiple boot. The upside is that the operating system is running directly on the hardware. The downside is that if you want to revert the system back to its original state or if you irrevocably mess something up, it is much harder to fix. With a virtual machine all you need to do is delete the machine and start over. It is also a nice way to test out different operating systems before committing to switching over or to dual boot what you have. I tried out several different Linux distributions before settling on Mint. Mint is not perfect but it is easy to use, gives you the control you expect from Linux and, I personally, can be productive with this operating system.

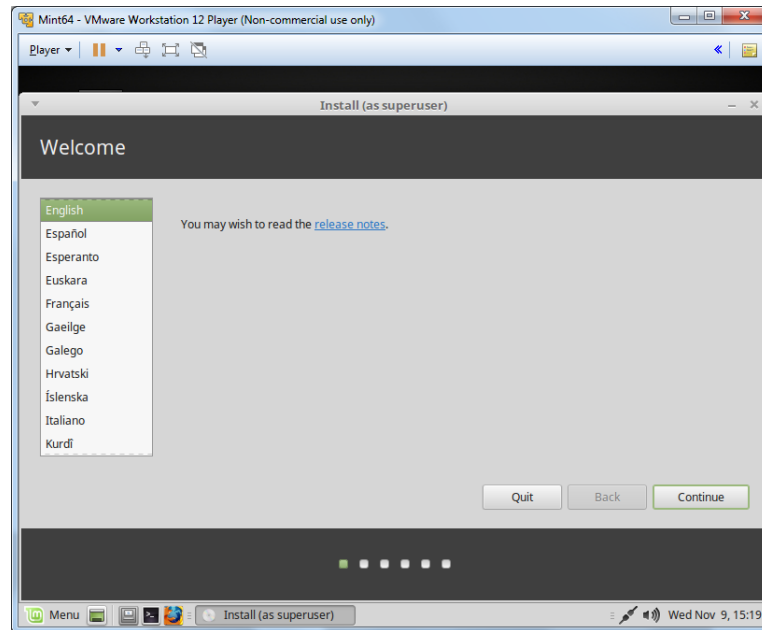
1. Go to the home screen of VMWare or VirtualBox, select the machine and power it on. At this point the virtual machine will start, and it will run the iso image, i.e. start up the process of installing Linux Mint on the virtual machine. Keep in mind that if you mess up somewhere here it is no big deal, you are altering the operating system of the virtual machine, not the host computer.



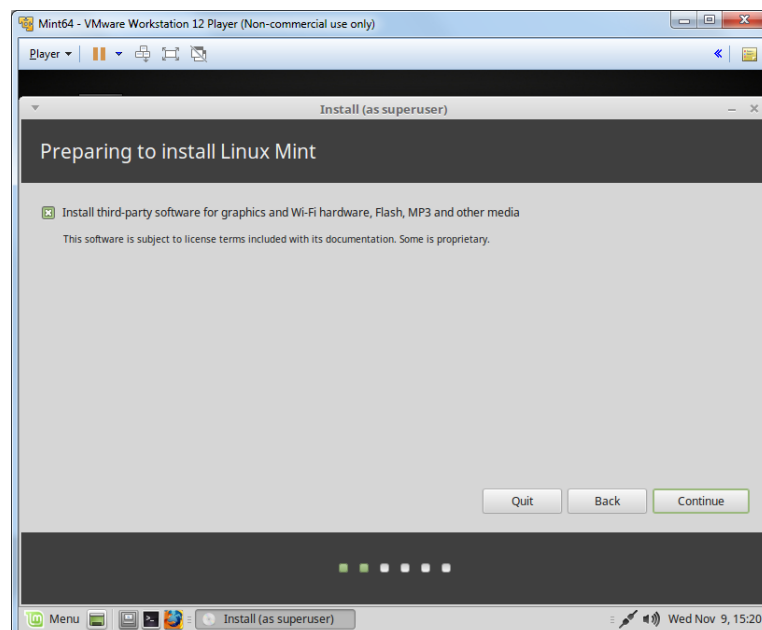
As this is starting up you will be able to click on the virtual machine window to enter that computer. This will lock the mouse and keyboard to the virtual machine. To

escape from the virtual machine to the host press both the Ctrl and Alt keys. When we are finished, we will have installed software that will seamlessly go from one machine to the other, as if this was just another application. Once you see the above screen you are running Linux from the iso image (as if it were running from a CD or DVD). We need to install the system on the virtual machine. Double-click the Install Linux Mint icon.

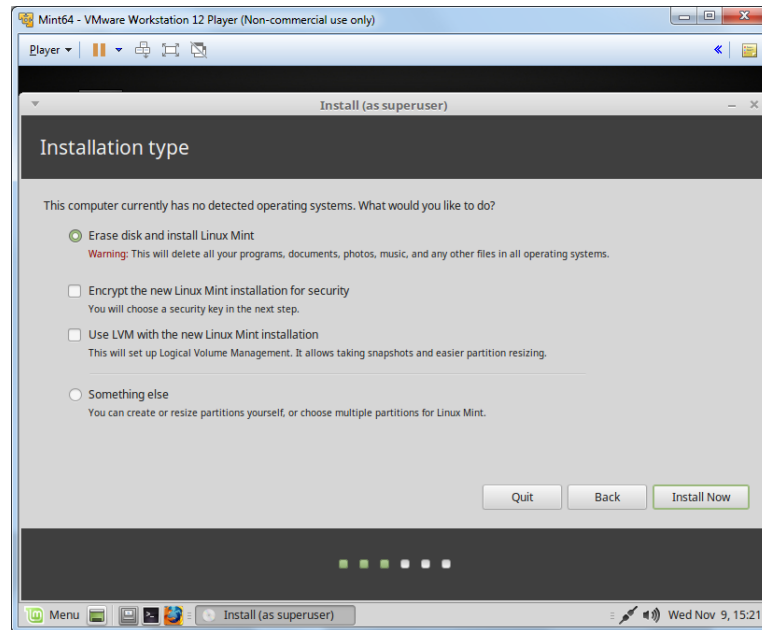
2. Select the language you want to use and click Continue.



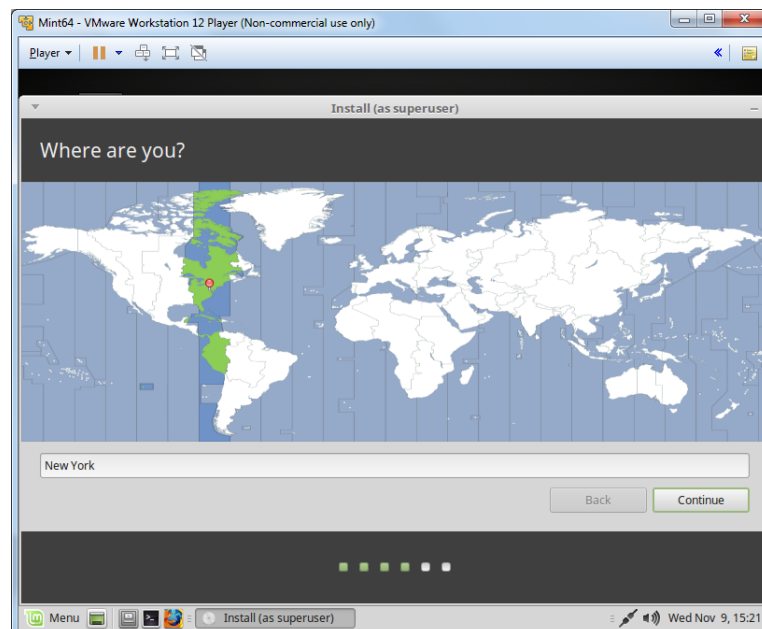
3. Select to install third-party software and click Continue. It probably not matter for our purposes if you do not select this.



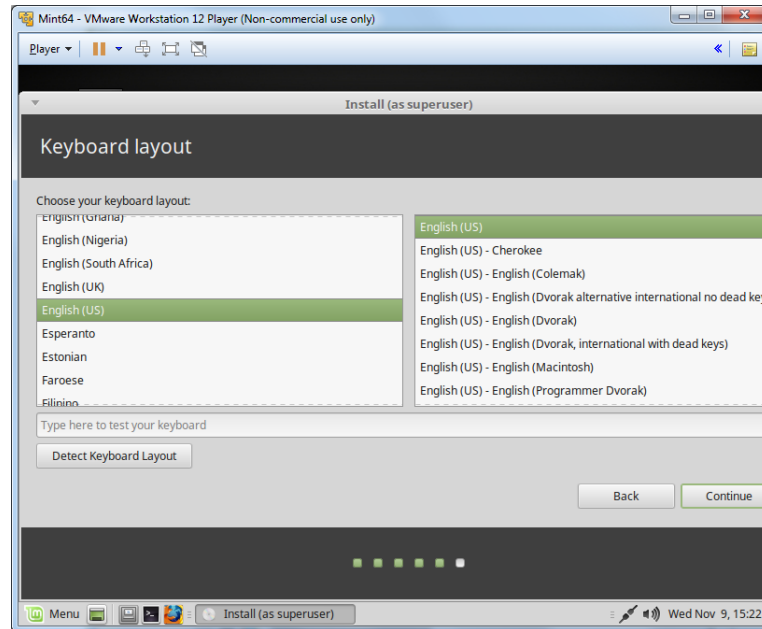
4. Select the installation type, use Erase disk and install Linux Mint. Remember this is the disk of the virtual machine, not your host machine.



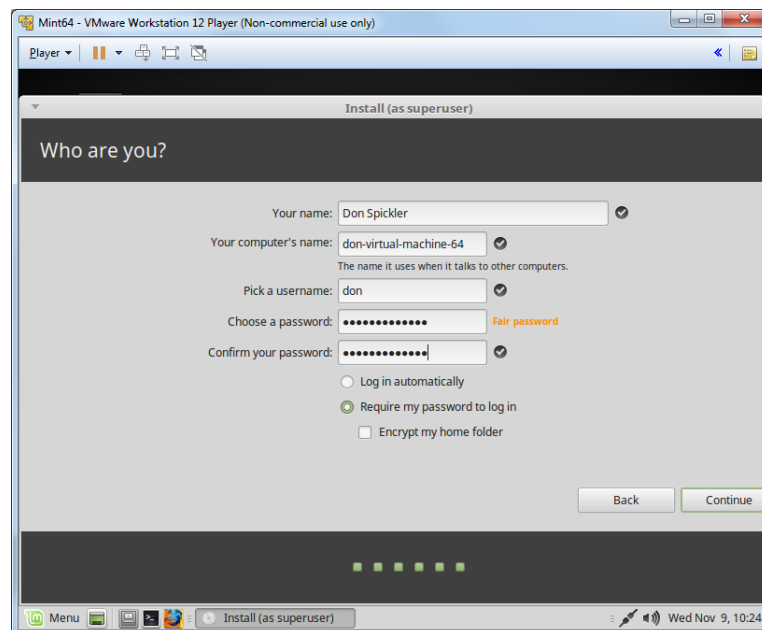
5. Select the location and click Continue.



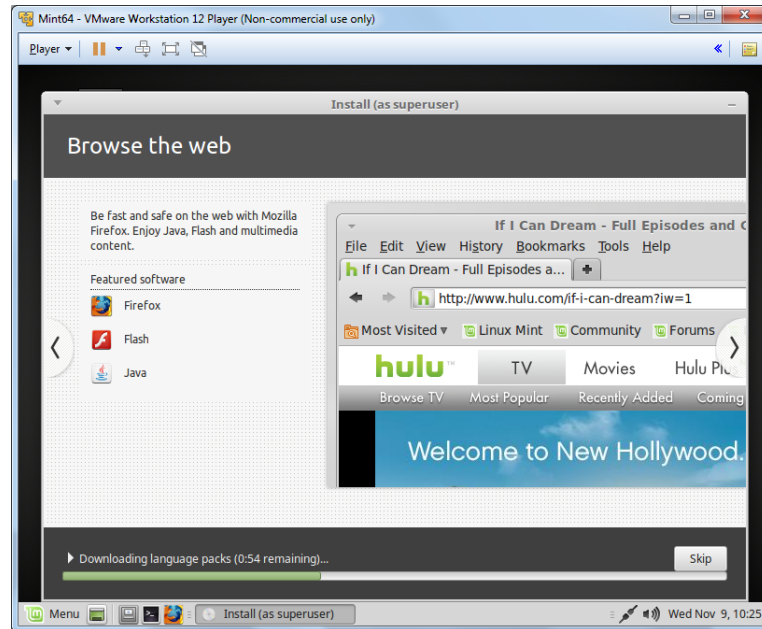
6. Select the keyboard layout and click Continue.



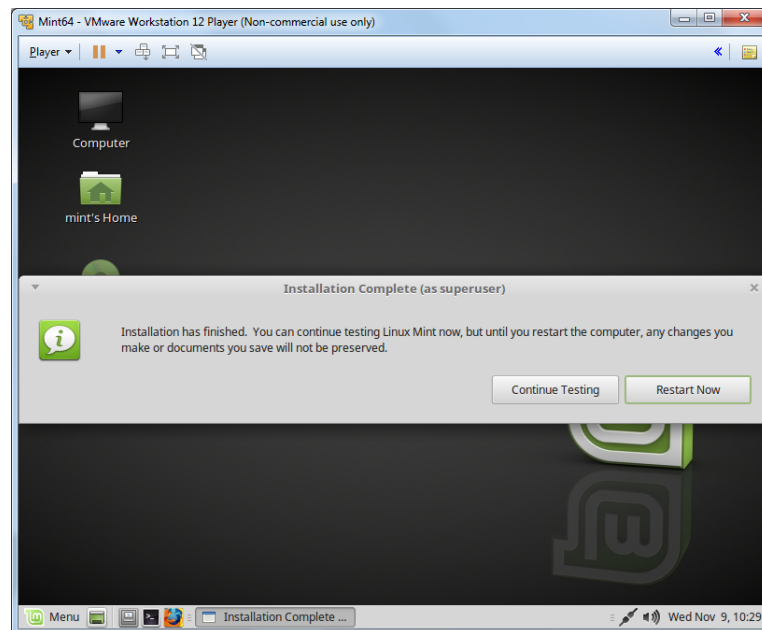
7. Type in your name, give the computer a name, pick a username and password. Do not forget this password, when you install anything on Linux that requires administrative rights you will need to use your password. You can choose to have the system log you in automatically, I personally do not do that. Click Continue.



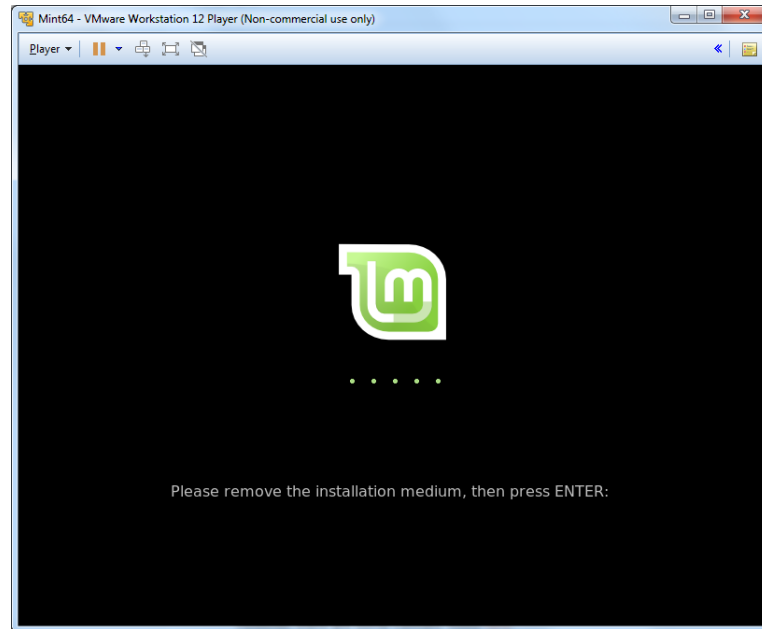
8. At this point the installation process will begin. It does take a while to install the system but it is much quicker than other distributions and far faster than installing Windows.



9. When the installation is finished you will get a prompt to restart the virtual machine, click the Restart Now button.

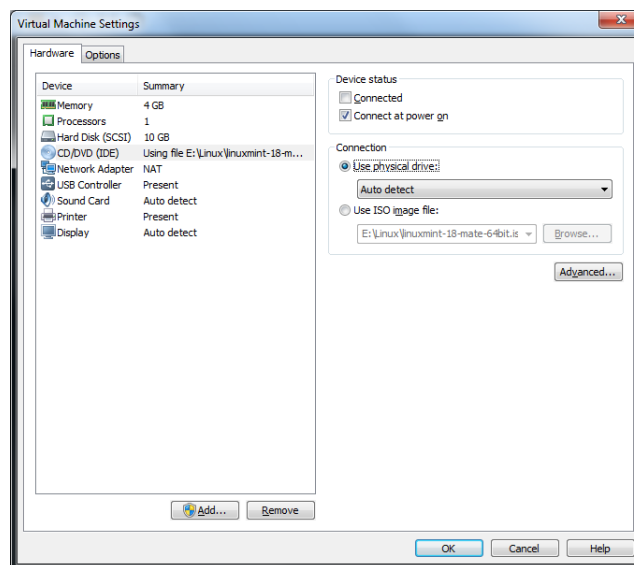


10. The machine will shut down and give you a message to remove the install media.

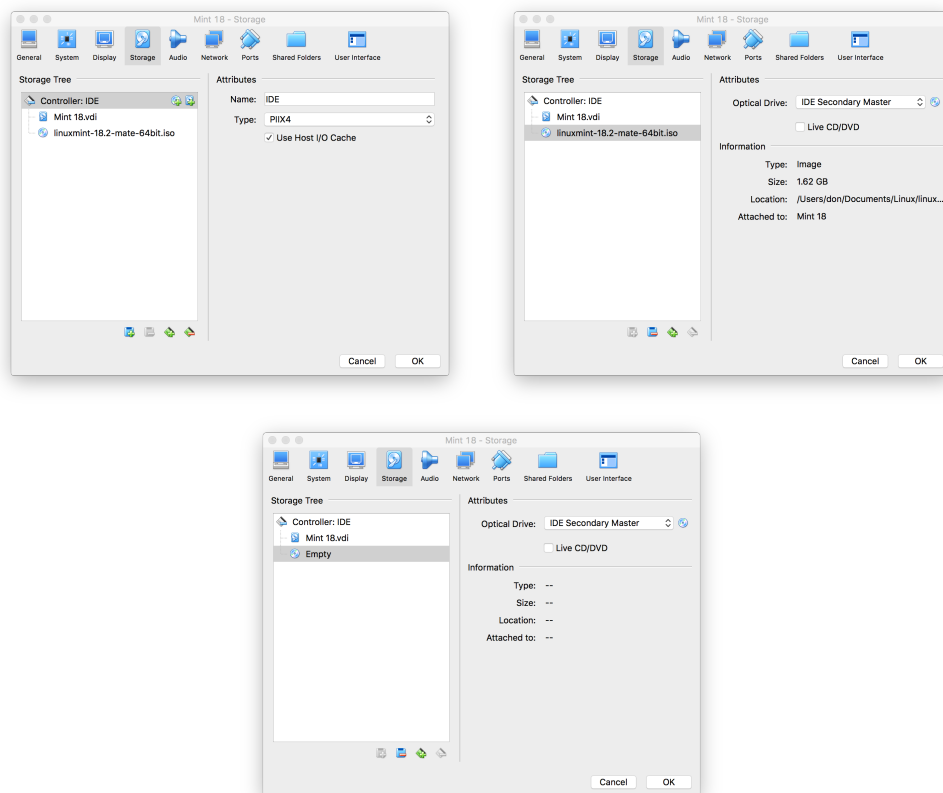


11. Remove the virtual CD as follows.

VMWare: Click Player > Removable Devices > CD/DVD (IDE) > Settings. At this point the settings dialog will appear, select Use physical drive and click OK. Then back in the previous window press Enter.



VirtualBox: Click Storage, select the CD drive on the left, click the CD icon on the far right, select Remove Disk from Virtual Drive. The information should clear out and then click OK.



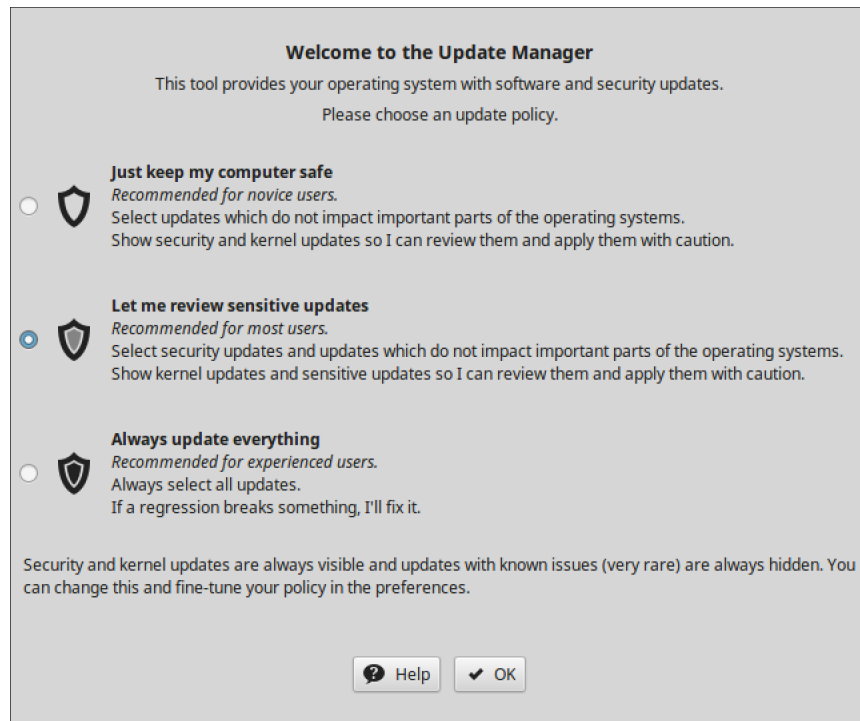
The virtual machine will now restart. Enter your username and password to log in.

3 A Few Notes

1. For Mac users, the keyboard shortcuts for Linux are like Windows in that they use the Control key and not the Command key. So to copy it is Control+C instead of Command+C. So if you are on the Mac side then use Command and when you switch to the Linux VM use Control.
2. The virtual machine will connect to the internet if your computer's host operating system is connected. The virtual machine uses an internal network local to your computer to connect. So if the VM is not connected to the internet, check your computer's connection.
3. A virtual machine is like a real computer and should be shut down in the same manner. So to shut down Linux Mint go to the menu button in the taskbar and select Quit. A small dialog will open asking if you want to shut down, restart, etc. click the shut down button. Clicking the close (x) titlebar icon is like unplugging the machine, not always the best thing to do.

4 Installing Updates

You should install updates before we start downloading and installing more software. This is a little different in Linux than it is in Windows, but it is easy to do. In the task bar on the right you will see a small shield probably with a blue information icon inside it. Click it. The Update Manager will open and ask you for the level of update notifications you wish, you will see a dialog like the one below.



I would recommend using the default setting and clicking OK. You will only need to make this selection one time. Once this is selected, the Update Manager will display a list of updates, the first one is usually an update to the operating system, click Install Updates. You will be prompted for your password again. When the install is finished you may see other updates that need to be installed, install those as well.

Unlike Windows, updates are not installed automatically nor are you forced to update packages you do not wish to update. In Linux you are free to select the updates you want and deselect those you do not. Furthermore, you are notified about updates, the shield will have a blue information icon in it, but you are the one who initiates the update. In addition, you need to type in your password for any updates to be installed, this adds a level of security to your system.

5 Installing Needed Applications on Linux Mint

At this point we have the basic virtual machine installed. Now we will do a couple steps to make it easier to use and install the assembler. There are a lot of different ways to install programs in Linux but the main two are through the terminal window and through the Software Manager. Note that different flavors of Linux have different types of software managers but all incorporate the terminal in one way or another.

1. Open up the terminal, this is like the command prompt in Windows. Unlike Windows the terminal in Linux is actually useful. It is in the application bar at the bottom, it is the black icon beside the firefox icon. When it opens up type in the following command,

```
sudo apt-get update
```

The sudo gives the command administrative rights and hence requires a your password. **Note that when you type in your password, nothing will be shown on the terminal screen, no password or even stars.**

- If you are using VMWare, type in the command,

```
sudo apt-get install open-vm-tools open-vm-tools-desktop
```

If prompted for a yes or no question just say yes. When these are both finished, restart the virtual machine using by selecting the Menu option in the lower left, then Quit. A dialog box will appear, click the Restart button.

Once you log back into the virtual machine you should have more mouse and display functionality. You should be able to resize the window and the virtual machine will automatically resize. There is also a full screen option that removes the menu bar and boarder of the VMWare window so it displays as if Mint were running locally. Also, you will be able to click and drag from Windows Explorer to Caja (the Mint version of Windows Explorer) and vice-versa. So file transfer between the virtual machine and the host machine is easy.

- If you are using VirtualBox, go to the menu and make sure that under View the Auto-Resize Guest Display option is checked and that under Devices the Shared Clipboard and Drag and Drop are both set to Bidirectional. If these are not in the menu or do not seem to work you may need to install Guest Additions or set up a Shared Folder.

2. Now we need to install the assembler. From the terminal type in,

```
sudo apt install nasm
```

Again, you will be asked for your password. When this finishes you will have the netwide assembler installed.

3. Most Linux distributions will automatically install gcc (which is a C compiler), we would also like to use C++ in the class so we need to install g++,
 - (a) Select Menu > Software Manager. You will be asked for your password.
 - (b) In the search bar, search for g++. It will come up as the first hit.
 - (c) Double-click g++ and the information window will appear, click the Install button.
4. At this point you are good to go. There is a simple text editor called xed that you can use to type in your assembly programs and you can use the terminal to assemble and run your programs. One editor I personally like is Kate, it has syntax highlighting and you can link in a terminal window into the editor. This is optional but if you want to set this up here is what you do.
 - (a) In the Software Manager search bar, search for Kate. It will come up as the first hit.
 - (b) Double-click Kate and the information window will appear, click the Install button.
 - (c) In the search bar, search for Konsole. It will come up close to the top.
 - (d) Double-click Konsole and the information window will appear, click the Install button.
 - (e) When these are finished, select Menu > All Applications > Kate. Note that if you right-click on Kate you will get an option to show it in your favorites window, directly from the Menu.
 - (f) Go to Settings > Configure Kate.
 - (g) Select Plugins.
 - (h) Check the Terminal tool view and then Apply.
 - (i) Now click on the Terminal in the application list, and check Automatically synchronize ... option and click OK.
 - (j) At this point, there will be a terminal option at the bottom. If selected, a terminal window will appear inside the editor.
 - (k) One strange thing is that the toolbar icons are not loaded automatically, there is a reason for this, but if you like to have icons here is what you do,
 - i. Close Kate.
 - ii. Go back to the Software Manager.
 - iii. In the search bar, search for libqt5libqgtk2. It should have only one hit.
 - iv. Install it.
 - v. When that is finished. Go back to the terminal and type in,

```
sudo apt-get install oxygen-icon-theme*
```

and then

```
sudo apt-get install kdelibs-bin kdelibs5-data kdelibs5-plugins
```
 - vi. Open Kate back up and you should now have nifty little icons.

6 First Assembler Program

Open Kate or other text editor and type in the following program. Save it as `helloworld.asm`.

```
1 ; Hello World Program
2
3 SECTION .data
4 msg      db      'Hello World!', 0Ah
5
6 SECTION .text
7 global _start
8
9 _start:
10
11     mov     edx, 13
12     mov     ecx, msg
13     mov     ebx, 1
14     mov     eax, 4
15     int     80h
16
17     mov     ebx, 0      ; return 0 status on exit - 'No Errors'
18     mov     eax, 1      ; invoke SYS_EXIT (kernel opcode 1)
19     int     80h
```

Either have the terminal open in Kate or the system terminal. With the option we set in Kate you should automatically be in the same directory as the saved file. If you are using the system terminal, you will need to navigate to the same directory as the saved file. In Linux, the way you change directories is to use `cd <Directory Name>` where the directory name is the new directory you want. You can also use Caja to get into the correct folder and then select File > Open in Terminal from the menu.

Once you are there you can use the `ls` or `ls -l` or `ll` commands to get a file listing to make sure that we have the correct folder. We will now assemble the code using,

```
nasm -f elf helloworld.asm
```

After this get another file listing and you will see a new file, `helloworld.o`. This is the object code file, it is the same way as in C or C++ when you compile a program with `gcc` or `g++`. Now we link it into an executable file with,

```
ld -m elf_i386 helloworld.o -o helloworld
```

After this get another file listing and you will see a new file, `helloworld`. This is the executable file, no need for the `exe` at the end like Windows. To run the program type,

```
./helloworld
```

You will get the output of Hello World!, you would have been disappointed if we had written anything else.

7 Submit Your Work

As you can see from the code, a comment line begins with a semi-colon. Put your name at the top of the program as a comment and then upload the code, object, and executable files to MyClasses. Since MyClasses is a web-based system you can do this through firefox inside the virtual machine.

8 Quick Introduction to Linux Mint

We are just going to go through some of the basics of Linux in this section. As with any new operating system, the more you use it the more proficient you will become. Most flavors of Linux have a wealth of applications that are either free or open source (that is, you can download the source code for these programs, alter them, and recompile the updated software). As we pointed out above, the two main ways to install programs are through the Software Manager and through the terminal.

Linux developers also assume that the users of Linux are a little more sophisticated, hence there are more options to users and things are more open to being changed. On the other hand it is also easier to make a change that you do not want and may be difficult to reverse. There are very active online communities of Linux users and finding a solution to a particular problem is relatively easy with a few searches.

For these explorations you will probably want to open the terminal window, most of what we will be doing is looking at commandline commands. Linux Mint has many graphical user interface programs, including LibreOffice (free version of word processor, spreadsheet, presentation package, drawing package, and database), GIMP (free version of a graphics editor), Caja (file explorer), VLC (free media player) ...that are fairly easy to use and figure out through the menu.

8.1 File Structure in Linux & Directory Navigation

The file structure in Linux is closer to that of the Mac than it is in Windows.

- In the terminal run the command `pwd`, this stands for print working directory. You will see home and then your user id. Linux was designed like Unix, a multi-user system, so each user on the system has their own space inside the home directory.

- Run the command `ls`, which stands for listing, that is a directory listing. You will probably see something like,

```
Desktop  Documents  Downloads  Music  Pictures  Public
Templates  Videos
```

These are default directories that your installation put there. By the way, what most people call folders are called directories in the Linux world.

Most commands have options that allow you to run the command to produce different levels of output or to specialize the running in some way. For example, the listing command has `ls -l` for a long listing, `ls -a` for listing all files (even those that are hidden, like `.*` files), `ls -al` a long listing of all files, For example, `ls -l` gives you a listing like the one below.

```
don@HAL9000 ~ $ ls -l
total 34
drwxr-xr-x 2 don don 4096 Oct  5 12:29 Desktop
drwxr-xr-x 3 don don 4096 Oct  5 13:35 Documents
drwxr-xr-x 2 don don 4096 Oct  5 12:29 Downloads
drwxr-xr-x 2 don don 4096 Oct  5 12:29 Music
drwxr-xr-x 2 don don 4096 Oct  5 12:29 Pictures
drwxr-xr-x 2 don don 4096 Oct  5 12:29 Public
drwxr-xr-x 2 don don 4096 Oct  5 12:29 Templates
drwxr-xr-x 2 don don 4096 Oct  5 12:29 Videos
```

This shows the permission structure, the user and group membership, size, date, time, and file/directory name.

Some flavors of Linux will set up aliases for these commands, that make them easier to use. For example, Mint defines the commands `l` (for `ls`), `ll` (for `ls -l`), and `la` (for `ls -a`). You can define your own aliases by editing the `.bashrc` file, I would not recommend doing that at this point.

Many Linux commands take wildcards, one of them is the common `*`. So if you run the command `ls *.jpg` the listing will include all of the JPEG image files in the directory.

- In Caja, the file explorer for Mint, the icon in the taskbar beside the terminal icon, you can navigate the file system just like in Windows Explorer or Finder. In addition, you can open documents, create directories, remove files and directories, everything you would expect from a file system program. You can also open the terminal in the directory you are currently in by selecting File > Open in Terminal from the menu.

You can also navigate the file system using terminal commands.

- The `cd` command is to change the current directory. Run `cd Documents`, now you are in the Documents directory. Do a listing, you will probably not see anything since there are no files or subdirectories in this folder.

- Now we will create a subdirectory of documents to store all of our work for this class. The command `mkdir` creates a new directory, run `mkdir NASM`. This now created a subdirectory of Documents called NASM, we will store all of our programs here. This could have been done in Caja just as easily.
- Linux usually offers some shortcuts to typing. For example, run the command `cd`, this will take you back to your home directory. The command `cd ~` will do the same thing. The `~` is a shortcut for your home space. You can also use `cd ..` to move back one directory.
- Linux also has an auto-completion feature. Navigate back to your home directory, then type in `cd Doc` then hit the Tab key, it should complete the directory name of Documents, then enter will change your directory.
- The terminal window also keeps a history of the commands you type in. So to go back and rerun a command or put it in the command line for editing, use the up and down arrow keys.
- If you are running a program in the terminal and are either inside an infinite loop or the program is not responding then Control+C or Control+Z will abort the execution of the program. To test this, in the terminal run the command `yes`, this will go into an infinite loop of printing “y” to the screen, now type Control+C.

8.2 Permissions

Linux uses a permission structure to control access to files and directories. If you do a long listing of a directory you will see entries like the following.

```
drwxrwxr-x 4 don don 4096 Oct 29 11:22 ASM/
drwxrwxr-x 3 don don 4096 Oct 29 11:26 CPP/
-rwxrwxr-x 1 don don 648 Oct 5 13:40 helloworld*
-rw-r--r-- 1 don don 108 Oct 26 20:36 main.cpp
-rwxrwxr-x 1 don don 9216 Oct 26 20:37 prog*
```

The first 10 characters are the permission structure for the file or directory. The first character is either a `d` for directory or `-` for a file, there are other possibilities but it is usually these two. The rest of the permission structure is blocks of three characters `rwX`. The `r` stands for read, `w` for write, and `x` for execute (the file is a program that can be run). The blocks of three are as follows, the first block is the user block (you), the second block is the group (each user belongs to several groups of users on the system and each file belongs to a particular group), the third block is other (everyone else on the system). For example,

```
drwxrwxr-x
```

is a directory, the user can read files, write files and execute programs in the directory. Any member of the group can read files, write files and execute programs in the directory. All

other people on the system can read files and execute programs in the directory but they cannot write to the directory, which includes deleting files, this protects you from other people on the system and their actions.

Another example,

```
-rw-r--r--
```

This is a file that the user can read and write to (i.e. edit). All other users on the system can read the file but cannot alter its contents. You can change the permissions of the files you own through Caja or using the command `chmod` in the terminal. We may look at this later but we do not need it now.

8.3 man and info Pages

Ever since the creation of Unix, all commands had help screens that documented in detail the usage and options of each command. These help screens are called man pages (short for manual pages). In the terminal run the command `man ls`. This will list the man pages for the `ls` command. You can use the arrow and paging keys to scroll through the documentation and when you are done hit the `q` key to quit. You can also see the info pages by `info ls`, or any other command.

8.4 Commandline Compiling and Assembling

Most IDE's, like Eclipse, VS, CodeBlocks, . . . , have the ability to compile and run a program by using a menu option or a toolbar button. When you select these options what is really happening under the hood is that a commandline command is being run on your system. Linux has many such IDE's available and some IDE's like Eclipse and CodeBlocks are cross platform and will run on several operating systems. Since this class is dealing with hardware and low-level interfacing of hardware and software we will get our hands dirty and do only commandline assembling and compiling. If you have taken CS II or data structures you may have already done this in C++, we will use both C++ and Assembly. You will also do this in higher level courses in the curriculum.

- Create a subdirectory of NASM called HelloWorld, open Kate and type in the following program. Save it as `helloworld.asm` in the HelloWorld directory you just created.

```
1 ; Hello World Program
2
3 SECTION .data
4 msg      db      'Hello World!', 0Ah
5
6 SECTION .text
7 global  _start
```

```
8
9 _start:
10
11     mov     edx, 13
12     mov     ecx, msg
13     mov     ebx, 1
14     mov     eax, 4
15     int     80h
16
17     mov     ebx, 0      ; return 0 status on exit - 'No
                          Errors'
18     mov     eax, 1      ; invoke SYS_EXIT (kernel opcode 1)
19     int     80h
```

Open the terminal, navigate to the HelloWorld directory you just created. Run the command,

```
nasm -f elf helloworld.asm
```

This command just assembled (like compiling) the `helloworld.asm` source file. Get a file listing and you will see a new file, `helloworld.o`. This is the object code file, it is the same way as in C or C++ when you compile a program with `gcc` or `g++`. Now we link it into an executable file with,

```
ld -m elf_i386 helloworld.o -o helloworld
```

The i386 portion linked it as a 32-bit application. Get another file listing and you will see a new file, `helloworld`. Notice the permissions for the file `helloworld`, it is set as an executable file and hence can be run on the system as a program. Finally run the program by,

```
./helloworld
```

This will be the general process for all of our assembly programs.

- We will also be writing some easier C++ programs and be comparing the structure and process of these with that of assembly. We will also be compiling and linking the C++ files by the commandline.

Create a new subdirectory of Documents called CPP, we will store all of our C++ files there. Inside the CPP directory create another subdirectory called HelloWorld. In Kate, create the following program, one you probably did in introductory C++ programming.


```
1 #include <iostream>
2
3 using namespace std;
4
5 int main()
6 {
7     cout << "Hello World!" << endl;
8     return 0;
9 }
```

Save the program as `main.cpp` in the subdirectory you just created. Open the terminal, navigate to the subdirectory you just created, and run the following command.

```
g++ main.cpp -o helloworld
```

This command will both compile and link the program. You can do this in two steps as well and when we link assembly to C or use more than one source file we will do just that. Run the program as before using,

```
./helloworld
Hello World!
```

8.5 Other Commands

Here are some more Linux commands that are used inside the terminal, some are useful and some are just for fun. You can learn more about the commands by looking at the man pages for each of them. We will add to this list as the semester goes on.

- `time` — displays the execution time of a program.
- `rm` — removes files.
- `rmdir` — removes directories.
- `mv` — moves or renames files.
- `lscpu` — returns information about your CPU. Since we are running Linux through a virtual machine you will not get the same information as you would if Linux were installed directly.
- `cloc` — counts the lines of code in a program or set of source code files. You may need to install this but if you run `cloc` and it is not on the system it will tell you the command to use to install it.
- `cal` — shows a calendar for the current month. You can also use `cal [year]` to get the yearly calendar for that year.

- `exit` — closes the terminal window.
- `fortune` — try the command `fortune`.
- `cowsay` — try the command `cowsay I love COSC 250`.