



Practical Linux with Raspberry Pi OS



Quick Start

—

Ashwin Pajankar

Practical Linux with Raspberry Pi OS

Quick Start

Ashwin Pajankar

Apress®

Practical Linux with Raspberry Pi OS: Quick Start

Ashwin Pajankar
Nashik, Maharashtra, India

ISBN-13 (pbk): 978-1-4842-6509-3
<https://doi.org/10.1007/978-1-4842-6510-9>

ISBN-13 (electronic): 978-1-4842-6510-9

Copyright © 2021 by Ashwin Pajankar

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

Trademarked names, logos, and images may appear in this book. Rather than use a trademark symbol with every occurrence of a trademarked name, logo, or image we use the names, logos, and images only in an editorial fashion and to the benefit of the trademark owner, with no intention of infringement of the trademark.

The use in this publication of trade names, trademarks, service marks, and similar terms, even if they are not identified as such, is not to be taken as an expression of opinion as to whether or not they are subject to proprietary rights.

While the advice and information in this book are believed to be true and accurate at the date of publication, neither the authors nor the editors nor the publisher can accept any legal responsibility for any errors or omissions that may be made. The publisher makes no warranty, express or implied, with respect to the material contained herein.

Managing Director, Apress Media LLC: Welmoed Spahr
Acquisitions Editor: Aaron Black
Development Editor: James Markham
Coordinating Editor: Jessica Vakili

Distributed to the book trade worldwide by Springer Science+Business Media New York, 1 NY Plaza, New York, NY 10014. Phone 1-800-SPRINGER, fax (201) 348-4505, e-mail orders-ny@springer-sbm.com, or visit www.springeronline.com. Apress Media, LLC is a California LLC and the sole member (owner) is Springer Science + Business Media Finance Inc (SSBM Finance Inc). SSBM Finance Inc is a **Delaware** corporation.

For information on translations, please e-mail booktranslations@springernature.com; for reprint, paperback, or audio rights, please e-mail bookpermissions@springernature.com.

Apress titles may be purchased in bulk for academic, corporate, or promotional use. eBook versions and licenses are also available for most titles. For more information, reference our Print and eBook Bulk Sales web page at <http://www.apress.com/bulk-sales>.

Any source code or other supplementary material referenced by the author in this book is available to readers on GitHub via the book's product page, located at www.apress.com/978-1-4842-6509-3. For more detailed information, please visit <http://www.apress.com/source-code>.

Printed on acid-free paper

*I dedicate this book to Subrahmanyan Chandrasekhar,
a great Indian-American astrophysicist.*

Table of Contents

About the Author	xi
About the Technical Reviewer	xiii
Acknowledgments	xv
Introduction	xvii
 Chapter 1: Introduction to Raspberry Pi.....	 1
Single-Board Computers.....	2
Raspberry Pi.....	2
Linux and Distributions	5
Raspberry Pi OS.....	6
Raspberry Pi OS Setup.....	6
Preparing the SD Card Manually.....	14
Booting Up the Pi Board for the First Time	17
Configuring the RPi Board.....	18
Connecting Various RPi Board Models to the Internet	29
Summary.....	34
 Chapter 2: Getting Ready.....	 35
Operating System Shell.....	36
Raspberry Pi OS GUI.....	36
The Command Prompt	38
Updating the RPi OS	39

TABLE OF CONTENTS

Linux Filesystem	39
Remotely Accessing the RPi.....	43
Summary.....	51
Chapter 3: Directory Commands and Text Editors	53
Absolute and Relative Paths	54
Commands: pwd, tree, and cd.....	54
Command: ls	57
Command: touch	60
Various Text Editors.....	61
Create and Delete Directories	62
Case-Sensitive Names of Directories and Files	64
Summary.....	65
Chapter 4: More Commands	67
Configuring the RPi Board.....	68
What Is sudo?	69
Getting Help on Commands	69
Network-Related Commands	70
Commands: File Operations	73
Printing a String	75
Control Operators	75
Filename Globbing	77
Command: History.....	78
Pipes	78
Summary.....	79

Chapter 5: Useful Unix Commands and Tools	81
Shell and Environment Variables	81
Useful Linux Commands	83
Useful Unix Tools	86
Summary.....	89
Chapter 6: Shell Scripting.....	91
Unix File Permissions.....	92
Command: nohup	94
Beginning Shell Scripting.....	95
User Input.....	96
Expressions in the Shell.....	97
If Statement	99
Switch Case	101
Length of a Shell Variable	102
Command-Line Arguments	102
Function	103
Loops in the Shell	104
Comparing Strings	106
File Operations	108
Summary.....	110
Chapter 7: I/O Redirection and Cron	111
I/O Redirection	111
stdin.....	112
stdout	112
Stderr.....	113

TABLE OF CONTENTS

Crontab	114
Summary.....	116
Chapter 8: Introduction to High-Level Programming Languages	117
C and C++ Programming.....	118
Python Programming Language.....	120
History of the Python Programming Language.....	120
Python Enhancement Proposals.....	121
Applications of Python.....	122
Python 3 on Debian Derivatives	123
Python Modes	123
Interactive Mode.....	127
Script Mode	128
Summary.....	131
Chapter 9: Programming with RPi GPIO	133
General-Purpose Input/Output Pins	133
Programming with GPIO.....	138
Summary.....	141
Chapter 10: Explore the RPi OS GUI	143
GUI Utilities on the RPi OS.....	143
Other Desktop Environments	145
XFCE	145
KDE Plasma	148
Summary.....	150

Appendix: Additional Tools	151
Raspberry Pi Imager	151
Additional Utilities	152
Manjaro Linux	153
FreeBSD	153
Additional OSs.....	153
Index.....	155

About the Author

Ashwin Pajankar holds a Master of Technology from IIIT Hyderabad. He started programming and tinkering with electronics at the tender age of 7. BASIC (Beginners' All-Purpose Symbolic Instruction Code) was the first programming language he worked with. He was gradually exposed to C programming, 8085, and x86 assembly programming during his higher secondary schooling. He is proficient in x86 assembly, C, C++, Java, Python, and Linux shell programming. He is also proficient with Raspberry Pi, Arduino, BBC Micro Bit, and other single-board computers (SBCs) and microcontrollers. Ashwin is passionate about training and mentoring. He has trained more than 100,000 trainees and professionals through live training sessions and online training courses. He has published more than a dozen books with both international and Indian publishers. He has also reviewed numerous books and educational video courses. This is his sixth book with Apress, and he is working on more books. He regularly conducts programming boot camps and hands-on training for software companies in Nashik, India.

He is also an avid YouTuber with more than 10,000 subscribers to his channel. You can find him on LinkedIn.

About the Technical Reviewer

Massimo Nardone has more than 22 years of experiences in security, web/mobile development, the cloud, and IT architecture. His true IT passions are security and Android.

He has been programming and teaching how to program with Android, Perl, PHP, Java, VB, Python, C/C++, and MySQL for more than 20 years.

He holds a Master of Science in Computing Science from the University of Salerno, Italy.

He has worked as a project manager, software engineer, research engineer, chief security architect, information security manager, PCI/SCADA auditor, and senior lead IT security/cloud/SCADA architect for many years.

Acknowledgments

I am thankful to Mr. Massimo Nardone, the technical reviewer of the book. I want to express my gratitude toward him for helping me make this book better. I would also like to express my gratitude to the Apress team. Aaron Black helped with the coordination of the entire book process, and Jessica Vakili guided the editorial process. James Markham helped me with the editorial review. I am also thankful to Celestin Suresh and Aditee Mirashi for giving me an opportunity to write this book.

Introduction

I have been working with Raspberry Pi since 2014. I was introduced to it while volunteering as an organizer at a hackathon at my former workplace. And as I have mentioned in my author biography, I have decent experience with assembly programming, microcontrollers, and digital electronics since my time as an undergraduate student of computer science. Raspberry Pi and Arduino are great choices for someone who wants the best of both of the worlds of computer science and electronics. Additionally, if you wish to use Linux, C, Python, and shell programming to drive your motors, LEDs, and other peripherals, then Raspberry Pi and similar single-board computers are the best fit for your applications.

While this is an introductory book for beginners who are new to the world of SBCs and hardware hacking, once you follow the book in detail, you will be very much comfortable exploring the world of SBCs and Raspberry Pi on your own.

This entire book is based on the challenges and struggles I faced while working the very first time with Raspberry Pi (abbreviated as RPi hereafter). I have listed all the tips and tricks I learned while exploring the RPi in the first few months. At that time, I really wished that I could get a book that would make my journey easier and so decided to write one myself. So, when the opportunity presented itself, I compiled all my experiences in this book so that anyone looking for help to get started with Raspberry Pi can benefit from this.

INTRODUCTION

While this book primarily covers the RPi OS flavor of Linux, I have made sure that I also introduce the readers to other important topics, such as programming with high-level languages like C, C++, and Python. I also introduce readers to GPIO (General-Purpose Input/Output) programming and various buses. Finally, I cover installation of a few popular Linux desktop environments such as XFCE, LXDE, and KDE Plasma. The appendix covers a few additional tips and tricks.

I hope that the book serves the readers well and they will enjoy the book as much as I enjoyed writing it.

CHAPTER 1

Introduction to Raspberry Pi

I hope you have gone through the Table of Contents and Introduction. If not, I highly recommend you go through them. This is the very first chapter of the book, and I welcome you all to the exciting journey of learning Linux with the Raspberry Pi Operating System.

In this chapter, we will learn the details about the most popular platform and single-board computer family of our times, the Raspberry Pi. Then we will learn a bit about Linux and the distribution of Linux that is popularly used with the Raspberry Pi family (hereafter, I will use the abbreviation RPi), the Raspberry Pi Operating System. We will learn how to install it on a RPi board. The following is the list of the topics that we will learn in this chapter:

- Single-board computers
- Raspberry Pi
- Linux and distributions
- Raspberry Pi OS setup
- Configuring the RPi board
- Connecting various RPi board models to the Internet

After completing this chapter, we will be comfortable with the installation and the basic usage of the RPi board and the RPi OS.

Single-Board Computers

Single-board computers (also known as SBCs) have all the components of a fully functioning computer like the processor, GPU, RAM, and I/O on a single printed circuit board. This is in contrast with desktop or laptop computers that have a motherboard which has various slots for RAM, the processor, and the graphics card. Desktop or laptop computers can be upgraded by replacing processors and graphics cards. We can also add more RAM chips in the RAM slots. However, SBCs cannot be upgraded like that. This is one of the major differences between traditional desktops/laptops that are totally modular and SBCs. The key benefit of the lack of modularity of SBCs is that the size of an entire computer is very small. Most of the SBCs are a little bigger than a regular credit/debit card, and they are very compact.

SBCs are used as technology demonstrators (prototypes), educational computers, and embedded systems. There is a recent surge in the popularity of SBCs due to advances in the fabrication process and manufacturing technologies. We are living in an era where a new SBC or a new version of an existing one is announced almost on a monthly basis. The market is full of various SBCs and SBC families. A few prominent SBC families are Raspberry Pi, Banana Pro, BeagleBoards, and Orange Pi. Raspberry Pi is the most popular family of single-board computers available in the market, and it is one of the best-selling computers in the world. In the next section, we will have an overview of the Raspberry Pi family of computers.

Raspberry Pi

Raspberry Pi is a family of SBCs developed by the Raspberry Pi Foundation (www.raspberrypi.org/). It consists of many board models, and all the current models under production are listed on the foundation's products

page (www.raspberrypi.org/products/). Throughout the book, I will be using a Raspberry Pi 4 Model B (the latest board model in the family) with 4 GB RAM.

Table 1-1 lists the specifications of the Raspberry Pi 4 Model B.

Table 1-1. *Technical Specifications of Raspberry Pi 4 B*

Component	Specification
Processor	Broadcom BCM2711, quad-core Cortex-A72 (ARM v8) 64-bit SoC at 1.5 GHz
RAM	LPDDR4-3200 SDRAM (2 GB or 4 GB or 8 GB)
Networking	2.4 GHz and 5.0 GHz IEEE 802.11ac wireless, Bluetooth 5.0, BLE Gigabit Ethernet
USB	2 USB 3.0 ports, 2 USB 2.0 ports
General-Purpose Input/Output	Raspberry Pi standard 40-pin GPIO header
Display	2 micro-HDMI ports (up to 4kp60 supported) Two-lane MIPI Display Serial Interface port (www.mipi.org/specifications/dsi)
Camera connector	Two-lane MIPI Camera Serial Interface port
Audio	Four-pole stereo audio and composite video port
Secondary storage	MicroSD card slot for OS and data storage
Power	5 V DC via USB-C connector or 5 V DC via GPIO header (minimum 3A)