BAHIRDARUNIVERSITYINSTITUTEOF
TECHNOLOGY

SOFTWAREENIGEENERINGOPERATINGSYSTEM

INDIVIDUALASSIGNMENT

DocumentationforInstallationofRaspberryPiOsinaVirtual Environment

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A. Introduction

RaspberryPiOS,formerlyknownasRaspbian,isalightweightLinuxdistributiontailoredfortheRaspberry Pifamilyofsingle-boardcomputers.Itservesasapowerfulplatformforeducationalpurposes,prototyping, andexperimentationinembeddedsystemsandIoTprojects.Inanacademiccontext,RaspberryPiOS providesstudentswithauniqueopportunitytoexploretheunderlyingprinciplesofoperatingsystems, system-levelprogramming,andhardware-softwareintegration.

ThemotivationforselectingRaspberryPiOSinthisprojectstemsfromitsaccessibility,simplicity,andrich ecosystem ofopen-sourcetools.Bydeploying Raspberry PiOSina virtualized environment,students can gain practical experience in OS installation, configuration, and system-level interactions withoutneeding physicalRaspberryPihardware.Thisapproachfostersdeeperunderstandingofsystemarchitectureand enhancesproblem-solvingskillsintherealmofsystemprogramming.

RaspberryPiOSisaDebian-basedoperatingsystemdesignedfortheRaspberryPihardware.Installingitin avirtualenvironmentsuchasVirtualBoxenablesdevelopmentandtestingwithoutneedingphysical Raspberry Pi hardware.

B. Objectives

Theobjectivesofthisprojectareasfollows:

- TounderstandandperformtheinstallationofRaspberryPiOSinavirtualenvironment.
- ToexplorethefeaturesandcapabilitiesofRaspberryPiOSfromasystemprogrammingperspective.
- Todevelophands-onskillsinmanagingandinteractingwithanoperatingsystematalowlevel.
- Todocumenttheinstallationprocess,problemsencountered,andsolutionsimplemented.

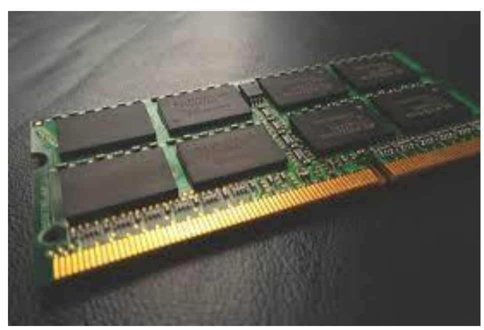
C. Requirements

HardwareRequirements:

- Acomputerwithatleast4GBofRAM
- 10GBormoreoffreediskspace
- ACPUwithvirtualizationsupport(IntelVT-xorAMD-V)

SoftwareRequirements:

- OracleVMVirtualBoxorVMwareWorkstation
- RaspberryPi OSISOimage(Debian-based)
- Optional:BalenaEtcherforflashingSDcards(ifusingrealhardware)
- Internetconnectionfordownloadingpackagesandupdates



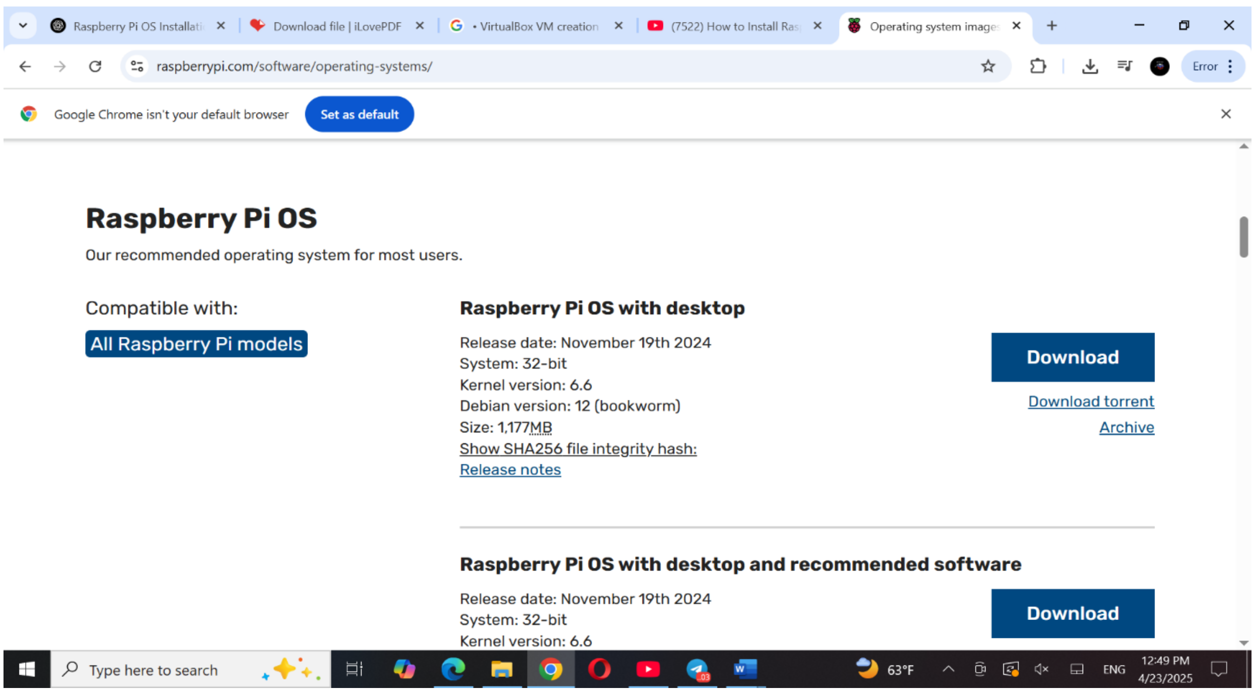
D. Installation Steps

Installation Steps

1, Step 1: Download Required Files

• Visit the official Raspberry Pi website: https://www.raspberrypi.com/software/operating-systems/

• Download the Raspberry Pi OS (64-bit) ISO (or 32-bit if your system is older).



Step 2: Install Vmware workstation

• Download Vmware workstation from:https://support.broadcom.com/group/ecx/downloads

• Install it using the on-screen instructions.

• Optionally, install VirtualBox Extension Pack for additional features like USB and network support.

Step 3: Installation Wizard

Click **Next** to begin.

Accept the license agreement, then click **Next**.

Choose **installation options**:

Enable/disable product updates.

Choose whether to join the VMware Customer Experience Program.

Select the **installation directory** (default is fine for most users), then click **Next**.

Choose whether to create desktop/start menu shortcuts.

Click **Install**.

Step 4: Finish Installation

Wait for the installation to complete (it may take a few minutes).

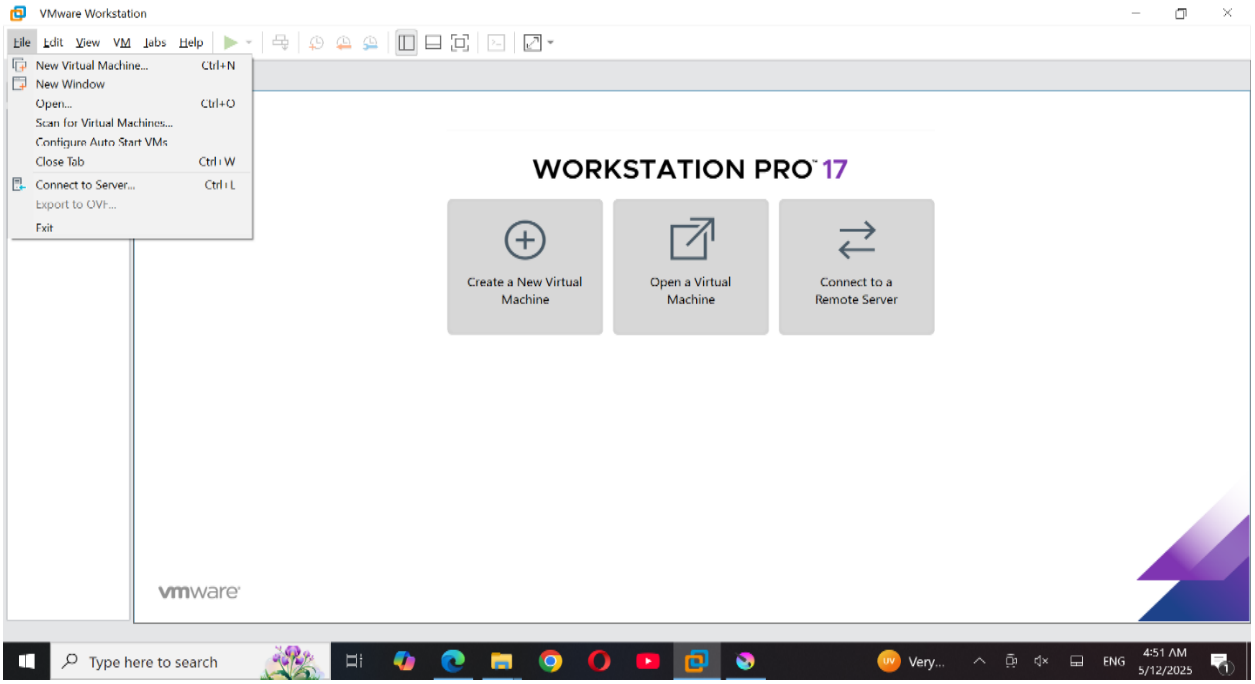
Click **Finish** when it’s done.

Restart your computer if prompted.

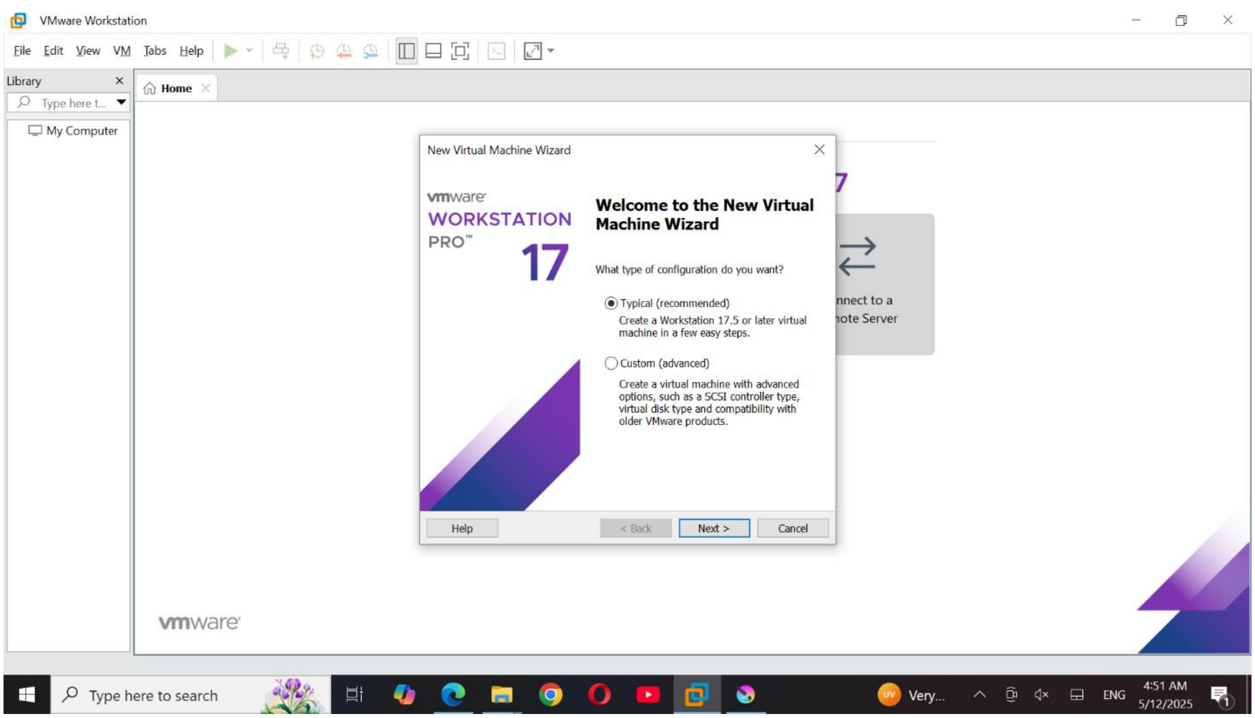
Step 5: Launch VMware Workstation

Double-click the **VMware Workstation** icon on your desktop or search for it in the Start Menu.

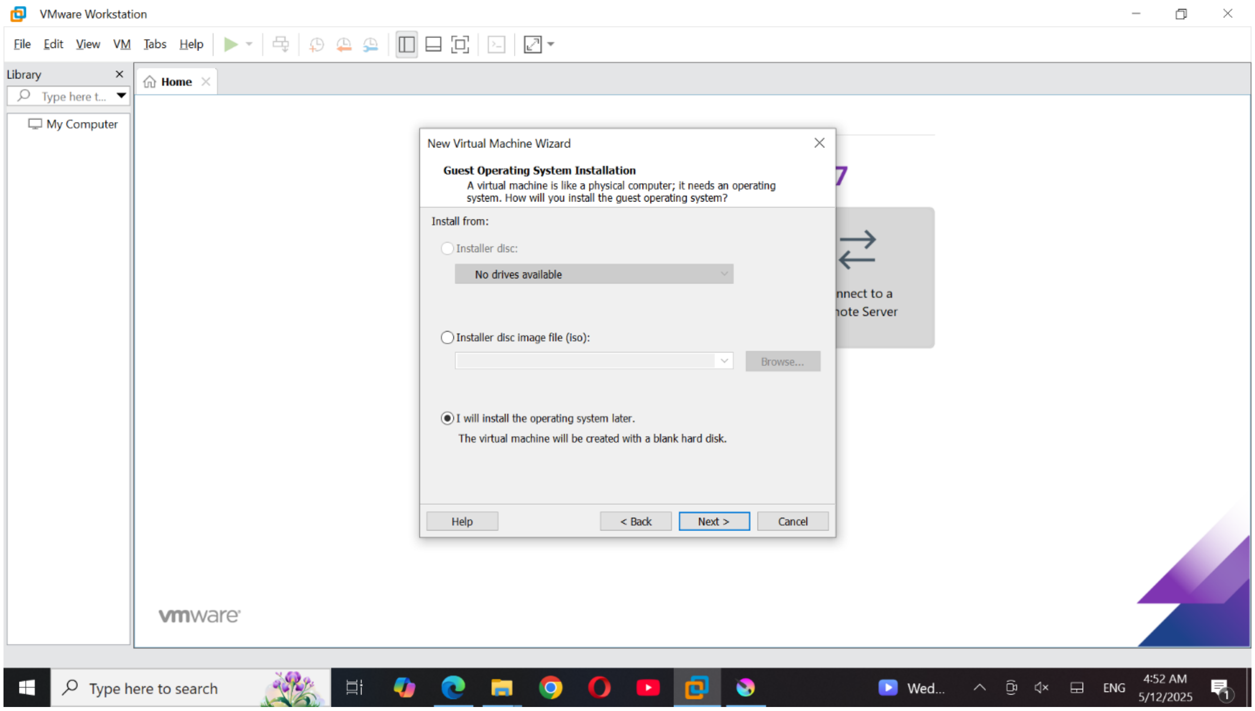
Step 6:click on new virtual machine



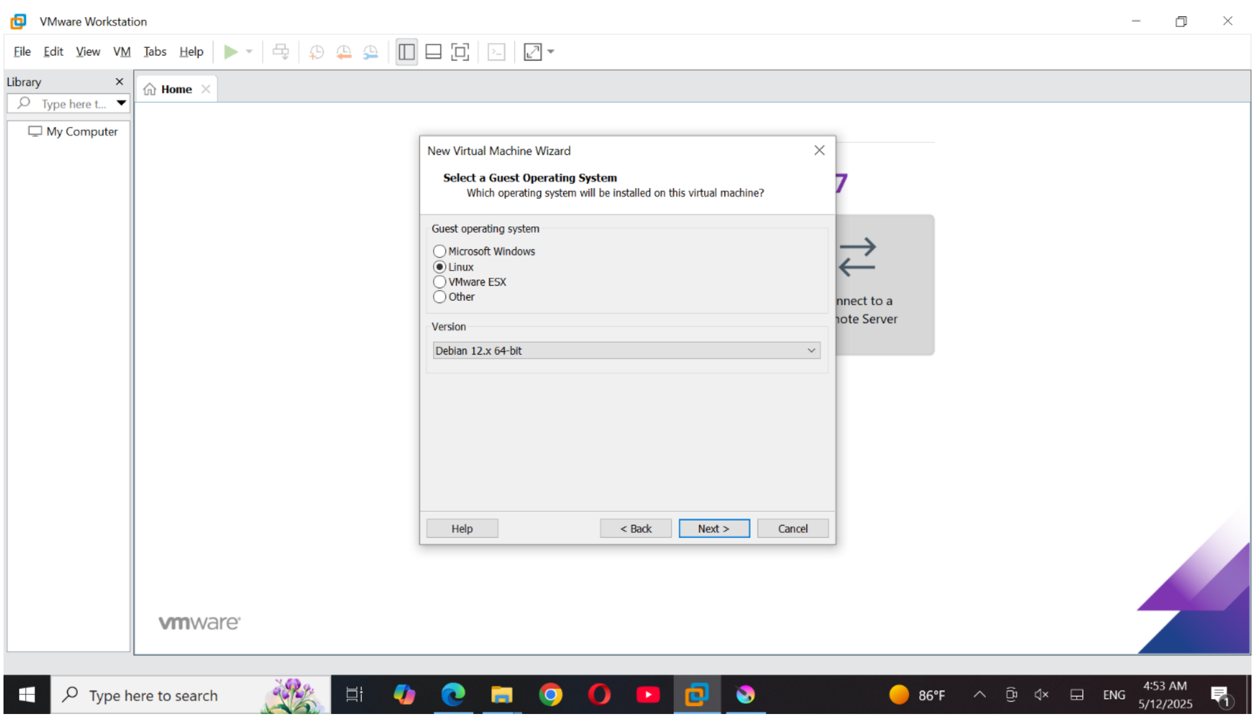
Step 7: click on next



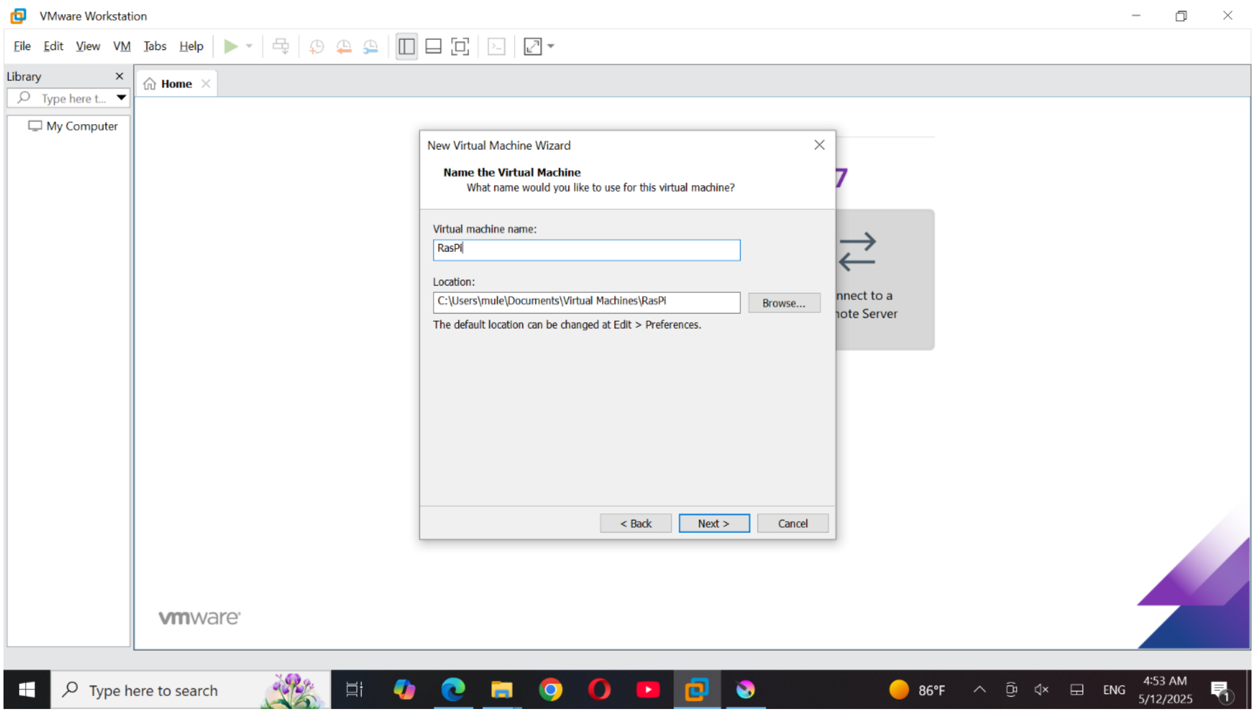
Step 8: select I will install the os later then next



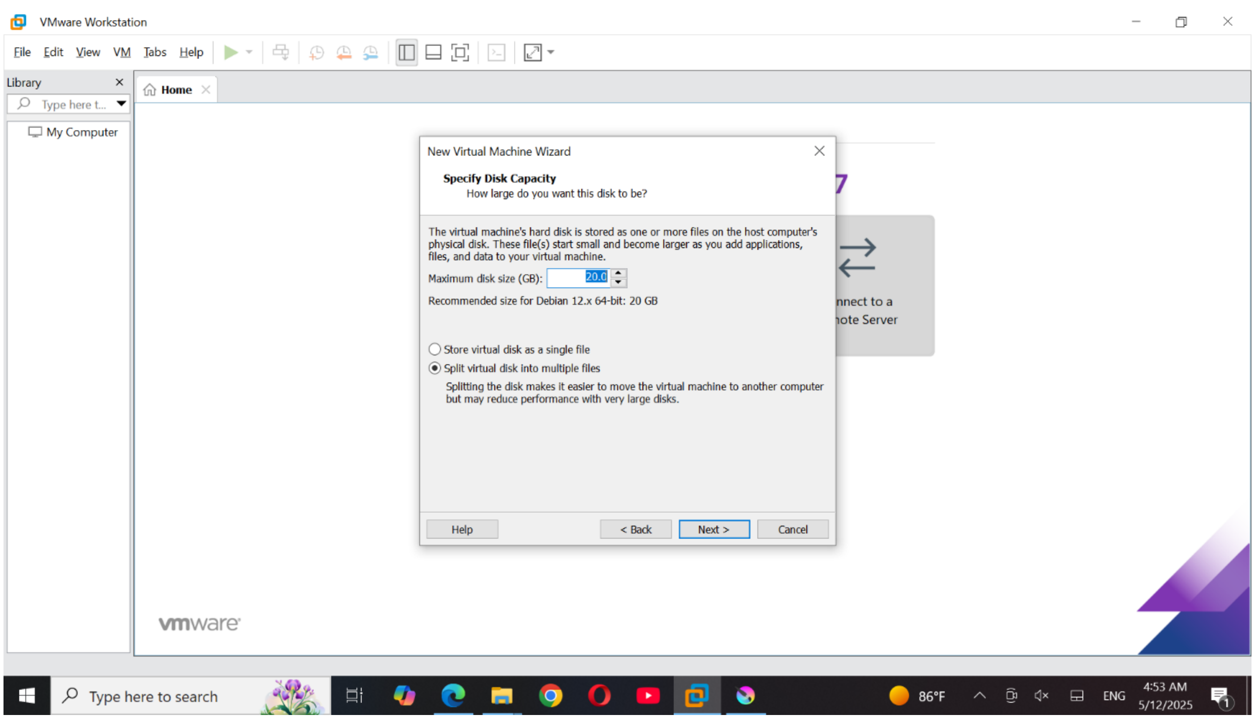
Step 9: select linux and debian12.x 64-bit then next



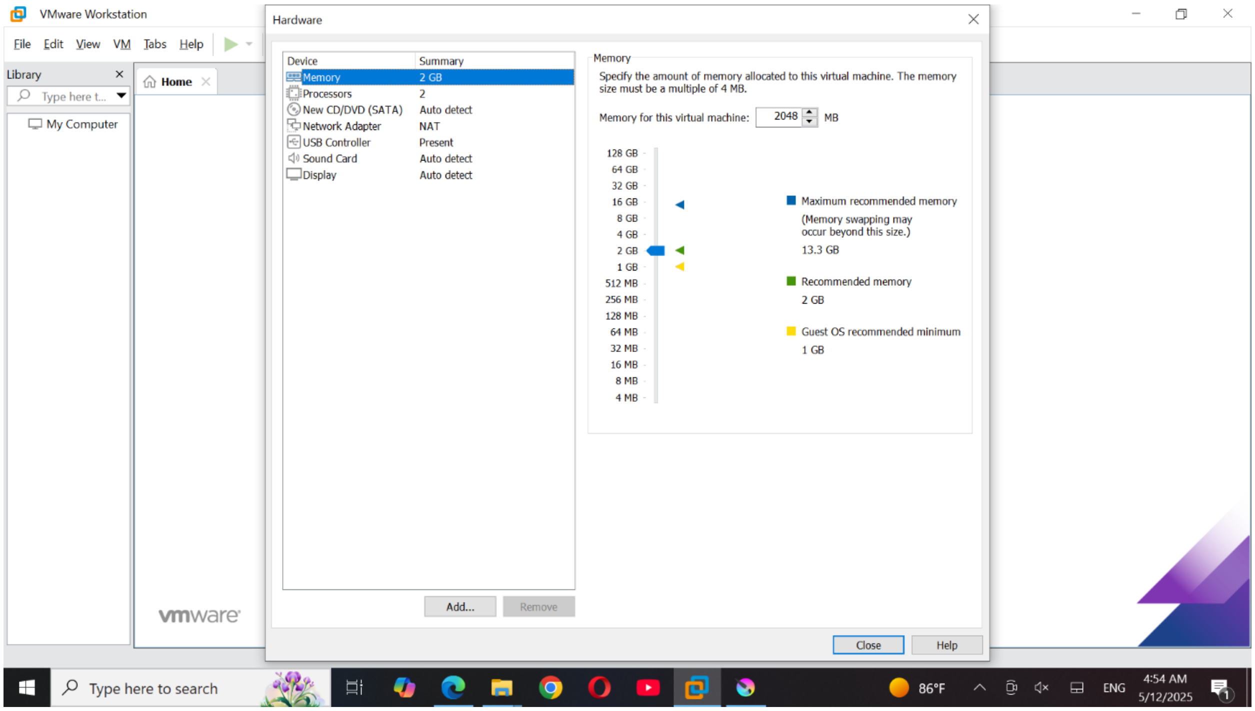
Step 10: give name RasPi then browse the file you download before and click next



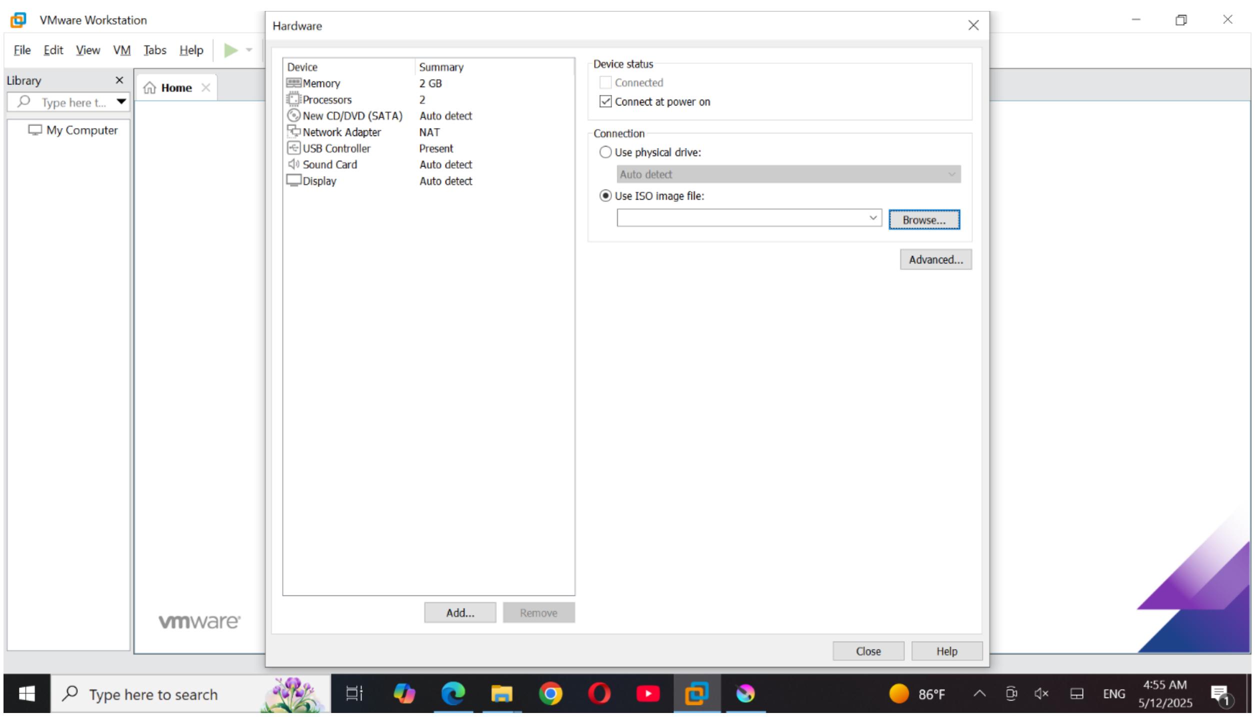
Step 11: set disk capacity and split virtual disk into multiple files



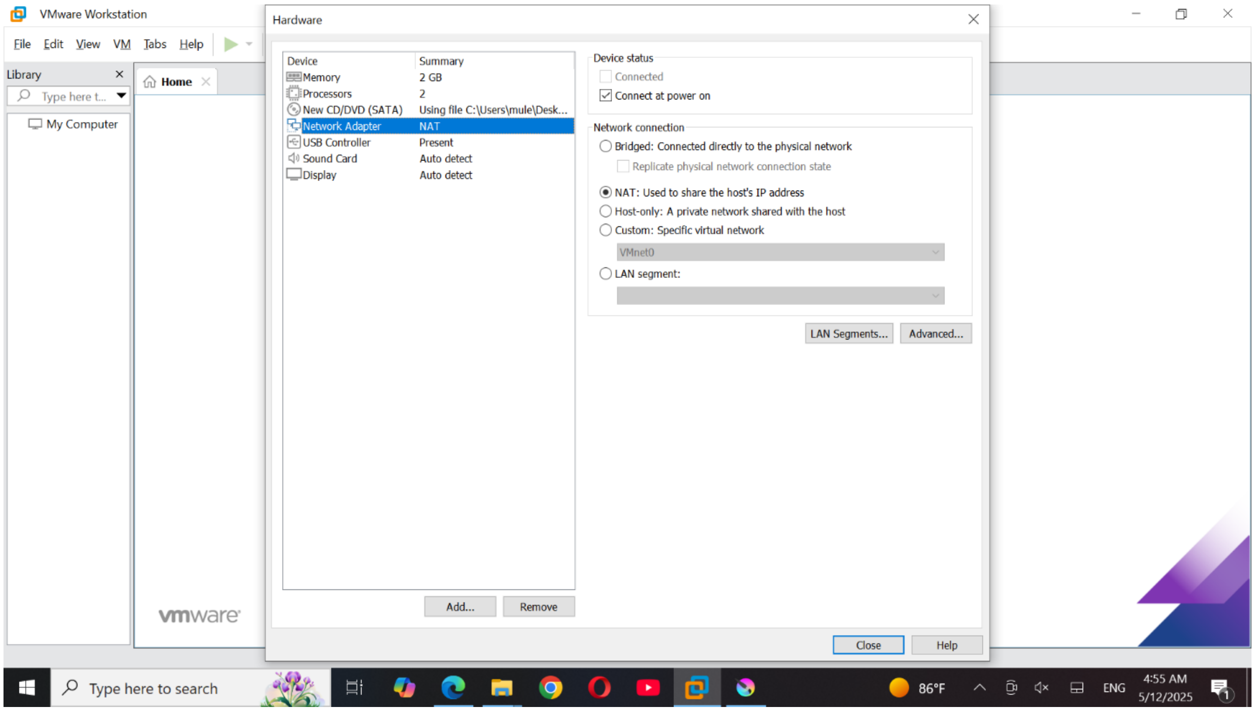
Step 12:click customize hardware



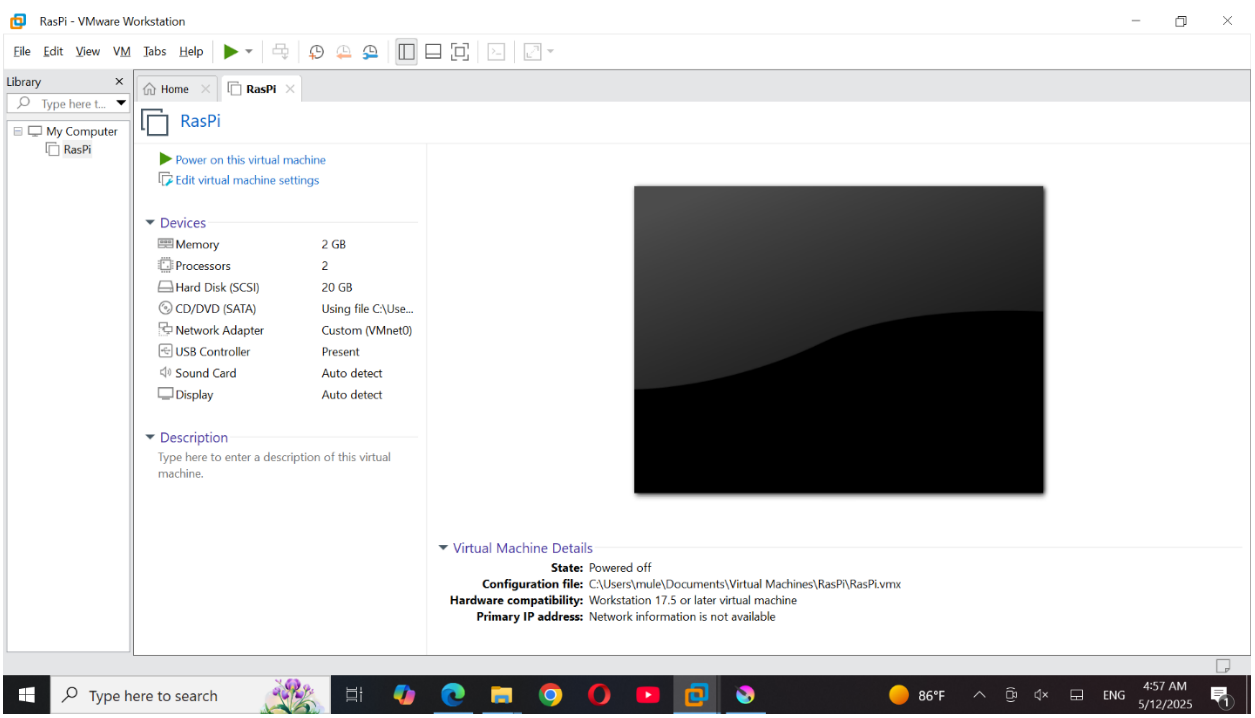
Step 13: select new cd/dvd(sata) and browse the file of raspberry pi



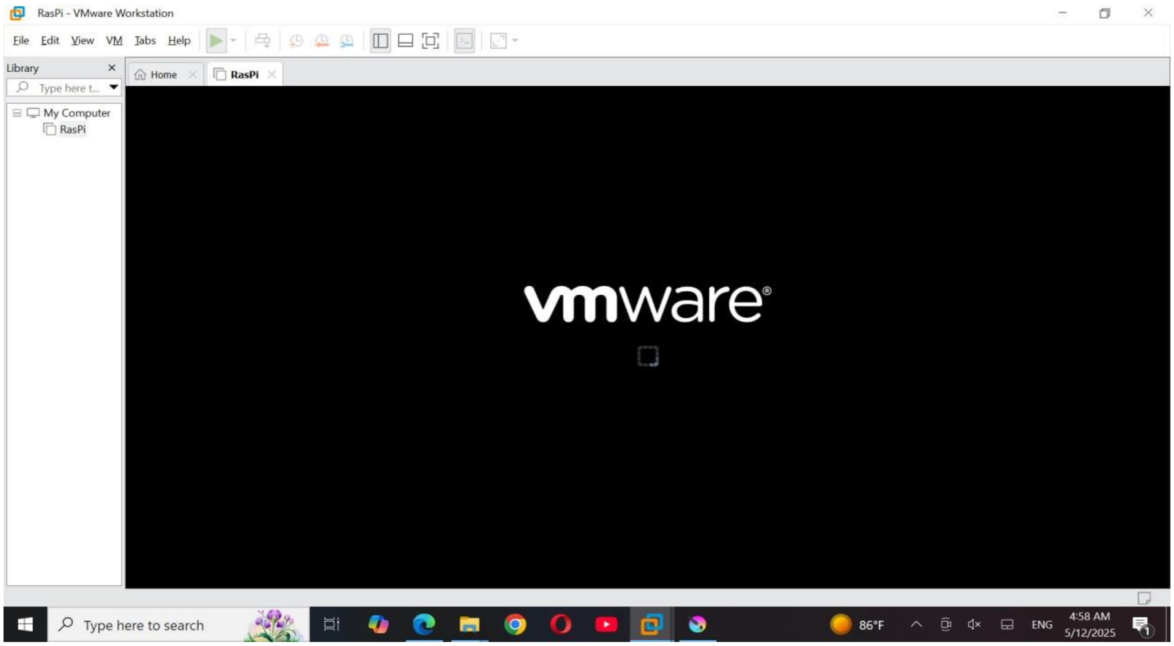
Step 14: click on network adpter and choose custom then close and finish



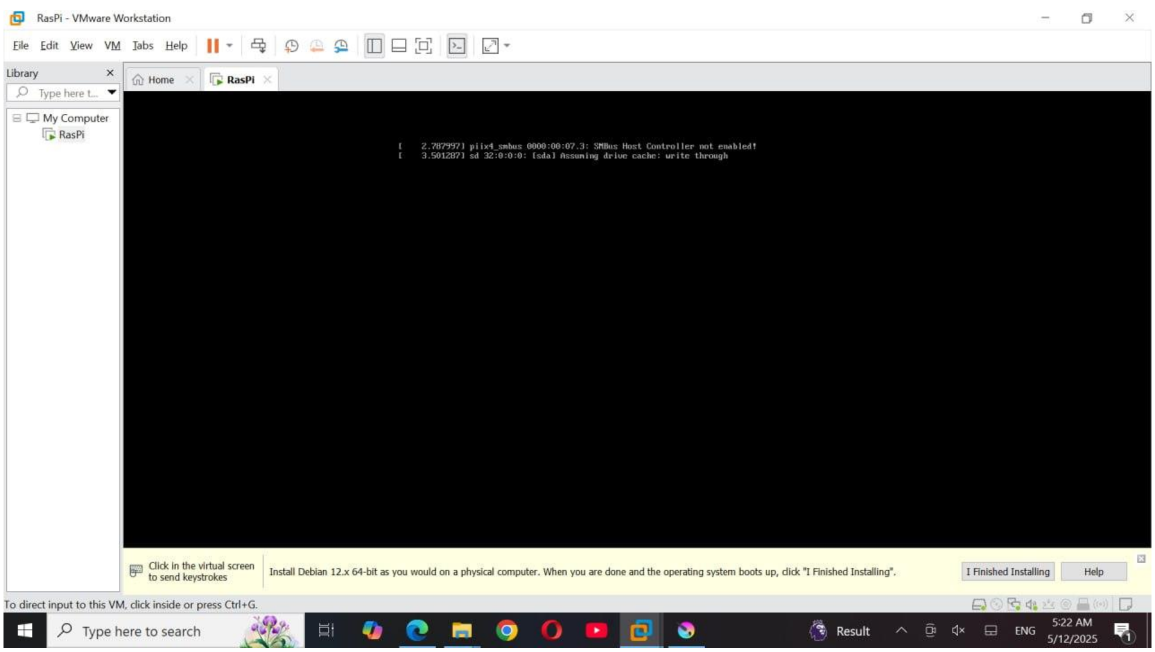
Step 15: then it is successfully created then click on power on this virtual machine

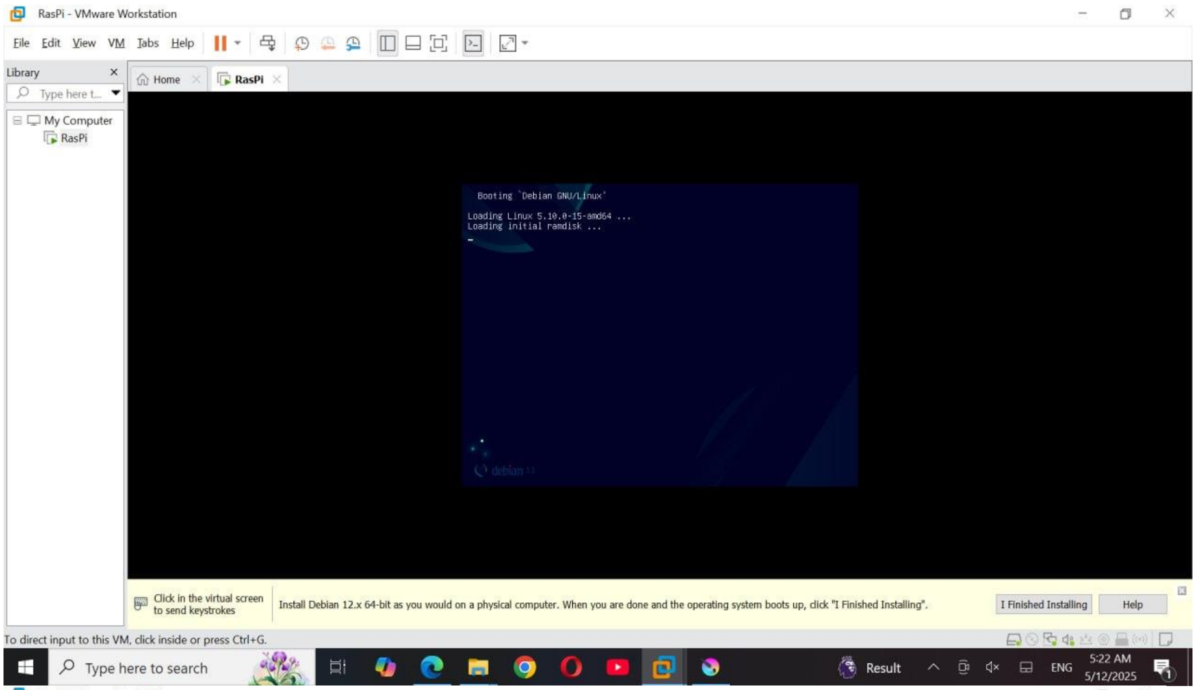


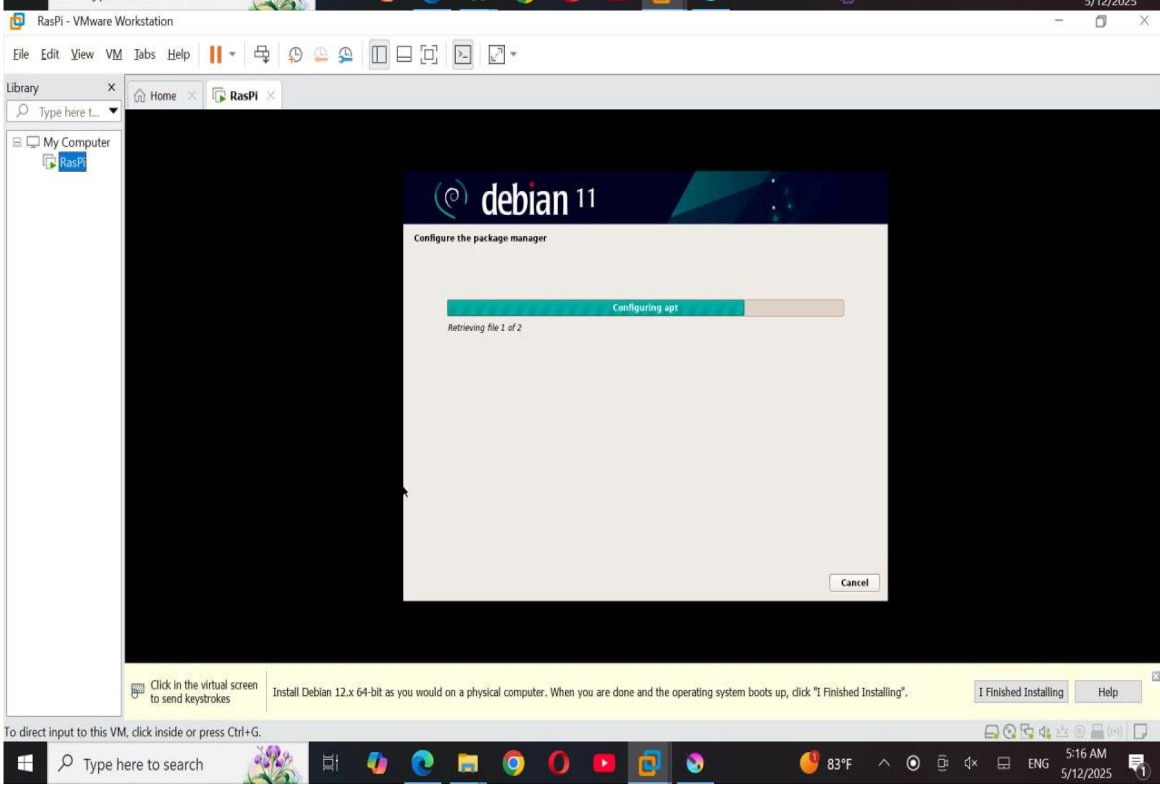
Step 16: you will see this after you power on virtual address

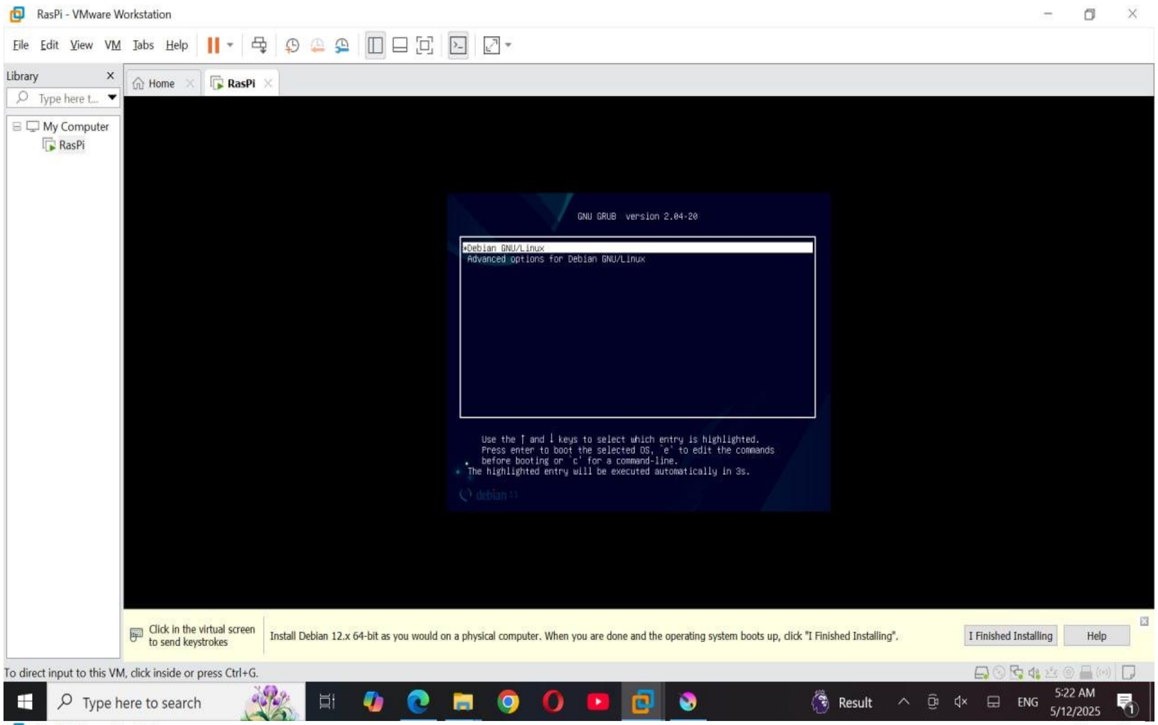


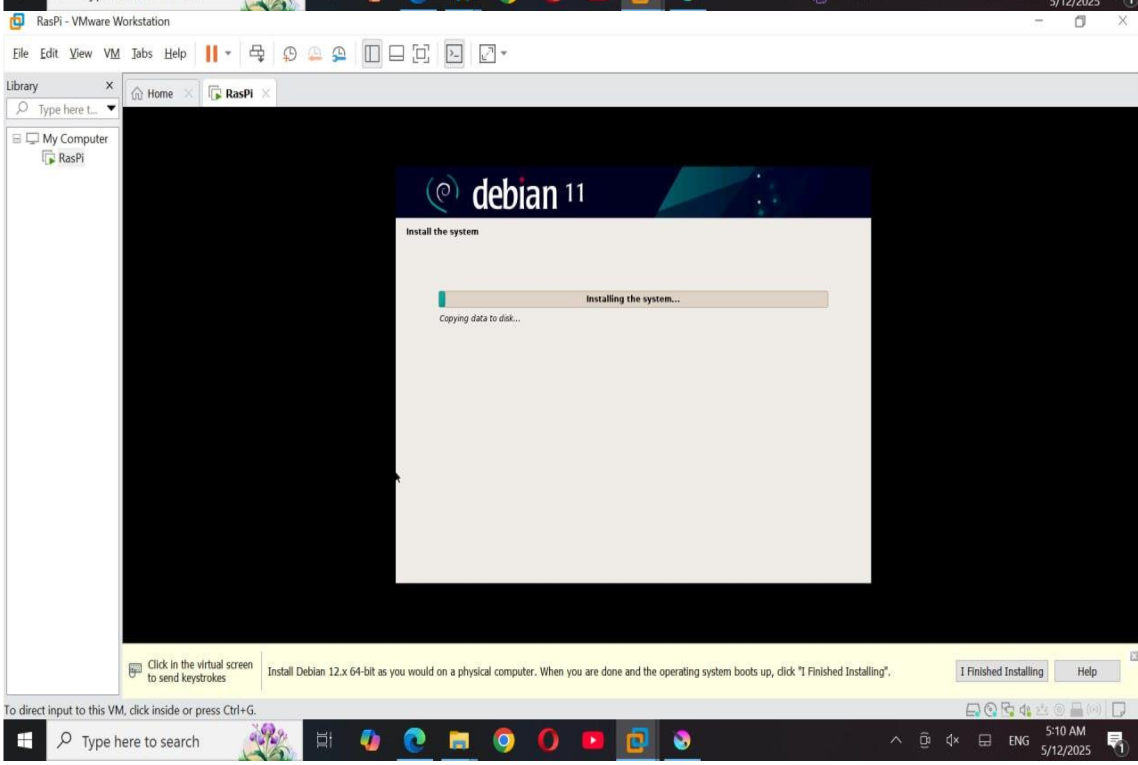
Step 17: follow the steps on the picture

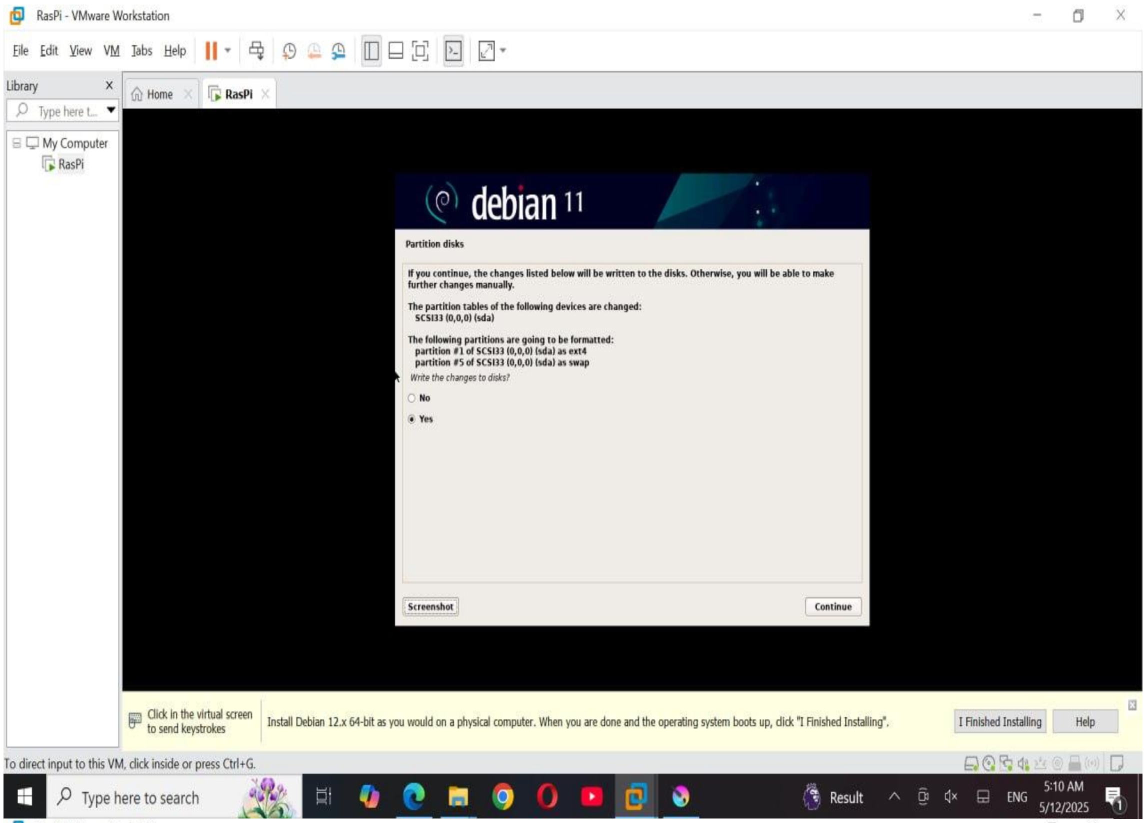


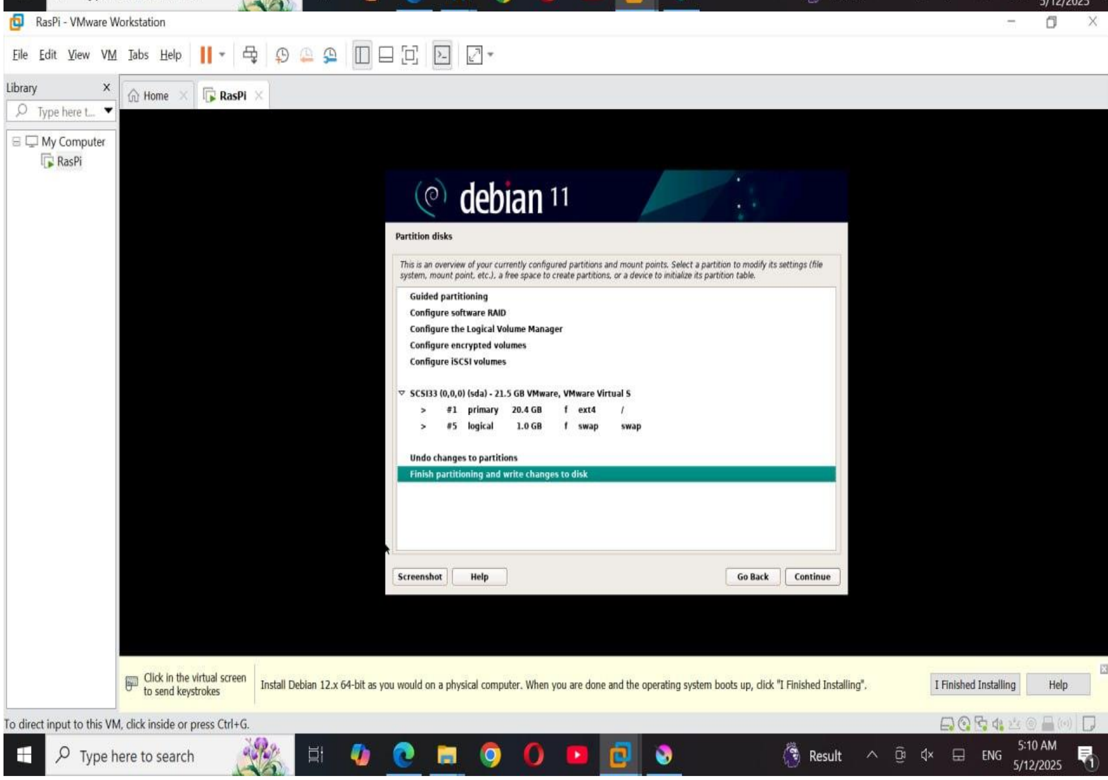

RasPi - VMware Workstation
Booting `Debian GNU/Linux'
Loading Linux 5.10.0-15-amd64 ...
Loading initial ramdisk ...
Click in the virtual screen to send keystrokes
Install Debian 12.x 64-bit as you would on a physical computer. When you are done and the operating system boots up, click "I Finished Installing".
I Finished Installing
Help
To direct input to this VM, click inside or press Ctrl+G.
5:22 AM
5/12/2025

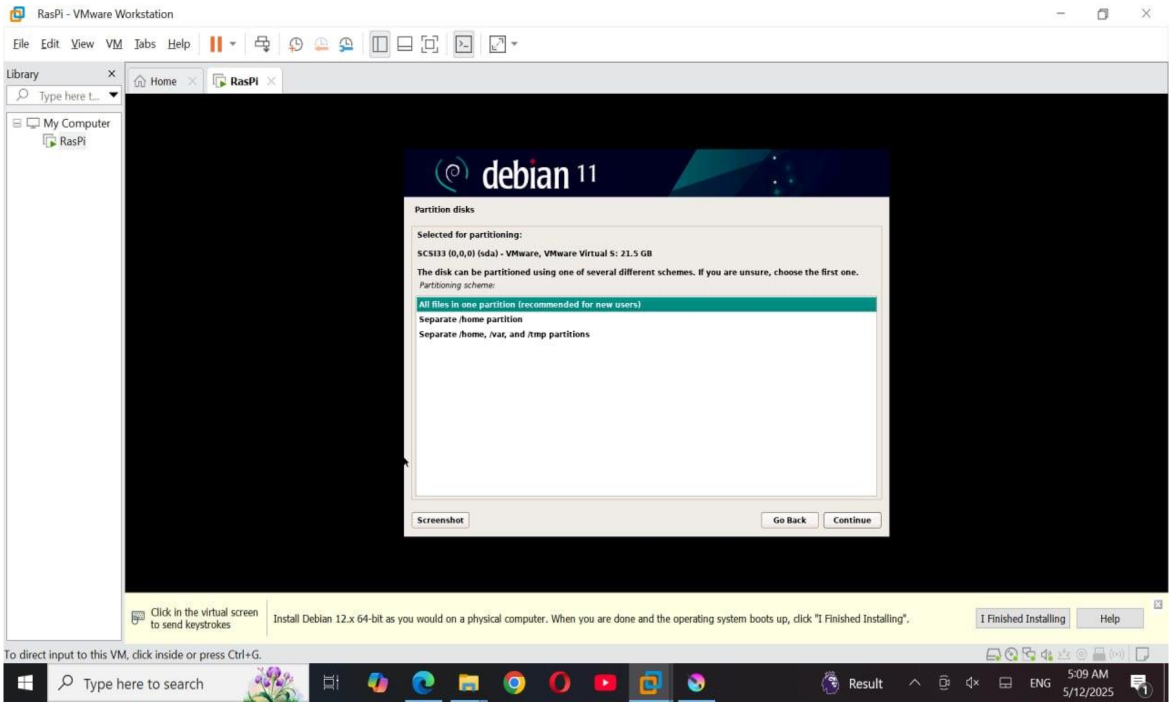

RasPi - VMware Workstation
debian 11
Configure the package manager
Configuring apt
Retrieving file 1 of 2
Cancel
Click in the virtual screen to send keystrokes
Install Debian 12.x 64-bit as you would on a physical computer. When you are done and the operating system boots up, click "I Finished Installing".
I Finished Installing
Help
To direct input to this VM, click inside or press Ctrl+G.
5:16 AM
5/12/2025


RasPi - VMware Workstation
GNU GRUB version 2.04-20
*Debian GNU/Linux
Advanced options for Debian GNU/Linux
Use the ↑ and ↓ keys to select which entry is highlighted.
Press enter to boot the selected OS, `e' to edit the commands
before booting or `c' for a command-line.
The highlighted entry will be executed automatically in 3s.
Install Debian 12.x 64-bit as you would on a physical computer. When you are done and the operating system boots up, click "I Finished Installing".
I Finished Installing
Help
To direct input to this VM, click inside or press Ctrl+G.

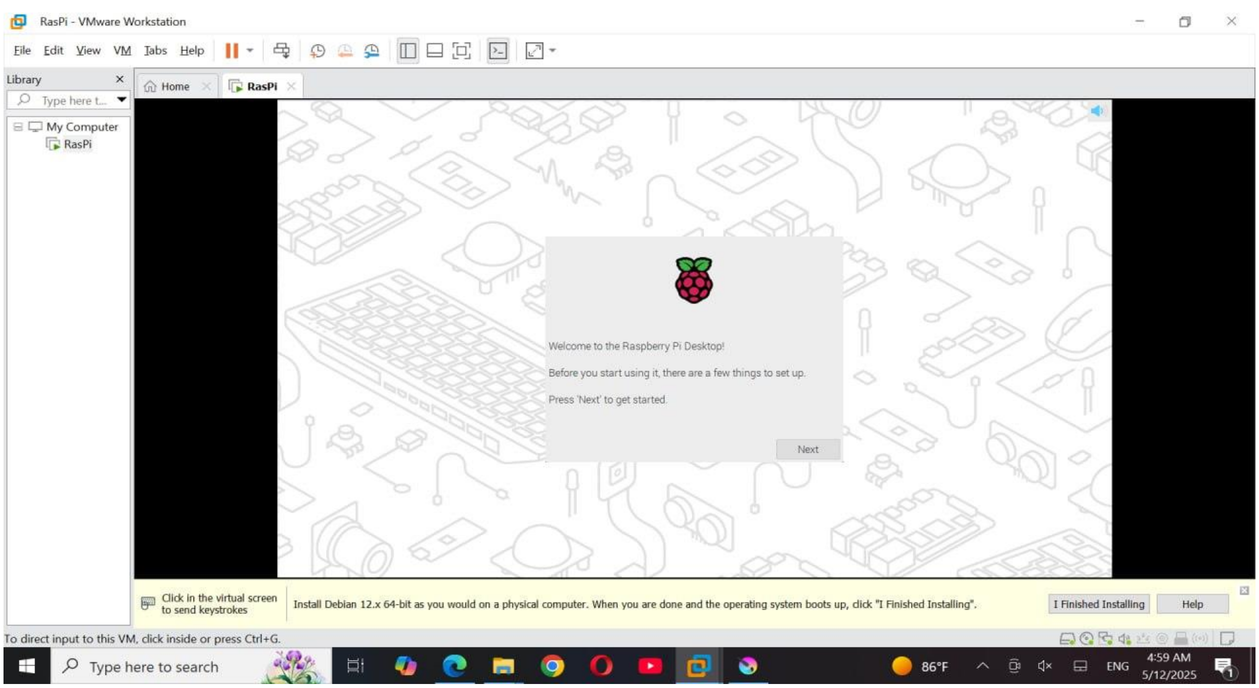

RasPi - VMware Workstation
debian 11
Install the system
Installing the system...
Copying data to disk...
Install Debian 12.x 64-bit as you would on a physical computer. When you are done and the operating system boots up, click "I Finished Installing".
I Finished Installing
Help
To direct input to this VM, click inside or press Ctrl+G.

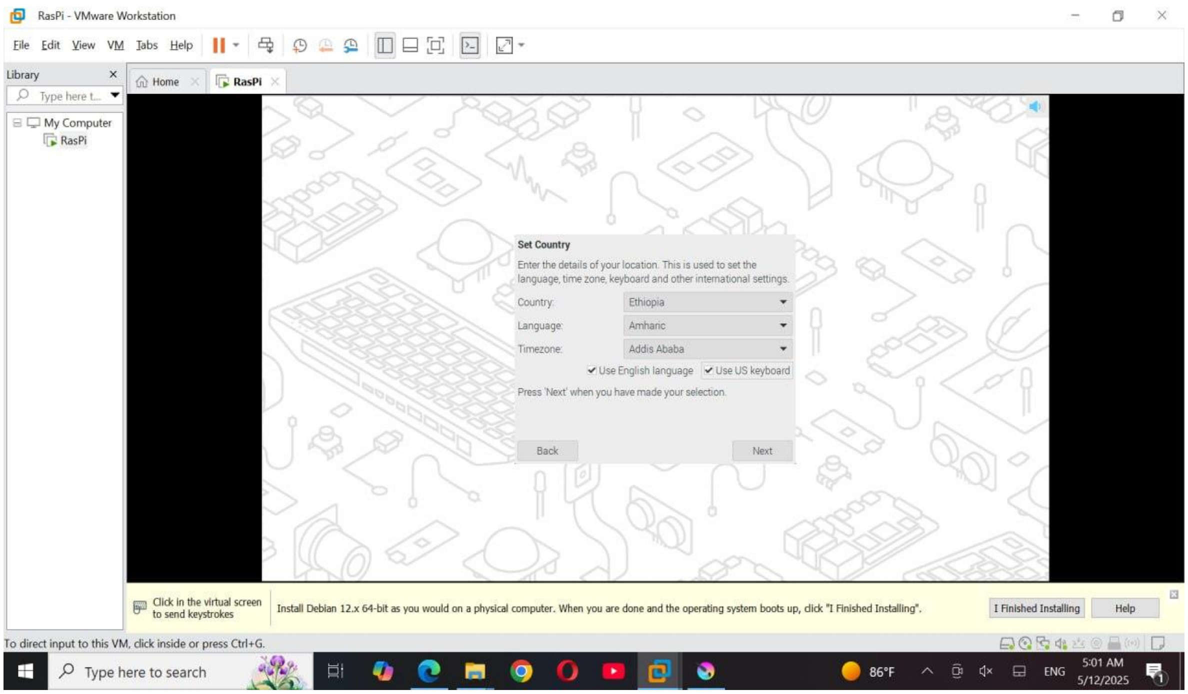

RasPi - VMware Workstation
debian 11
Partition disks
If you continue, the changes listed below will be written to the disks. Otherwise, you will be able to make further changes manually.
The partition tables of the following devices are changed:
SCSI33 (0,0,0) (sda)
The following partitions are going to be formatted:
partition #1 of SCSI33 (0,0,0) (sda) as ext4
partition #5 of SCSI33 (0,0,0) (sda) as swap
Write the changes to disks?
No
Yes
Screenshot
Continue
Install Debian 12.x 64-bit as you would on a physical computer. When you are done and the operating system boots up, click "I Finished Installing".
I Finished Installing
Help

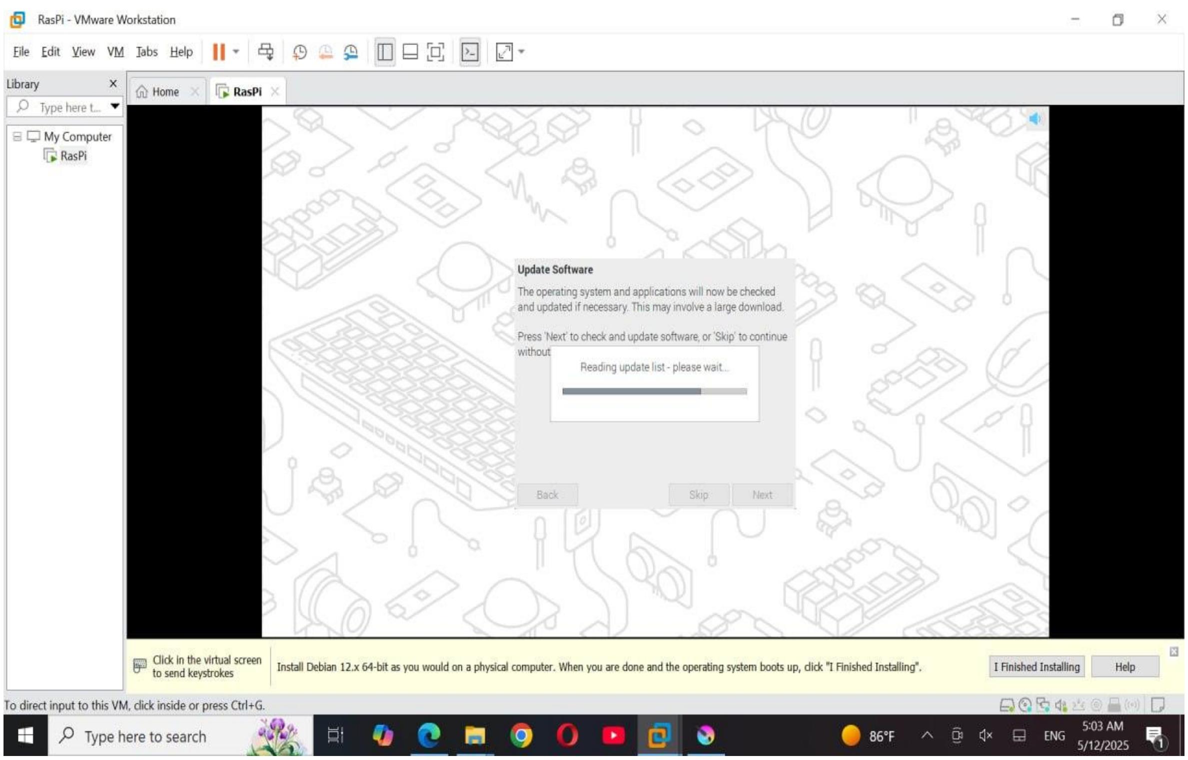

RasPi - VMware Workstation
debian 11
Partition disks
This is an overview of your currently configured partitions and mount points. Select a partition to modify its settings (file system, mount point, etc.), a free space to create partitions, or a device to initialize its partition table.
Guided partitioning
Configure software RAID
Configure the Logical Volume Manager
Configure encrypted volumes
Configure iSCSI volumes
SCSI33 (0,0,0) (sda) - 21.5 GB VMware, VMware Virtual S
> #1 primary 20.4 GB f ext4 /
> #5 logical 1.0 GB f swap swap
Undo changes to partitions
Finish partitioning and write changes to disk
Screenshot
Help
Go Back
Continue
Install Debian 12.x 64-bit as you would on a physical computer. When you are done and the operating system boots up, click "I Finished Installing".
I Finished Installing
Help

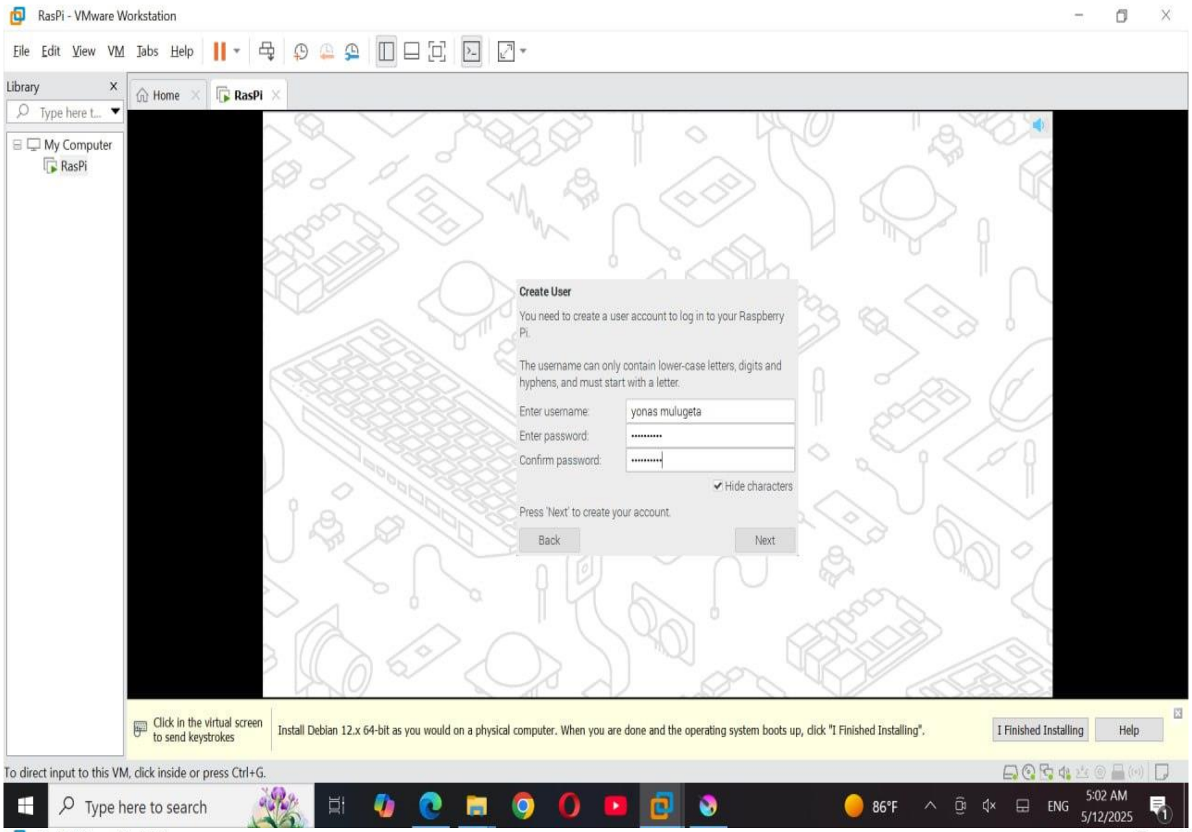


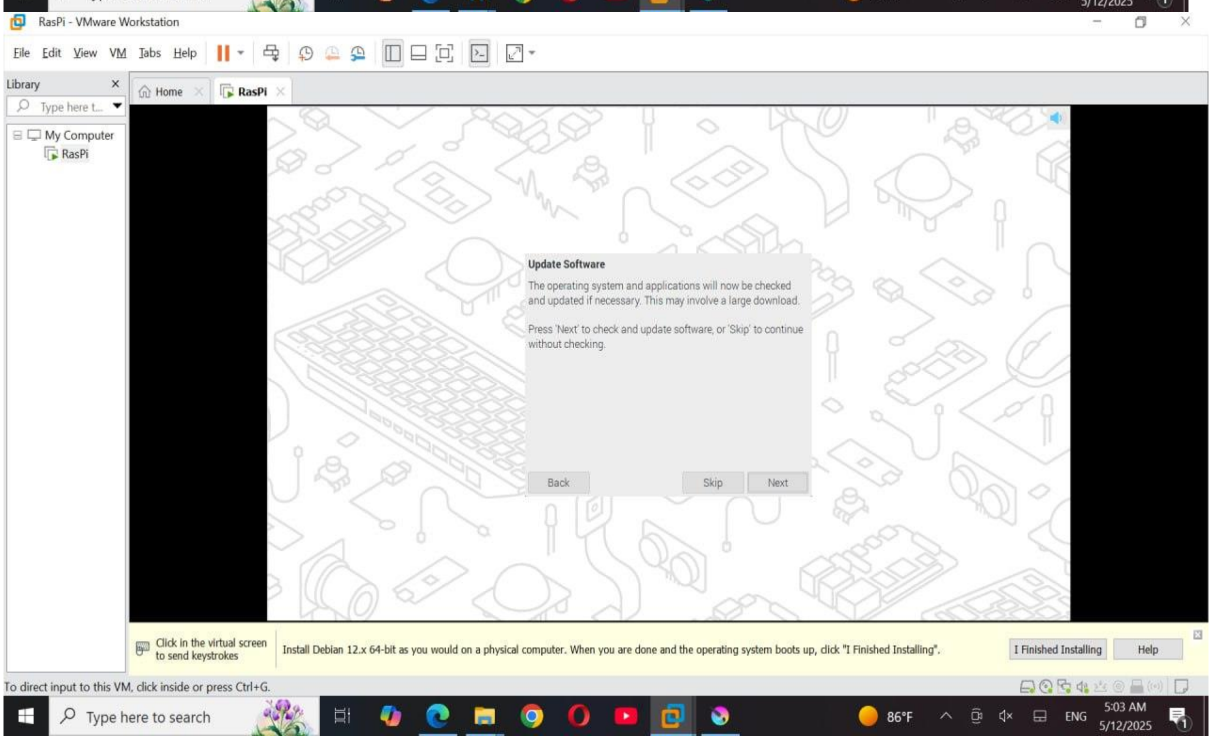
Step 17: create accout by using the following picture

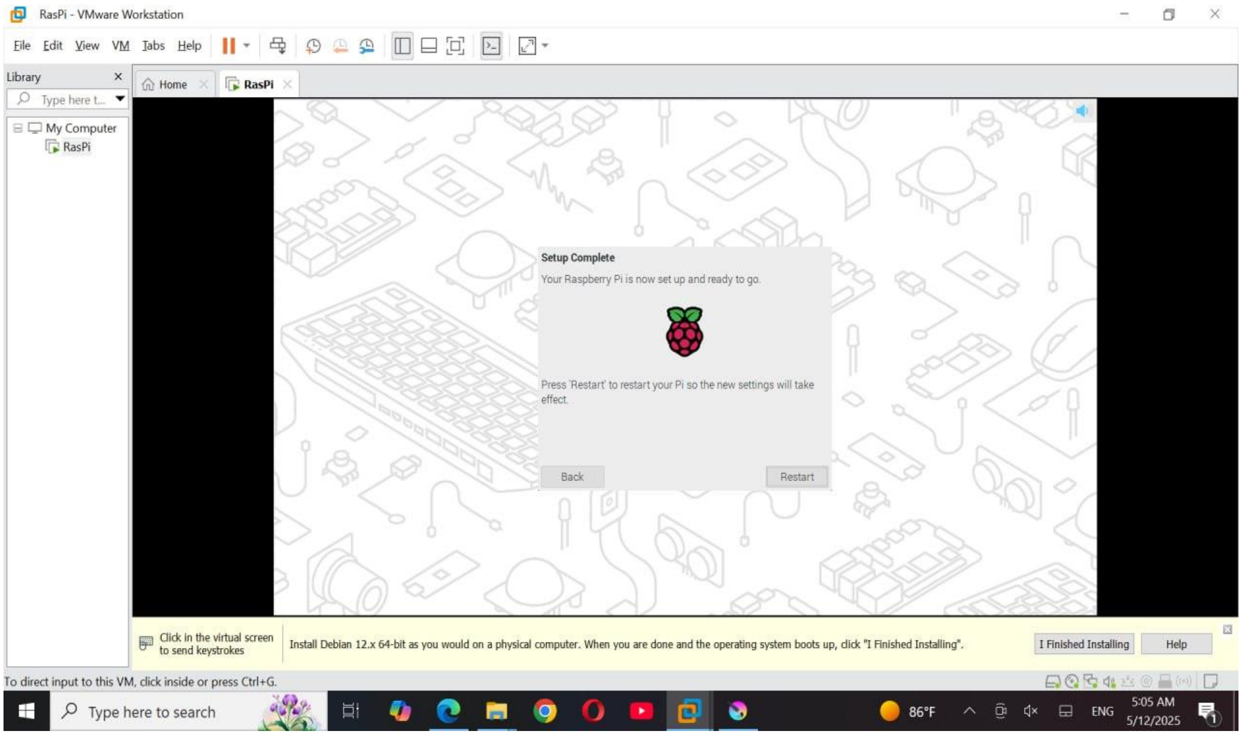



RasPi - VMware Workstation
File Edit View VM Tabs Help
Library
Type here t...
My Computer
RasPi
Home
RasPi
Set Country
Enter the details of your location. This is used to set the language, time zone, keyboard and other international settings.
Country: Ethiopia
Language: Amharic
Timezone: Addis Ababa
Use English language
Use US keyboard
Press 'Next' when you have made your selection.
Back
Next
Click in the virtual screen to send keystrokes
Install Debian 12.x 64-bit as you would on a physical computer. When you are done and the operating system boots up, click "I Finished Installing".
I Finished Installing
Help
To direct input to this VM, click inside or press Ctrl+G.
Type here to search
86°F
ENG
5:01 AM
5/12/2025

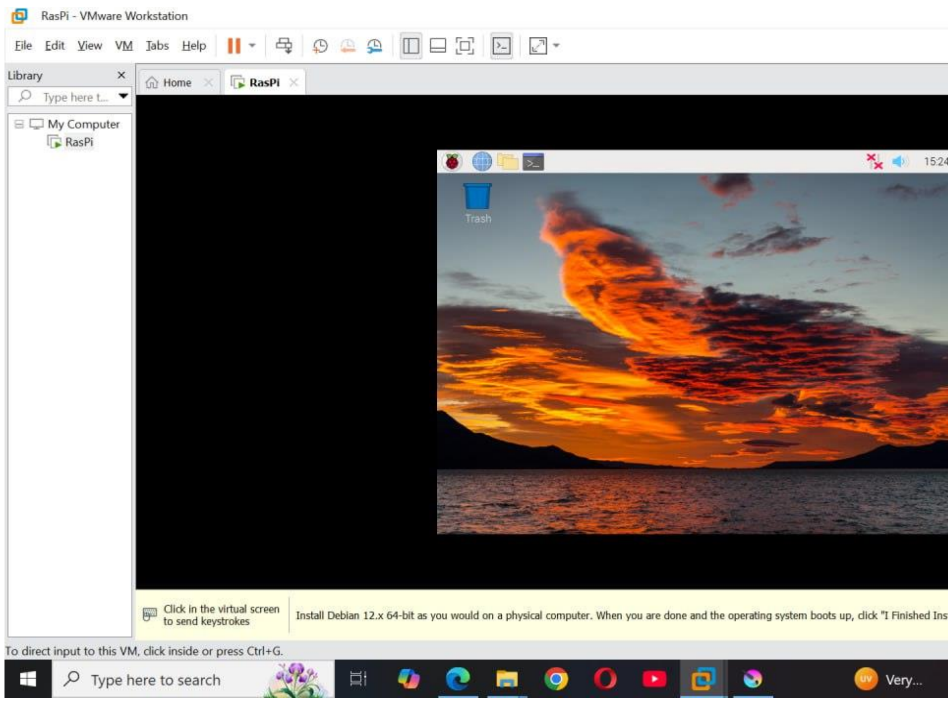

RasPi - VMware Workstation
File Edit View VM Tabs Help
Library
Type here t...
My Computer
RasPi
Home
RasPi
Update Software
The operating system and applications will now be checked and updated if necessary. This may involve a large download.
Press 'Next' to check and update software, or 'Skip' to continue without
Reading update list - please wait...
Back
Skip
Next
Click in the virtual screen to send keystrokes
Install Debian 12.x 64-bit as you would on a physical computer. When you are done and the operating system boots up, click "I Finished Installing".
I Finished Installing
Help
To direct input to this VM, click inside or press Ctrl+G.
Type here to search
86°F
ENG
5:03 AM
5/12/2025


RasPi - VMware Workstation
Create User
You need to create a user account to log in to your Raspberry Pi.
The username can only contain lower-case letters, digits and hyphens, and must start with a letter.
Enter username: yonas mulugeta
Enter password:
Confirm password:
Hide characters
Press 'Next' to create your account.
Back
Next
Click in the virtual screen to send keystrokes
Install Debian 12.x 64-bit as you would on a physical computer. When you are done and the operating system boots up, click "I Finished Installing".
I Finished Installing
Help
To direct input to this VM, click inside or press Ctrl+G.
5:02 AM
5/12/2025


RasPi - VMware Workstation
Update Software
The operating system and applications will now be checked and updated if necessary. This may involve a large download.
Press 'Next' to check and update software, or 'Skip' to continue without checking.
Back
Skip
Next
Click in the virtual screen to send keystrokes
Install Debian 12.x 64-bit as you would on a physical computer. When you are done and the operating system boots up, click "I Finished Installing".
I Finished Installing
Help
To direct input to this VM, click inside or press Ctrl+G.
5:03 AM
5/12/2025



Finally you will see the following interface



E. Issues

1. SlowPerformance

Description:AfterinstallingRaspberryPiOSinVirtualBox,thesystemcanfeel sluggishorunresponsive, especially during updates or graphical usage.

- Cause:LimitedRAMorCPUresourcesallocatedtothevirtualmachine;defaultsettingsinVirtualBoxare not optimized for performance.

2. DisplayResolutionProblems

- Description:ThedesktopenvironmentmaynotautomaticallyresizetofittheVirtualBoxwindow.In some cases, the resolution may be stuck at a low value like 800x600.
- Cause:MissingVirtualBoxGuestAdditions,whichprovidedriversandintegrationsforbetterdisplayand mouse control.

3. MouseIntegrationNotWorkingProperly

- Description:Themousepointermaynotbecapturedormaybehaveerraticallywheninteractingwith the Raspberry Pi OS window.
- Cause:GuestAdditionsarenotinstalled,orVirtualBoxisnotusingthecorrectinputcapturesettings.

4. USBDeviceDetectionFailure

- Description:USBdevices(e.g.,flashdrives)arenotrecognizedinsidetheVM.
- Cause:USBcontrollernotenabledinVirtualBoxsettings,orExtensionPacknotinstalled.

5. BootLoaderFreezeorBlackScreen

- Description:AfterstartingtheVM,thebootloadergetsstuck,orablackscreenappears.
- Cause:IncorrectISO,damagedISOimage,ormisconfiguredvirtualhardware(e.g.,wrongOSversion type selected).

F. Solutions Implemented

1. OptimizingVMResources

- IncreasedtheRAMallocationto2048MBandassigned2CPUcores.
- Enabled3DaccelerationinVirtualBoxsettingsforimprovedUIrendering.

2. InstallingVirtualBoxGuestAdditions

- InsertedtheGuestAdditionsISO:
Devices→InsertGuestAdditionsCDImage...
- MountedtheCDandrantheinstallerinsideRaspberryPiOSterminal: bash

sudo mount /dev/cdrom /media/cdromsudo

/media/cdrom/VBoxLinuxAdditions.run

- RebootedVMtoenabledynamicdisplayresizingandbettermouseintegration.

3. EnablingUSBSupport

- InstalledtheVirtualBoxExtensionPackfromtheofficialwebsite.
- InVirtualBoxsettings:
  Settings→USB→EnableUSB2.0or3.0Controller
- AddedspecificUSBdevicefiltersifnecessary.

4. ISOImage Troubleshooting

- VerifiedtheSHA256checksumofthedownloadedISO toensureit'snotcorrupted.
- SelectedthecorrectOStypeinVMsettings:Debian(64-bit)for64-bitRaspberryPiOS.

5. GeneralTips

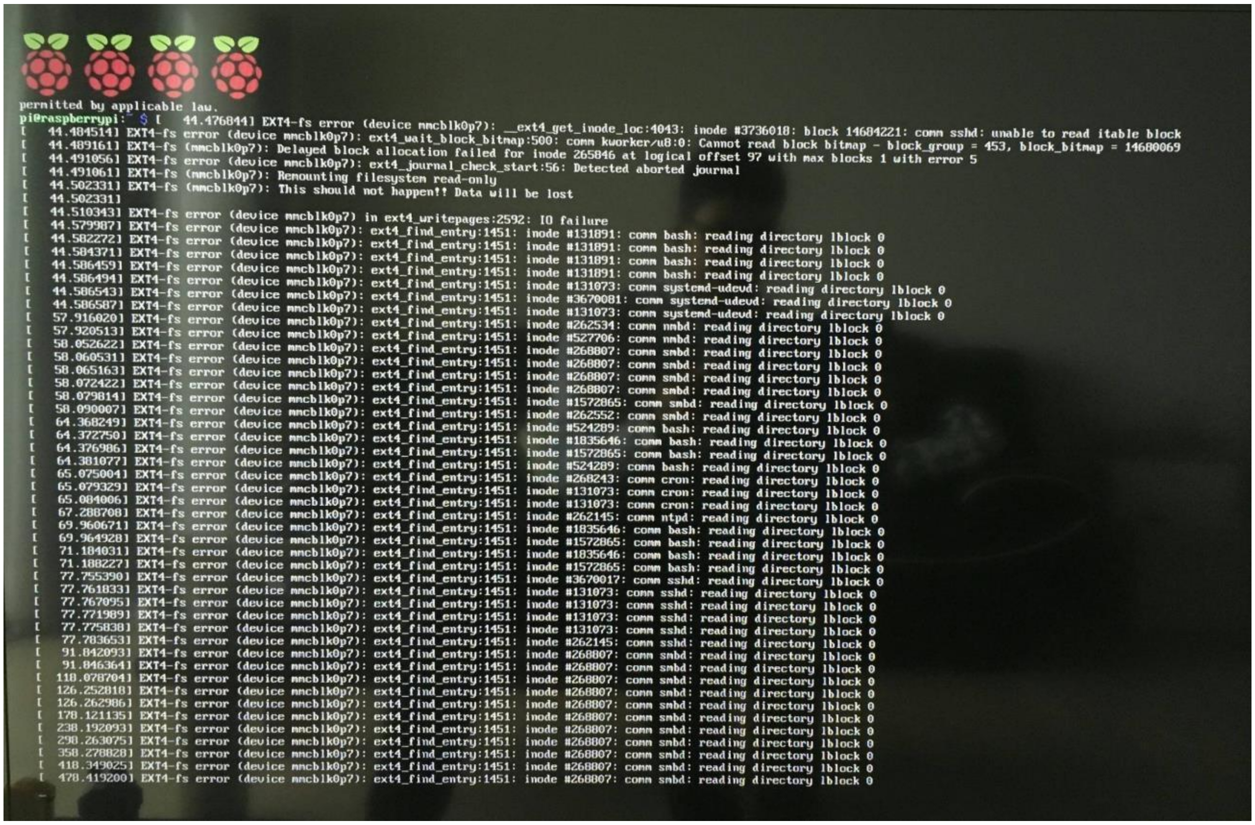
- AlwayskeepVirtualBoxandExtensionPackupdated.
- UseVirtualBoxlogs(ShowLoginVMsettings)todiagnoseobscurebooterrors.
- EnableEFI(specialOSesonly)ifneededunderSystem→Motherboard.
- **g.FilesystemSupportinRaspberryPiOS**
  - RaspberryPiOS,beingaDebian-basedLinuxdistribution,supportsawidevarietyoffilesystems. However,certainfilesystemsarepreferreddependingontheusecase,especiallyforsystempartitions and external devices.

G. FILESUPPORTSYSTEM

1. ext4(FourthExtendedFilesystem)

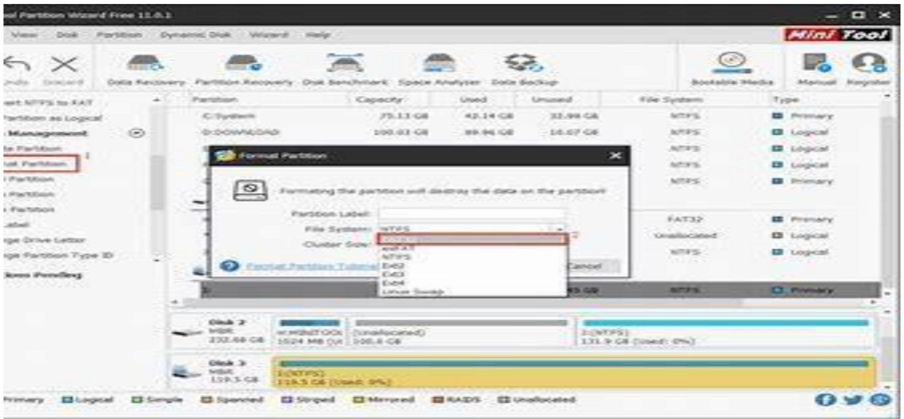
- **DefaultandRecommendedFilesystemforRaspberryPiOS**
- **Features:**
- Journalingforimprovedreliability
- Largefileandvolumesupport
- Backwardcompatibilitywithext2andext3

- **Whyit'sused:**
  Itisthedefaultbecauseitisrobust,fast,andspecificallyoptimizedforLinuxsystems.Itsupports permissions and security features required by the OS.



2. FAT32(FileAllocationTable)

- **UsedmainlyforbootpartitionsandSDcards**
- **Features:**
- Cross-platformcompatibility(Windows,Linux,macOS)
- Limitedfilesizesupport(max4GBperfile)
- **Whyit'sused:**
  RaspberryPiOSusesFAT32forits/bootpartitionsothatitcanbereadandmodifiedbyotheroperating systems like Windows, especially when preparing the SD card before boot.



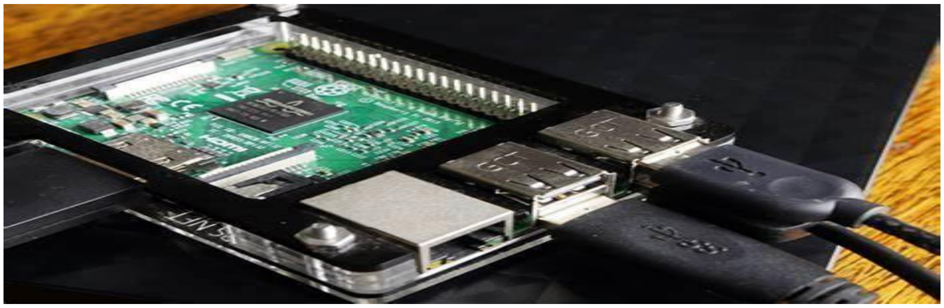
3. exFAT(ExtendedFileAllocationTable)

- **UsedforlargeexternaldrivesorUSBsticks**
- **Features:**
- Supportslargefiles(>4GB)
- Betterperformanceforflashstorage
- **Whyit'sused:**
  exFATisidealforremovablestoragewherelargefiles(e.g.,videos)arehandled,anditoffersbetter speed and compatibility than FAT32 without the 4GB file size limitation.

4. NTFS(NewTechnologyFileSystem)

- **Windows-nativefilesystem**
- **Features:**
- Journalingandadvancedpermissions
- BettersupportforlargefilesandpartitionsthanFAT32

- **Whyit'sused:**
RaspberryPiOScan**readandwrite**toNTFS-formatteddrivesusingntfs-3g,makingitusefulforfile sharing between Raspberry Pi and Windows systems.



H. AdvantagesandDisadvantagesofUsingRaspberryPiOSinaVirtual Environment

Advantages

- 1.Performance-OptimizedandLightweight
- RaspberryPiOSisdesignedtoberunonlow-powerplatforms,thuslightweightandefficient.
- Evenrunningavirtualmachine,itdoesjustfinewhenwell-provisionedwithresources.

2. EducationalandDeveloper-Focused

- IdealforlearningandteachingLinux,systemadministration,anddevelopmentinlanguageslikePython, C, and Shell.
- Preloadedwithusefultoolslikethetermina l,ThonnyIDE,andPythonpackages.

3. ZeroCostandOpenSource

- Totallyopen-source,withawelcometoexplore,adapt,anddistribute.
- Nolicensefeesorsubscriptionchargesarerequiredforuseinvirtualoractualenvironments.

4. SafeTestingEnvironment

- RaspberryPiOScanbeinstalledintoavirtualenvironmenttotestsystemprogramming,package installation, and setup without risking actual hardware.

5. LargeSupportBase

- Excellentglobalsupportwithforums,how-to's,andtroubleshootingguides.
- MuchdocumentationisreleasedthatexplainscomplextopicslikeGPIOsimulationorcross-compilation.

6. Customizability

- Theuserhasfullcontroltoinstall,remove,orpersonalizepackages,desktops,andstartupservices.

- IdealforembeddedsystemsandIoTsimulation.

Disadvantages

1. LimitedHardwareAccessinVM

- ThosefunctionalitiesrelyingonGPIOpins,cameramodules,orotherhardwareinterfacesarenot supported in a virtualized environment.
- Itlimitssimulatingthewholehardwareoractuallyutilizingitforroboticsandhardwareprojects.

2. PoorerPerformanceinVirtualMachines

- Whilelight,performancecannonethelessbeaffectedbyvirtualizationoverhead.
- Multitaskingandgraphicsapplicationscanbeslowifnotenoughresources(RAM/CPU)areallocated.

3. VirtualizationCompatibilityIssues

- Somedriversorfeatures(e.g.,auto-resizedisplay,drag-and-drop)maynotbeworkingout-of-the-box without Guest Additions installation and setup.

4. NotSuitableforResource-HungryApplications

- RaspberryPiOSisnotdesignedforresource-hungryapplicationslikevideoediting,3Dmodeling,or heavy development.
- Designedforlearning,prototyping,andlow-endcomputing.

5. ManualConfigurationRequired

- Powerusersmayneedtotweakkernelparameters,installmissingpackages,orfixbrokendependencies —alearningcurvefornewbies.

I.Conclusion

Theprocess ofinstallingandexploringRaspberryPiOSinavirtualenvironmenthasprovidedinvaluable insight into the inner workings of Linux-based operating systems and their real-world applications. Throughthisexercise,wehavenavigatedthecompletelifecycleofsystemdeployment—fromsettingup virtual hardware and configuring an operating system, to identifying issues and applying low-level solutions using system programming.

RaspberryPiOS,withitsbalanceofsimplicity,flexibility,andpowerfulcommand-linetools,provestobe an excellent platform for academic and practical learning. Despite the limitations posed by virtualized environments, the OS performed reliably, offering all the tools necessary for system-level experimentationandsoftwaredevelopment.

Thisprojectnotonlystrengthenedfoundationalconceptssuchasfilesystems,systemcalls,and virtualization,butalsonurturedhands-onskillsthatareessentialforcareersinsoftwareengineering, systemadministration,andembeddedsystemsdevelopment.Thestructuredapproachtodiagnosing problems,applyingfixes,anddocumentingoutcomessimulatesreal-worldprofessionalpracticesand prepares students for future challengesin operating system and system programming tasks.

J.FutureOutlook&Recommendations

1. RaspberryPiOSasaLearningandDevelopmentPlatform

RaspberryPiOSwillcontinuetobeamajorforceineducation,prototyping,andembeddedsystems.Its slim footprint and Debian roots make it ideal for:

- Computerscienceeducation:Itisutilizedbyuniversitiesandschoolsto instructLinux fundamentals, programming (Python, C, etc.), and electronics.
- HobbyistandMakerprojects:ItisGPIOandsensor-enabled,whichmakesitagreatfitforIoT, robots, and home automation.
- Remotelearninglabs:Duetovirtualization,theRaspberryPiOScanbeinstalledremotelyon virtual machines, lessening physical hardware requirements.

2. VirtualizationTrends

Virtualmachinesareslowlybeingreplacedorsupplementedbycontainers(e.g.,Docker).Nevertheless, understanding full virtualization is still necessary:

- RaspberryPiOSwithinaVMisalsoidealforsandboxing,emulation,andtestingappsaheadof time.
- DeveloperscantestARMenvironmentsonx86machinesusingemulationorQEMU.
- VirtualBox/VMwareofferssafeexperimentationwithoutdamagingrealdevices.

3. Utilizingpivot_root()inReal-WorldSituations

Thepivot_root()systemcallplaysanimperativerolein:

- ContainerruntimeslikeDocker,runc,andsystemd-nspawn,whichisolateprocessesintheirown root filesystem.
- EmbeddedLinuxenvironmentstoboottominimalandthencontinuebootingtheentireOS.
- OScustombootorderings,whereinearlyRAMdisk(initramfs)boots-indriversandbringsin actual real root.

Tip:Tinkerwithpivot_root()viamakingsimplecontainerenvironmentsorspecializedbootableroot filesystems for Raspberry Pi OS. This assists in learning about process isolation, file system administration, and low-level Linux internals.

4. ResearchandInnovationOpportunities

ExplorehowRaspberryPiOScanbetransformedintolightweightLinuxcontainersusingpivot_rootand namespaces.

Developlightweightscriptsortoolsforautomaticrootswitching,whichwouldbeusefulinadvanced mbedded or rescue systems.

Explorefuturesupportfornewfilesystems(likeBtrfsorZFS)inRaspberryPiOSforenhanced snapshotting and data integrity.

5. StudentRecommendation

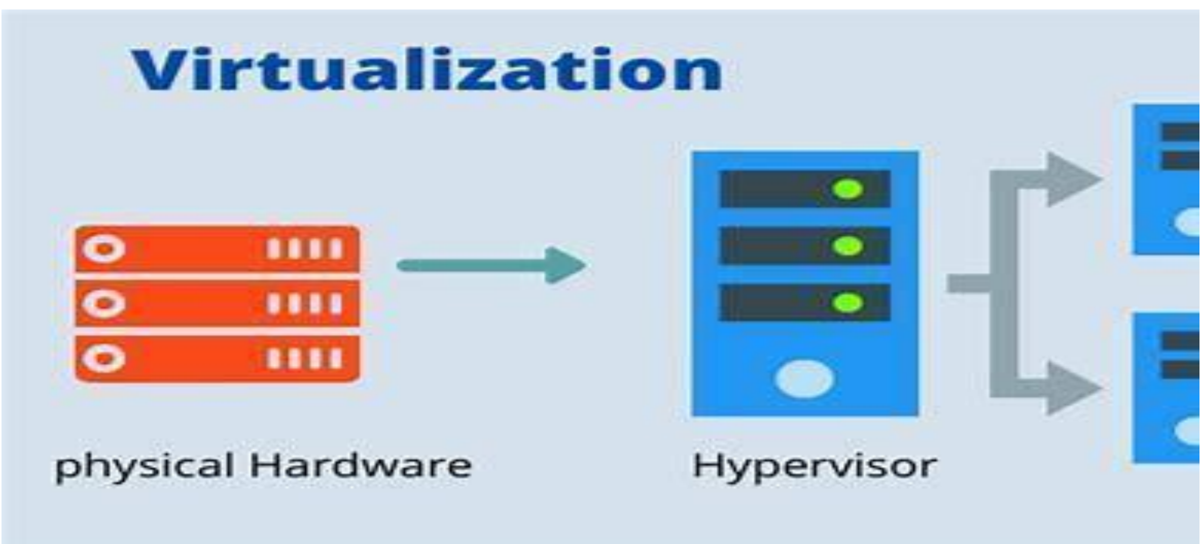
- LearnLinuxbasicsusingRaspberryPiOSwithinaVM.
- Experimentwithsystemcallslikepivot_root()usingsmall,testableenvironments.
- Documentandscriptyourwork—buildyourowntoolsusingshellorPython.
- TrytocombinevirtualizationwithDevOpstools(e.g.,VagrantorAnsible)formanagingyourOS setups

2. Brieflyexplainthewhat,whyandhowvirtualizationinmodernoperating system.

WhatisVirtualization?

Virtualizationisatechnologythatallowsmultiplevirtualinstancesofcomputingenvironments—suchas operating systems, servers, or applications—to run on a single physical hardware system. These virtual environments are called **Virtual Machines (VMs)** and are managed by software known as a **hypervisor**.

Virtualization is the creation of a virtual version of a physical computer such as CPU, Memory and storage, enabling multiple operating systems or applications to run on the same hardware. Itachieves thisbyabstractingthehardwarelayer,allowingsoftwaretosimulatehardwarefunctionalityandcreate virtual machines (VMs). Itisatechnologythathelps us toinstall differentOperatingSystemson hardware. Theyare completelyseparatedandindependentfromeach other.



WhyisVirtualizationImportant?

1. **EfficientResourceUtilization**:Insteadofdedicatinganentirephysicalmachinetooneoperatingsystem or application, virtualization allows multiple VMs to share CPU, RAM, storage, and I/O resources.
2. **CostReduction**:Organizationssaveonhardware,power,andmaintenancebyconsolidatingworkloads onto fewer physical machines.
3. **IsolationandSecurity**:EachVMrunsinisolation,whichimprovessecurity.IfoneVMiscompromised, others remain unaffected.
4. **FlexibilityandScalability**:VMscanbeeasilycreated,modified,cloned,ordeleted,makingdevelopment, testing, and deployment much faster.
5. **DisasterRecovery**:Virtualmachinescanbebackedupandrestoredquickly,supportingbusiness continuity.

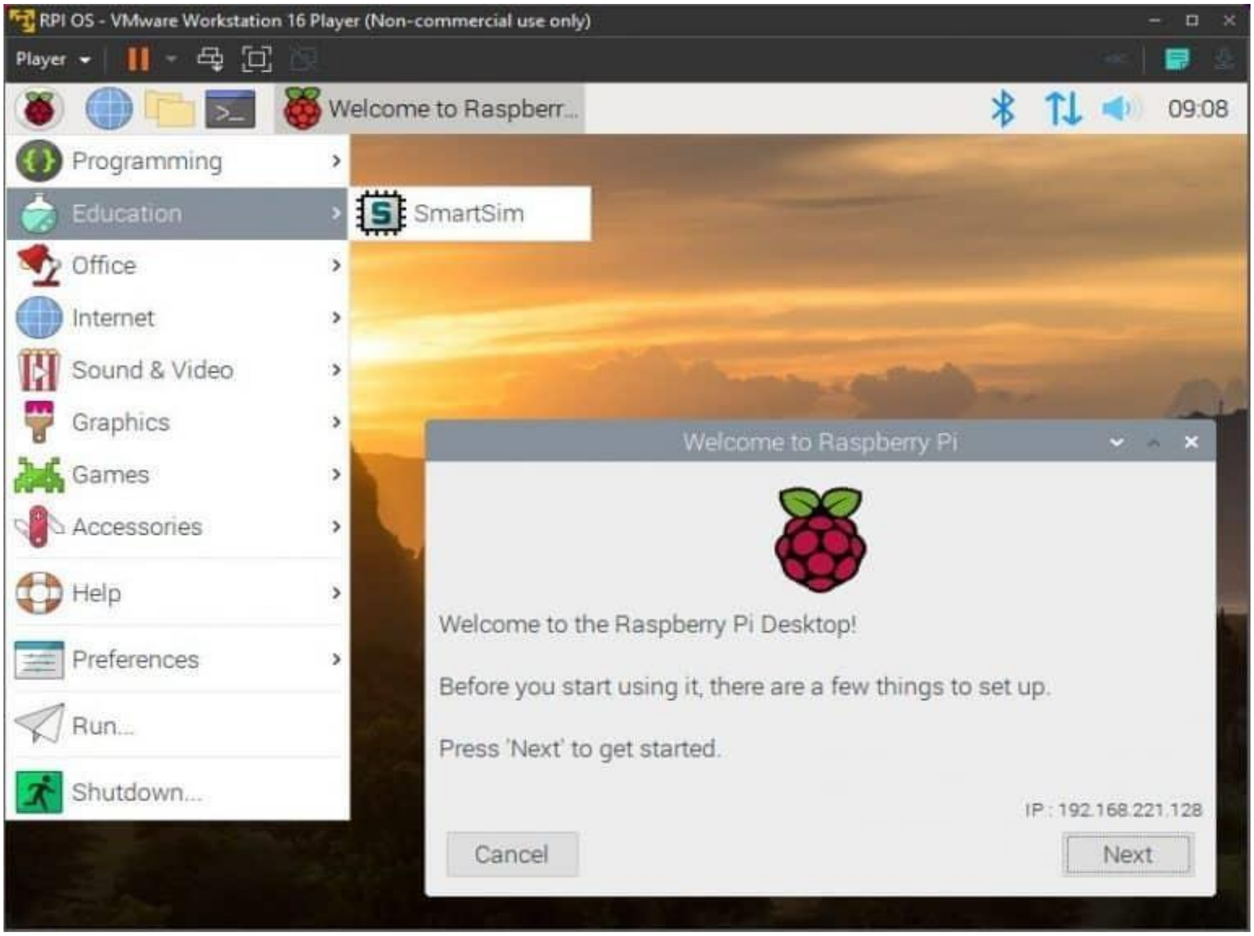
HowDoesVirtualizationWork?

Virtualizationisbasedon2majorconcepts:hypervisorsandvirtualmachines.

Virtualmachines

A virtual machine (VM) is a computer setting that is an isolated system with its own CPU, operating system(OS),memory,networkinterface,andstoragecomposedoutofapoolofresourcesofhardware. A VM can be defined by a single data file. As an isolated setting, it can be moved from 1 computer to another, opened on either, and be expected to do the same.

Virtualizationallowsmultipledistinctoperatingsystemstorunonasinglephysicalplatform simultaneously—likeaMacOSorWindowsenvironmentwithinaLinuxmachine.Eachoperatingsystem runs just as it would on a native OS or application on the host hardware, so the end user experience is essentially identical to a real-time OS experience on a physical platform.



Hypervisors

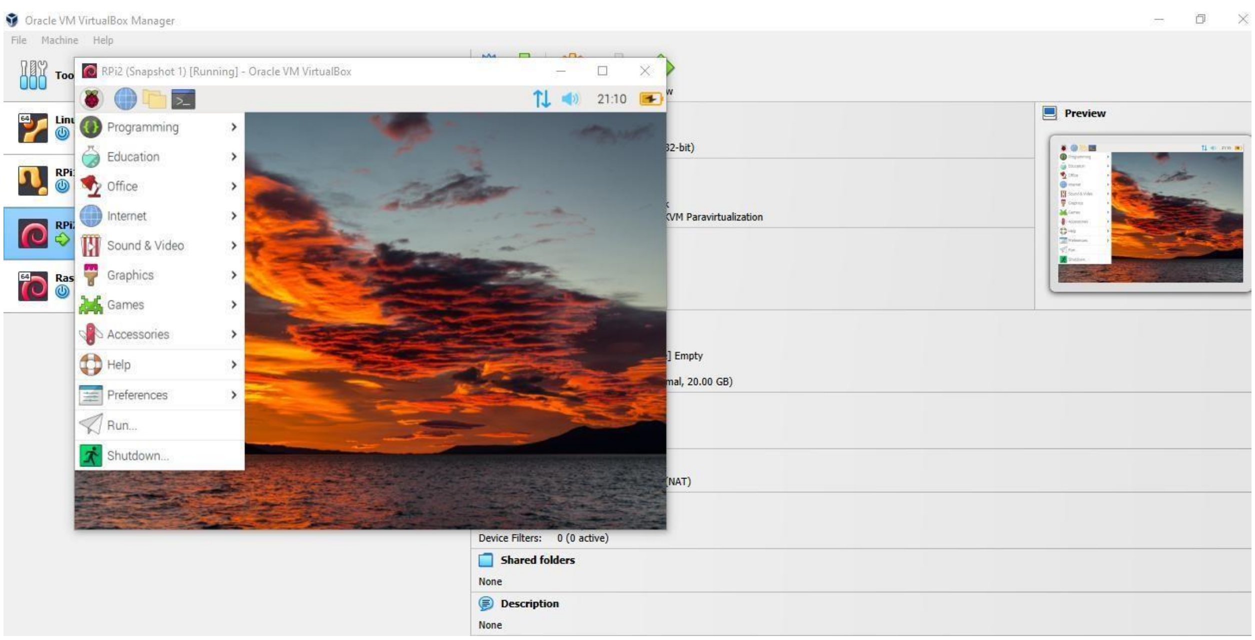
Alsoknownasavirtualmachinemonitor(VMM),ahypervisorissoftwarethatseparatesthephysical resources of a system and divides up these resources so virtual environments can access them as needed. A hypervisor abstracts physical resources (such as CPU,memory,and storage) from hardware andallocatesthemtomultipleVMsatonce,whichmeansnewVMscanbemadeand existingonescan bemanaged.Hypervisorscansitontopofanoperatingsystem(likeonalaptop)orbedirectlyinstalled onhardware(likeaserver). Theunderlying physical hardware, whenusedasa hypervisor,iscalledthe host, and the many VMs that tap into its resources are guests

Whenthevirtualenvironmentisupandrunningandaprocessoruserrequestssomethingthatrequires more resources of the physical environment,the hypervisor passes the request to the physical system and buffers the changes—everything at near-native speed.

Thereare2typesofhypervisorsthatfacilitatevirtualizationtotakeplacebasedonneed.

Type1:Itisalsoreferredtoasanativeorbare-metalhypervisorandrunsdirectlyonthehosthardware to host the guest operating systems. It substitutes a host operating system,and the VM resources are scheduleddirectlytohardwarebythehypervisor.Itisfoundtobemostcommoninanenterprise datacenter or other server-based environment.

Type2:Itisalsoknownasahostedhypervisor,anditrunsonanormaloperatingsystemasaprogramor layerofsoftware.Itworksonisolatingtheguestoperatingsystemsfromthe hostoperatingsystem.The resourcesof VMare allocatedagainstahost operating system,whichisthenrunagainsthardware. This kindisbettersuitedforindividualuseforthoseusers whowanttorun multipleoperatingsystemsonan individual computer.



3.Implementing System Call:pivot_root()

Implementing the pivot_root() system call on **Raspberry Pi OS** in C++ involves some specific steps that youneedtofollowtochangetherootfilesystemofarunningprocess.RaspberryPiOS,basedonDebian, provides full support for Linux system calls like pivot_root(), so the process of implementing it is similarto what you would do in a typical Linux environment. However, certain Raspberry Pi-specific considerations,likehandlingthefilesystem,memory,anddeviceconstraints,shouldbetakeninto account.

- Step-by-stepthroughtheimplementationandthedetailsofhowitworkson**RaspberryPiOS**.

1. Prerequisites:

Beforeimplementingthepivot_root()systemcallinC++onRaspberryPiOS,youneedtosetup the environment properly. Here's what you need to do:

- **InstallDevelopmentTools**:Makesureyouhavethenecessarydevelopmenttoolslikeg++,make,and libc6-dev installed on your Raspberry Pi OS.
- **MounttheNewRootFilesystem**:Thenewrootfilesystemshouldalreadybemountedbeforecalling pivot_root(). You'll need a valid new root (e.g., a directory or a mount point where the new root filesystem is located).
- **DevicePermissions**:pivot_root()requiresrootprivileges,soyourC++programneedstoberunwith elevated permissions.

2. System Call pivot_root() Overview

Thepivot_root()systemcallchangestherootfilesystemofthecurrentprocess.Here'sthebasicsyntax: int

pivot_root(const char *new_root, const char *put_old);

- **new_root**:Pathtothenewrootfilesystemdirectory.
- **put_old**:Pathtothedirectorywheretheoldrootfilesystemwillbemoved. After

the pivot_root() system call:

- Thenewroot(new_root)becomestherootdirectoryofthecurrentprocess.
- Theoldrootismovedtotheput_olddirectory.
- Theprocessneedstoswitchtothenewrootandensuretheoldrootisproperlyunmountedlater.

1. Create a new root mount point

sudo mkdir -p /mnt/new_root

2. Mount the desired root filesystem

sudo mount /dev/sdX1 /mnt/new_root

3. Verify contents of the new root

ls /mnt/new_root

4. Bind mount essential filesystems

sudo mount --bind /dev /mnt/new_root/dev

sudo mount --bind /proc /mnt/new_root/proc

sudo mount --bind /sys /mnt/new_root/sys

5.Create a directory to hold the old root

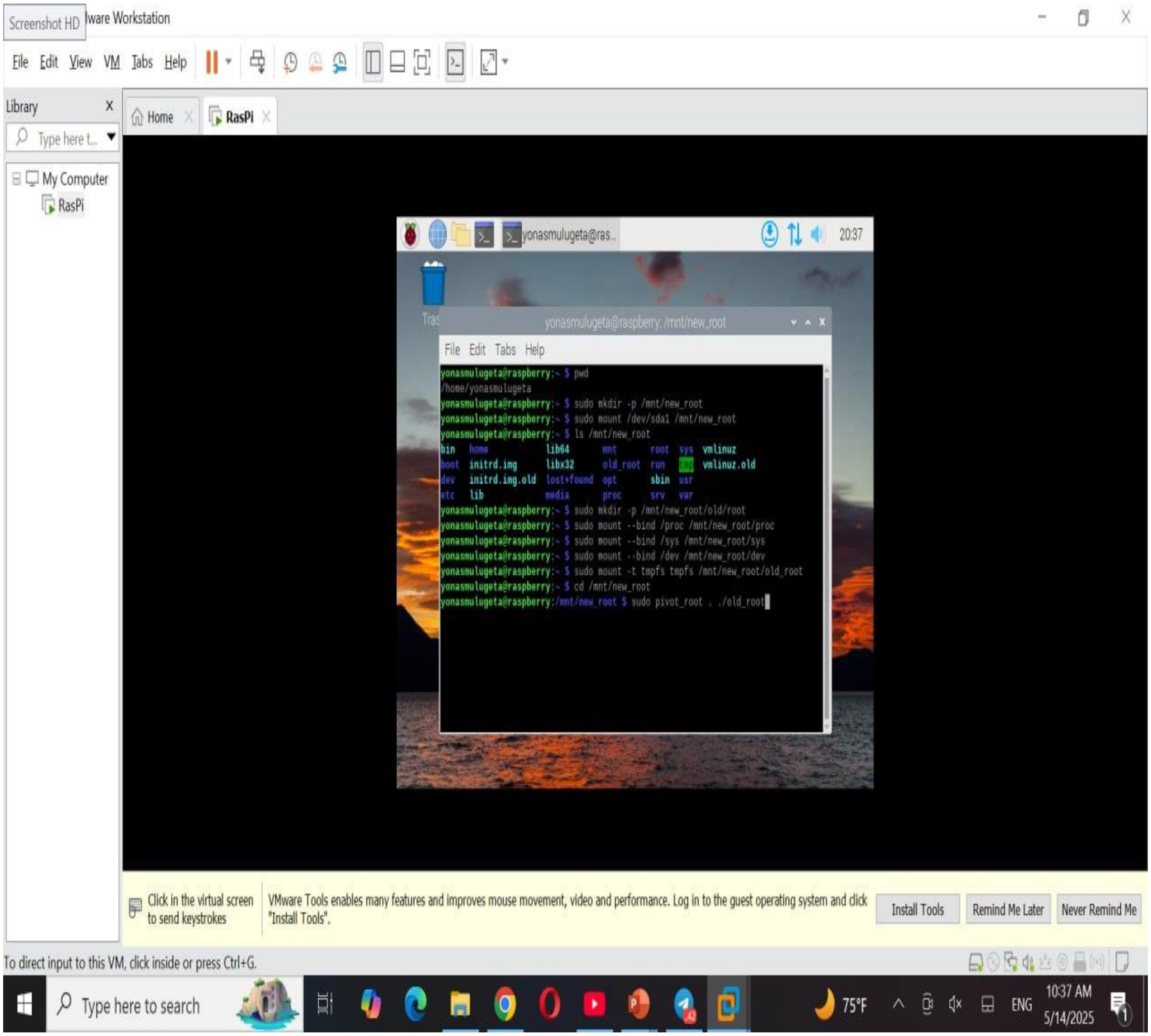
sudo mkdir /mnt/new_root/old_root

6. pivot_root operation

cd /mnt/new_root

sudo pivot_root . old_root

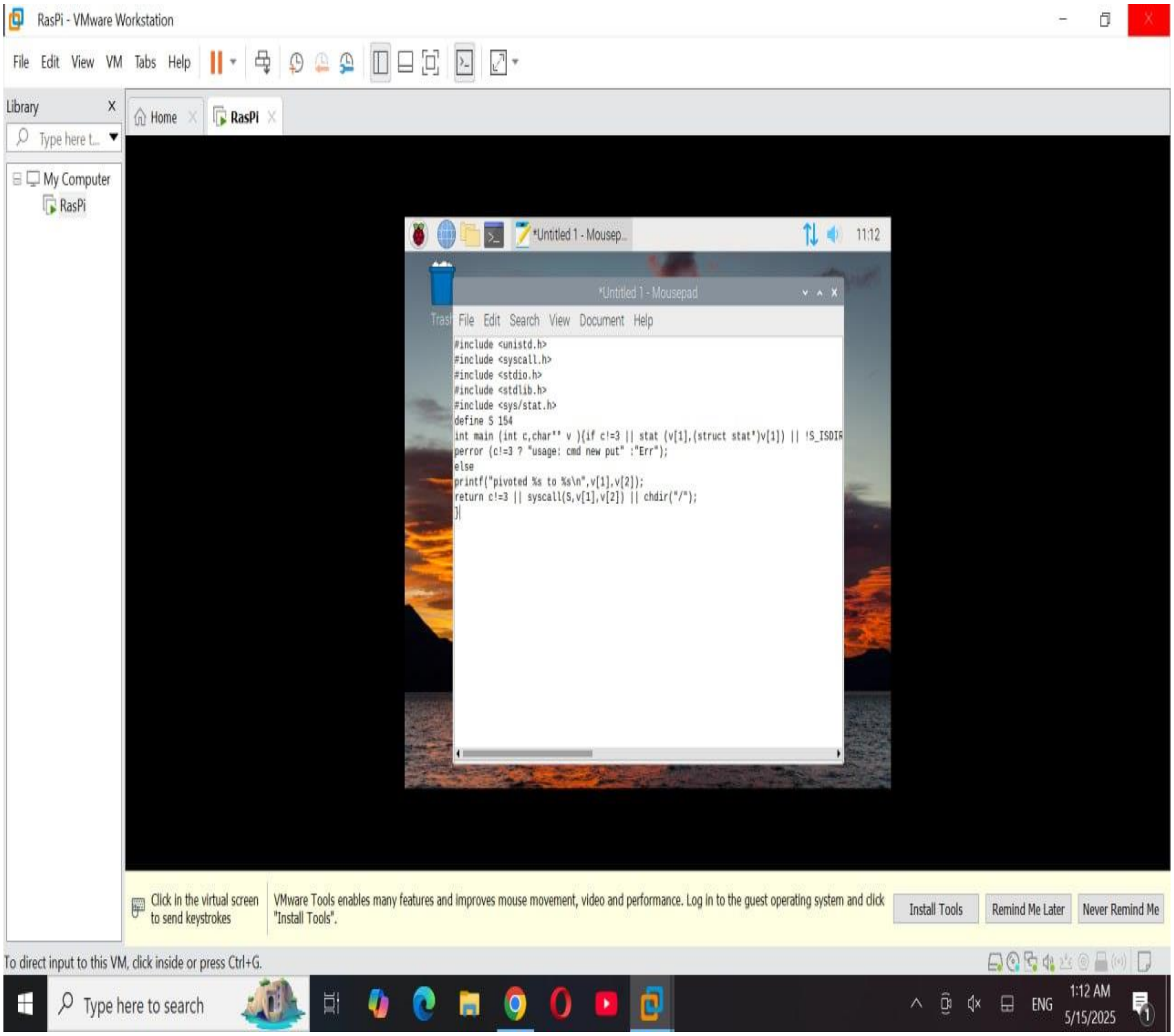
Click on terminal then write the above code



Here is a shorter and still functional version of the pivot_root code in C:

```
#include <unistd.h>

#include <sys/syscall.h>

#include <stdio.h>

#include <sys/stat.h>
```

```
#define PIVOT_ROOT 155

int main(int c, char **v) {
    struct stat s;
    if (c != 3 || stat(v[1], &s) || !S_ISDIR(s.st_mode) || stat(v[2], &s) || !S_ISDIR(s.st_mode)) {
        return fprintf(stderr, "Usage: %s new_root put_old\n", v[0]), 1;
    }
    if (syscall(PIVOT_ROOT, v[1], v[2]) || chdir("/")) {
        perror("pivot_root");
        return 1;
    }
    printf("pivoted to %s, old root -> %s\n", v[1], v[2]);
    return 0;
}
```



Then save the file pivot_root.c and compile the file by using these commands

gcc -o pivotroot pivotroot.c

sudo mount /dev/sdX1 /mnt/new_root

sudo mount --bind /dev /mnt/new_root/dev sudo mount --bind /proc /mnt/new_root/proc

sudo mount --bind /sys /mnt/new_root/sys

sudo mkdir /mnt/new_root/old_root

sudo ./pivot /mnt/new_root /mnt/new_root/old_root