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Certification Study Guide

Eighth Edition (Exam EX200)



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RHCSA[®]

Red Hat[®] Enterprise Linux[®] 9
Certification Study Guide
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Michael Jang
Alessandro Orsaria

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*For the young widows and widowers:
may they find the courage to face their fears,
to navigate their way through the pain,
and to find hope for a brighter future.*

ABOUT THE AUTHORS

Michael Jang (RHCE, LPIC-2, UCP, LCP, Linux+, MCP) is currently a Lead Technical Writer for Forescout. His experience with computers goes back to the days of jumbled punch cards. He has written other books on Linux certification, including *LPIC-1 in Depth*, *Mike Meyers' Linux+ Certification Passport*, and *Sair GNU/Linux Installation and Configuration Exam Cram*. His other Linux books include *Linux Annoyances for Geeks*, *Linux Patch Management*, and *Security Strategies in Linux Platforms and Applications*. He has also written or contributed to books on Microsoft operating systems, including *MCSE Guide to Microsoft Windows 98* and *Mastering Windows XP Professional, Second Edition*.

Alessandro Orsaria (RHCE, RHCA, CCIE x 2) is an IT professional with more than 20 years' experience in the industry. He has authored articles for technical Linux magazines and is currently employed by a proprietary trading firm. Alessandro is Red Hat RHCE and RHCA certified and has achieved two Cisco CCIE certifications in Routing & Switching and Datacenter. He holds an MBA from Imperial College of London and a degree in physics.

About the Technical Editor

Sam Doran is a Principal Software Engineer at Red Hat. He served in the U.S. Air Force as an aircraft mechanic and is a proud alumnus of the Virginia Tech Corps of Cadets. Prior to joining Red Hat, he worked for the U.S. government as well as private industry in jobs ranging from site reliability engineering to information security. He has used RHEL professionally since 2003 as well as a number of other Linux distributions.

CONTENTS AT A GLANCE

1	Prepare for the Red Hat RHCSA Certification	1
2	Fundamental Command-Line Skills	43
3	Managing Basic Networking	91
4	Software Management	127
5	systemd and the Boot Process	173
6	User Administration	215
7	Storage and Filesystem Administration	253
8	Linux Security	311
9	System Administration Tasks	353
10	An Introduction to Containers	405
A	Prepare a System for the Sample Exams	447
B	Solutions to RHCSA Sample Exam 1	451
C	Solutions to RHCSA Sample Exam 2	459
D	About the Online Content	467
	Index	471

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CONTENTS

<i>Acknowledgments</i>	<i>xix</i>
<i>Preface</i>	<i>xxi</i>
<i>Introduction</i>	<i>xxix</i>
<i>RHCSA Exam Readiness Checklist</i>	<i>xxxii</i>
1 Prepare for the Red Hat RHCSA Certification	1
The RHCSA Exam	4
The Exam Experience	4
Evolving Requirements	5
Basic Hardware Requirements	5
Hardware Compatibility	6
Architectures	6
RAM Requirements	7
Storage Options	7
Networking	8
Virtual Machine Options	8
Get Red Hat Enterprise Linux	9
Get a Subscription at No Cost	10
Purchase a Subscription	10
Third-Party Rebuilds	10
Check the Download	11
Exercise 1-1: Get Red Hat Enterprise Linux	12
An Environment for Practice Labs	12
System Roles	14
Getting VMware Workstation Player	14
Virtual Networks on a Hypervisor	16
Configure a Virtual Machine on VMware Workstation Player	18
RHEL 9 Installation	22
Boot Media	22
Basic Installation Steps	24
The Installation Perspective on Partitions	27
Partition Creation Exercise	30
Exercise 1-2: Partitioning During Installation	32
Wow, Look at All That Software!	34
Baseline Packages	35
During the Installation	35

	Initial Setup	36
	Certification Summary	37
✓	Two-Minute Drill	38
Q&A	Self Test	39
	Lab Questions	40
	Self Test Answers	41
	Lab Answers	42

2 Fundamental Command-Line Skills 43

Shells	46
Other Shells	46
Virtual Consoles	47
GUI Shell Interfaces	47
Differences Between Regular and Administrative Users	49
Standard Streams and Command Redirection	49
Standard Command-Line Tools	51
File and Directory Concepts	52
File Lists and ls	54
File-Creation Commands	55
Wildcards	58
File Searches	59
File Permissions	60
File Permissions and Ownership	60
Commands to Change Permissions and Ownership	63
A Basic Introduction of User and Group Concepts	66
Managing Text Files	68
Commands to Read Text Streams	68
Commands to Process Text Streams	70
Edit Text Files at the Console	73
Exercise 2-1: Using vi to Create a New User	75
If You Don't Like vi	77
Edit Text Files in the GUI	78
Accessing the Documentation	78
When You Need Help	79
A Variety of man Pages	80
The info Manuals	81
Detailed Documentation in /usr/share/doc	81
Certification Summary	82
✓ Two-Minute Drill	83
Q&A Self Test	85
Lab Questions	86
Self Test Answers	86
Lab Answers	87

3	Managing Basic Networking	91
	A Networking Primer	93
	IPv4 Networks	93
	Networks and Routing	94
	Tools and Commands	95
	Network Configuration and Troubleshooting	101
	Network Configuration Services	101
	Network Configuration Tools	103
	Exercise 3-1: Configure IPv4 Settings on a Network Interface ...	105
	Configure Name Resolution	109
	Hostname Configuration Files	109
	An Introduction to IPv6	111
	Basic IPv6 Addressing	111
	Troubleshooting Tools	113
	Configure IPv6 Addresses	114
	Administration with Secure Shell and Secure Copy	115
	Command-Line Access	116
	More SSH Command-Line Tools	117
	Graphical Secure Shell Access	117
	Certification Summary	119
	✓ Two-Minute Drill	119
	Q&A Self Test	120
	Lab Questions	121
	Self Test Answers	122
	Lab Answers	123
4	Software Management	127
	The RPM Package Manager	129
	What Is a Package?	129
	What Is the RPM Database?	130
	What Is a Repository?	130
	Install an RPM Package	131
	Uninstall an RPM Package	133
	Install RPMs from Remote Systems	133
	RPM Installation Security	134
	Updating the Kernel	134
	More RPM Commands	136
	Package Queries	137
	Package Signatures	137
	File Verification	138
	Exercise 4-1: Practice with rpm Commands	140

Dependencies and the dnf Command	141
An Example of Dependency Hell	142
Relief from Dependency Hell	143
Red Hat Subscription Management	144
Exercise 4-2: Subscribe a System to Red Hat Subscription Management	145
Basic dnf Configuration	148
Exercise 4-3: Create a dnf Repository from the RHEL 9 DVD ...	152
Third-Party Repositories	154
Exercise 4-4: Configure Access to the EPEL Repository	154
Basic dnf Commands	155
Installation Mode	155
Security and dnf	157
Updates and Security Fixes	157
Package Groups and dnf	157
More dnf Commands	160
Module Streams (*)	162
Certification Summary	165
✓ Two-Minute Drill	165
Q&A Self Test	167
Lab Questions	168
Self Test Answers	168
Lab Answers	169
5 systemd and the Boot Process	173
The Boot Process	175
Basic System Configuration	175
Startup Menus	176
Access to Linux Bootloaders	176
Bootloaders and GRUB 2	177
GRUB, the GRand Unified Bootloader	178
Exercise 5-1: Boot into a Different Target	180
Exercise 5-2: Recover the Root Password	181
Modify the System Bootloader	182
How to Update GRUB 2	184
The GRUB 2 Command Line	185
Exercise 5-3: Using the GRUB 2 Command Line	186
An Option for Booting from GRUB 2: Rescue Mode	187
Between GRUB 2 and Login	189
Kernels and the Initial RAM Disk	190
The First Process, Targets, and Units	191
Switch Between Targets	193

Reboot and Shut Down a System Normally	193
systemd Replaces Upstart and SysVinit	194
systemd Units	197
Virtual Consoles and Login Screens	199
Control by Target	200
Functionality by Target	200
The Innards of systemd Units	201
Service Configuration	203
Time Synchronization	204
Time Zone Configuration	205
Sync the Time with chronyd	206
Certification Summary	207
✓ Two-Minute Drill	207
Q&A Self Test	209
Lab Questions	210
Self Test Answers	210
Lab Answers	211

6 User Administration 215

User Account Management	216
Different Kinds of Users	217
The Shadow Password Suite	218
Command-Line Tools	225
Exercise 6-1: Add a User with Cockpit Web Console	228
Exercise 6-2: Real and Fake Shells	230
Modify an Account	230
Administrative Control	232
The Ability to Log In	232
The su Command	233
Limit Access to su	234
The sg Command	234
Superuser Access with the sudo Command	234
User and Shell Configuration	236
Home Directories and /etc/skel	236
Exercise 6-3: Another Way to Secure a System	238
Shell Configuration Files in User Home Directories	239
Login, Logout, and User Switching	239
Special Groups	240
Standard and Red Hat Groups	241
Shared Directories	241
Exercise 6-4: Control Group Ownership with the SGID Bit ...	242
Certification Summary	244
✓ Two-Minute Drill	244

Q&A	Self Test	245
	Lab Questions	246
	Self Test Answers	246
	Lab Answers	247
7	Storage and Filesystem Administration	253
	Storage Management and Partitions	255
	Current System State	255
	The fdisk Utility	257
	The gdisk Utility	264
	The parted Utility	265
	Using parted: Starting, Getting Help, and Quitting	266
	Graphical Options	271
	Exercise 7-1: Work with fdisk and parted	272
	Filesystem Formats	274
	Standard Filesystems	275
	Journaling Filesystems	276
	Filesystem Format Commands	276
	Swap Volumes	277
	Filesystem Check Commands	278
	Exercise 7-2: Format, Check, and Mount Different Filesystems	278
	Basic Linux Filesystems and Directories	279
	Separate Linux Filesystems	279
	Directories That Can Be Mounted Separately	281
	Logical Volume Manager (LVM)	282
	Definitions in LVM	282
	Create a Physical Volume	283
	Create a Volume Group	283
	Create a Logical Volume	283
	Make Use of a Logical Volume	284
	More LVM Commands	284
	Remove a Logical Volume	287
	Resize Logical Volumes	287
	Filesystem Management	288
	The /etc/fstab File	288
	Universally Unique Identifiers in /etc/fstab	290
	The mount Command	291
	More Filesystem Mount Options	292
	Virtual Filesystems	293
	Add Your Own Filesystems to /etc/fstab	293
	Removable Media and /etc/fstab	293
	Network Filesystems	294

The Automounter	296
Mounting via the Automounter	296
Exercise 7-3: Configure the Automounter	300
Certification Summary	301
✓ Two-Minute Drill	302
Q&A Self Test	303
Lab Questions	304
Self Test Answers	305
Lab Answers	306

8 Linux Security 311

Basic Firewall Control	313
Standard Ports	314
The firewalld Service	315
Exercise 8-1: Adjust Firewall Settings	320
Exercise 8-2: Firewall Configuration with the Cockpit Web Console	322
Securing SSH with Key-Based Authentication	324
SSH Configuration Commands	324
SSH Client Configuration Files	325
Basic Encrypted Communication	325
Set Up a Private/Public Pair for Key-Based Authentication	327
A Security-Enhanced Linux Primer	329
Basic Features of SELinux	329
SELinux Status	329
SELinux Configuration at the Command Line	331
Configure Basic SELinux Settings	331
Configure Regular Users for SELinux	332
Manage SELinux Boolean Settings	334
List and Identify SELinux File Contexts	334
Restore SELinux File Contexts	336
Exercise 8-3: Configure a New Directory with Appropriate SELinux Contexts	337
SELinux Port Labeling	338
Identify SELinux Process Contexts	338
Diagnose and Address SELinux Policy Violations	339
The GUI SELinux Administration Tool	341
Certification Summary	344
✓ Two-Minute Drill	345
Q&A Self Test	346
Lab Questions	346
Self Test Answers	347
Lab Answers	348

9	System Administration Tasks	353
	Resource Management and System Tuning	355
	System Resource Management Commands	355
	System Tuning Profiles	365
	Archives and Compression	367
	gzip and bzip2	367
	tar	368
	star	368
	Running Tasks on a Schedule: cron and at	369
	The System crontab and Components	369
	Hourly cron Jobs	372
	Regular anacron Jobs	372
	Setting Up cron for Users	373
	Exercise 9-1: Create a cron Job	374
	Running a Job with the at System	374
	Secure cron and at	375
	Bash Scripts	377
	A “Hello, World” Script	377
	Bash Variables	378
	Bash Control Structures	381
	Exercise 9-2: Create a Script	386
	Local Log Files	388
	System Log Configuration File	389
	Log File Management	390
	A Variety of Log Files	391
	Service-Specific Logs	392
	Exercise 9-3: Learn the Log Files	392
	View systemd Journal Log Entries	392
	Certification Summary	395
	✓ Two-Minute Drill	396
Q&A	Self Test	397
	Lab Questions	399
	Self Test Answers	399
	Lab Answers	400
10	An Introduction to Containers	405
	Fundamentals of Container Technology	407
	The Rise of Container Technologies	407
	Virtualization and Containers	409
	Understanding Container Architecture	410
	Docker and Podman	411

Getting Started with Containers	412
Installing Container Tools	412
Running Your First Container	413
Rootless and Rootful Containers	415
Building and Using Container Images	416
Image Registries	416
Building Container Images: A Primer	418
Exercise 10-1: Building and Running a Container Image	420
Exercise 10-2: Uploading an Image to Quay.io	421
Managing Containers	422
Podman Commands	422
Running a Container as a SystemD Service	430
Exercise 10-3: Running a Container as a Service	432
Persistent Storage	434
Exercise 10-4: Attaching Persistent Storage to a Container ...	435
Certification Summary	436
✓ Two-Minute Drill	437
Q&A Self Test	438
Lab Questions	439
Self Test Answers	440
Lab Answers	442
A Prepare a System for the Sample Exams	447
Sample Exam System Requirements	447
B Solutions to RHCSA Sample Exam 1	451
RHCSA Sample Exam 1 Discussion	453
C Solutions to RHCSA Sample Exam 2	459
RHCSA Sample Exam 2 Discussion	461
D About the Online Content	467
Single User License Terms and Conditions	467
Downloadable Book Resources	469
Lab Files	469
Appendix A: Prepare a System for the Sample Exams	469
Sample Exams	469
Technical Support	469
Index	471

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—Mike Jang

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—Alessandro Orsaria

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PREFACE

Linux is booming, and Red Hat is leading this growth with the help of skilled Red Hat Certified Systems Administrators (RHCSA).

Linux, which is free, became popular because it offered companies a cheaper alternative to the more costly Unix systems. But Linux has more to offer than just cost savings. Thanks to the Linux community, this operating system works well with many kinds of hardware. Today, you can use Linux on everything from laptops and mobile devices to servers and mainframes. This makes Linux a versatile option for many different situations.

Linux is also known for its strong security. Because it is open source, any security problems can be quickly found and fixed by the community. Linux also has strong rules about permissions and access, which makes it tough for harmful software to break in. Regular updates also help keep Linux safe and secure.

Linux also provides good support for virtualization, which lets users create and manage virtual machines (VMs) efficiently. With tools like Kernel-based Virtual Machine (KVM) and Xen, Linux allows users to run more than one operating system at the same time on a single machine. This is really useful in server environments, where virtualization makes things like software deployment and resource management easier.

On top of this, Linux is the go-to platform for container technologies like Docker and Kubernetes. Containers create isolated environments for applications, making them easier to move and run on different systems. Linux's built-in features, such as namespaces and cgroups, are the backbone of containerization. These features make it easier to manage resources, isolate processes, and scale up. By bringing together Linux and containerization, software development and deployment have become faster and more efficient.

Having discussed the diverse capabilities and advantages of Linux, it's essential to recognize the challenges that come with mastering it. Red Hat exams, for instance, are tough, and not many first-time test-takers pass the RHCSA exam. But don't let that scare you. While passing isn't guaranteed, this book is designed to help you prepare for and hopefully pass the RHCSA exam. The skills described in this book can also help you in your job as a Linux administrator. However, this book isn't a replacement for the Red Hat prep courses, which we'll talk about soon.

To prepare for the RHCSA exam, you should have a laptop or computer with at least 8GB of RAM so that you can run a couple of virtual machines. It doesn't matter whether your computer runs Linux, Windows, or macOS; you simply need to be able to create two VMs. In this book, we use VMware Workstation Player as our hypervisor, but you can choose another option like KVM, especially if you're running Linux on your computer.

You could also use cloud instances for the labs and exercises in this book, although some cloud providers' version of Red Hat Enterprise Linux might be slightly different from the standard one. You might also be unable to do some tasks, like installing the operating system from an ISO image. For these reasons, we recommend installing VMware Workstation Player, as explained in Chapter 1, or another hypervisor of your choice.

Getting Red Hat Enterprise Linux

Red Hat exams, including the RHCSA, test your proficiency with Red Hat Enterprise Linux. You might believe that you need to buy a subscription to RHEL to meet the exam objectives, such as installing software packages and updates via Red Hat Subscription Management (RHSM). However, Red Hat currently provides a no-cost Developer Subscription for Individuals if you join the Red Hat Developer program. This subscription includes access to Red Hat Enterprise Linux and a variety of other technologies. Joining the program, which you can do for free at <https://developers.redhat.com/register>, is the only requirement. Chapter 1 provides detailed instructions on how to join and install Red Hat Enterprise Linux.

Alternatively, you can choose to install one of the many derivatives of Red Hat Enterprise Linux. These derivatives are built from the RHEL source code, which is mostly released under the Linux General Public License (GPL) or other open-source licenses. These licenses grant anyone the right to construct Red Hat Enterprise Linux from the released Red Hat source code. However, if you're comfortable with the terms and conditions of the Red Hat Developer program, there's no clear advantage to using a derivative distribution for RHCSA exam preparation.

Red Hat also provides several Enterprise Linux subscriptions. While not required for RHCSA exam prep, familiarity with these can be beneficial if you plan to (or already) work with Red Hat Enterprise Linux systems:

- RHEL Server provides varying levels of support for three different CPU architectures, with costs based on the number of CPU sockets and supported virtual guests.
- RHEL Workstation includes varying levels of support ideal for workstation use.
- RHEL Developer Suite offers download access to RHEL 9 and several additional software packages, intended solely for development.
- RHEL add-ons enhance functionality in areas such as high availability, resilient storage, and load balancing, among others.

This book was developed using RHEL 9.1 Server. While RHEL's source code is open source, access to the binary packages requires a subscription. This can be free of charge if you select the Red Hat Developer Subscription for Individuals.

Enterprise-level operating systems like RHEL 9 offer the benefit of stability. When an enterprise upgrades to RHEL 9, they can trust that configuration revisions will be a one-time affair, with security updates and bug fixes handled automatically. Red Hat strives to ensure enterprises won't need to overhaul their systems for minor releases, such as RHEL 9.1. A necessity to reconfigure for minor updates would escalate costs.

Minor releases also should not impact Red Hat exam objectives. While RHEL 9.2 introduces bug fixes, security updates, and new features, it doesn't alter the defaults of any configuration files detailed in this book.

We expect future minor releases, such as RHEL 9.3, RHEL 9.4, and beyond, to follow this pattern. Our close monitoring of RHEL releases over the past ten years suggests no significant exam objective changes based solely on a minor release. Still, you should routinely check the exam objectives listed on the Red Hat website to ensure they align with the content of this study guide.

In This Book

Chapter 1 of this book is designed to assist you in preparing a study system for the RHCSA exam and offers detailed insight into the exam experience.

Except for Chapter 1, every chapter begins by outlining the objectives pertinent to that chapter's material. Following this, the topics are dissected and explained. We have chosen to present the topics in an order that we believe will be most beneficial to the majority of candidates, which doesn't necessarily follow the sequence of the exam objectives. However, if you are already well-versed with Linux, feel free to skip over certain sections or entire chapters during your initial reading.

Toward the end of each chapter, we've included a Self Test, a series of questions, along with their answers. While Red Hat exams don't typically involve multiple-choice questions, these types of questions can still be a valuable tool in assessing your understanding and retention of the chapter material. Furthermore, the short-answer questions format emphasizes the practical experience necessary for the exam.

Following this Self Test is a "Lab Questions" section that directs you to the companion website to access the lab exercises for the chapter. The solutions to the lab exercises are included in the book, at the end of each chapter. Please see Appendix D, "About the Online Content."

Remember, Red Hat exams are hands-on. Therefore, practice is key. You should repeatedly exercise your skills until you reach a level of confidence where you can complete tasks without the assistance of this book. The Red Hat RHCSA exam is designed to test candidate qualifications as Linux systems administrators. If you pass the exam, it's not because you've memorized a canned set of answers—it's because you have a set of Linux administrative skills and know how to use them under pressure, whether it be during an exam or in a real-world situation.

While this book is organized to serve as an in-depth review for the RHCSA exam for both experienced Linux and Unix professionals, it is not intended as a substitute for Red Hat courses—or, more important, real-world experience. Nevertheless, each chapter covers a major aspect of the exam, with an emphasis on the “why” as well as the “how to” of working with and supporting RHEL as a systems administrator or engineer.

Conventions and Abbreviations

Although logging in to the root user account is a risky practice on production systems, it is the fastest way to administer RHEL during the exam. The command prompt assumes use of that account. When logged in to the root account, you’ll see a command-line prompt similar to the following:

```
[root@server1 root]#
```

As the length of this prompt would lead to a number of broken and wrapped code lines throughout this book, we’ve normally abbreviated the root account prompt as

```
#
```

Be careful. The hash mark (#) is also used as a comment character in Linux scripts and programs. When logged in as a regular user, you will see a slightly different prompt; for user michael, it would typically look like the following:

```
[michael@server1 michael]$
```

Similarly, we’ve abbreviated this as

```
$
```

There are a number of command lines and blocks of code interspersed throughout the chapters. Commands embedded within regular text, such as **ls -l**, are shown in bold. User entries and some variables in regular text are also shown in bold.

Sometimes commands exceed the available length of a line. Take this example:

```
# virt-install -n outsider1.example.org -r 1024 --disk  
path=/var/lib/libvirt/images/outsider1.example.org.img,size=16  
-l ftp://192.168.122.1/pub/inst -x ks=ftp://192.168.122.1/pub/ks1.cfg
```

Unless this command is carefully formatted, line breaks might appear in unfortunate places, such as between the two dashes in front of the **--disk** switch. One way to address this is with the backslash (\), which “escapes” the meaning of the carriage return that follows. (The backslash can also “escape” the meaning of a space, making it easier to work

with multiple-word filenames.) Therefore, while the following command appears as if it is on four different lines, the backslashes mean that Linux reads it as one single command:

```
# virt-install -n outsider1.example.org -r 1024 --disk \
> path=/var/lib/libvirt/images/outsider1.example.org.img,size=16 \
> -l ftp://192.168.122.1/pub/inst \
> -x ks=ftp://192.168.122.1/pub/ks1.cfg
```

In some code snippets, we could not use the backslash character to split the output on more than one line. In those cases, we used a continuation arrow, as shown next:

```
5 2 * * 6 root /usr/bin/tar --selinux -czf /tmp/etc-backup-\$(/bin/date ↵
+%\m%d).tar.gz /etc > /dev/null
```

Sometimes, you'll need to actually type in a command or a response to a question at a command line. In that case, you'll see an instruction such as "Type *y*." Alternatively, some menus require a keypress; for instance, you may be asked to press *P* to access a password prompt. In that case, the letter *p* is not added to the screen when you press that key. In addition, the *A*, despite its appearances, is in lowercase. In contrast, *A* is the uppercase version of that letter.

One area where some publishers have trouble is with the double-dash. Some publishing programs change the double-dash to an em dash (—). But that can be a problem. The double-dash is common in many Linux commands. For example, the following command lists all packages currently installed on the local system:

```
# rpm --query --all
```

When we ran this command on our RHEL 9 systems, it listed over 1000 packages.

In contrast, the following command lists all files in all packages on the local system:

```
# rpm --query -all
```

When we ran this command on our RHEL 9 system, it listed over 150,000 files, a rather different result. So pay attention to the dashes, and rest assured that the team who produced this book took care to make sure that double-dashes are shown as is!

Exam Readiness Checklist

At the end of the Introduction, you will find an Exam Readiness Checklist. This table has been constructed to allow you to cross-reference the official RHCSA exam objectives with the objectives as they are presented and covered in this book. The checklist also allows you to gauge your level of expertise on each objective at the outset of your studies. This should allow you to check your progress and make sure you spend the time you need on more difficult or unfamiliar sections. The checklist lists all the objectives exactly as Red Hat presents them (www.redhat.com/en/services/training/ex200-red-hat-certified-system-administrator-rhcsa-exam?section=objectives) and cross-references the corresponding

coverage in this book, including chapter and page references. Additionally, the table features a column of blank boxes next to each objective. Readers can check these boxes when they feel confident that they are prepared for that specific exam objective.

In Every Chapter

For this series, we've created a set of chapter components that calls your attention to important items, reinforces important points, and provides helpful exam-taking hints. Take a look at what you'll find in every chapter:

- Every chapter begins with the **Certification Objectives**—the skills you need to master in order to pass the section on the exam associated with the chapter topic. The Objective headings identify the objectives within the chapter, so you'll always know an objective when you see it.
- **Exam Watch** notes call attention to information about, and potential pitfalls in, the exam. These helpful hints are written by authors who have taken the exams and received their certification—who better to tell you what to worry about? They know what you're about to go through!

exam

Watch

This book's coverage of the RHCSA exam objectives can be found in the RHCSA Exam Readiness Checklist at the end of this front matter.

- **Practice Exercises** are interspersed throughout the chapters. These are step-by-step exercises that allow you to get the hands-on experience you need in order to pass the exams. They help you master skills that are likely to be an area of focus on the exam. Don't just read through the exercises; they are hands-on practice that you should be comfortable completing. Learning by doing is an effective way to increase your competency with a product. Remember, the Red Hat exams are entirely "hands on"; there are no multiple-choice questions on these exams.
- **On the Job** notes describe the issues that come up most often in real-world settings. They provide a valuable perspective on certification- and product-related topics. They point out common mistakes and address questions that have arisen from on-the-job discussions and experience.
- **Inside the Exam** sidebars highlight some of the most common and confusing problems that students encounter when taking a live exam. Designed to anticipate what the exam will emphasize, they will help ensure you know what you need to know to pass the exam. You can get a leg up on how to respond to those difficult-to-understand labs by focusing extra attention on these sidebars.

on the job

Q&A

- **Scenario & Solution** sections lay out potential problems and solutions in a quick-to-read format.
- The **Certification Summary** is a succinct review of the chapter and a restatement of salient skills regarding the exam.
- The **Two-Minute Drill** at the end of every chapter is a checklist of the main points of the chapter. It can be used for last-minute review.
- The **Self Test** offers questions designed to help test the practical knowledge associated with the certification exams. The answers to these questions, as well as explanations of the answers, can be found at the end of each chapter. By taking the Self Test after completing each chapter, you'll reinforce what you've learned from that chapter. This book does not include multiple-choice questions because Red Hat does not include any such questions on its exams.
- The **Lab Questions** at the end of the Self Test section offer a unique and challenging question format that requires the reader to understand multiple chapter concepts to answer correctly. These questions are more complex and more comprehensive than the other questions because they test your ability to take all the knowledge you have gained from reading the chapter and apply it to complicated, real-world situations. Starting with Chapter 2, all lab questions are available only from the companion website that accompanies this book, consistent with the electronic format associated with the Red Hat exams. Remember, the Red Hat exams contain *only* lab-type questions. If you can answer these questions, you have proven that you know the subject!

Additional Resources

If you would like to pursue further reading beyond this book, perhaps the best way to do so is with Red Hat documentation. Much of what we've learned about RHEL 9 comes from the documents available at https://access.redhat.com/documentation/en/red_hat_enterprise_linux/9. For your purposes, the following may be the most important of these guides:

- **Performing a Standard RHEL 9 Installation** Although Red Hat exams are given on preconfigured systems, every Linux administrator should be able to install the operating system from scratch.
- **Configuring Basic System Settings** This system administrator guide includes essential skills that you should be able to master in your job.
- **Managing Software with the DNF Tool** This guide could serve as an additional resource that expands upon the software installation procedures detailed in Chapter 4.
- **Using SELinux** SELinux often poses a challenging topic for many candidates. This guide details various strategies that can aid in bolstering your SELinux policy's security.
- **Configuring and Managing Networking** Despite a majority of this guide's chapters being beyond the scope of the RHCSA exam, the initial chapters establish a strong foundation on network configuration.

Some Pointers

Once you've finished reading this book, set aside some time to do a thorough review. You might want to return to the book several times and make use of all the methods it offers for reviewing the material:

- *Reread all the Exam Watch notes.* Remember that these notes are written by authors who have taken the exam and passed. They know what you should expect—and what you should be on the lookout for.
- *Review all the Scenario & Solution sections* for quick problem solving.
- *Retake the Self Tests.* Focus on the labs, as there are no multiple-choice questions on the Red Hat exams. We've included questions just to test your mastery of the practical material in each chapter.
- *Complete the exercises.* Did you do the exercises when you read through each chapter? If not, do them! These exercises are designed to cover exam topics, and there's no better way to get to know this material than by practicing. Be sure you understand why you are performing each step in each exercise. If there is something you are not clear on, reread that section in the chapter.

INTRODUCTION

The Red Hat Exam Challenge

This section covers the reasons for pursuing industry-recognized certification, explains the importance of the RHCSA certification, and prepares you for taking the actual examination. It gives you a few pointers on how to prepare, what to expect, and what to do on exam day.

This book covers every published exam objective at the time of writing. For the latest objectives, see www.redhat.com/en/services/certification/rhcsa. Red Hat has also published a syllabus for each of its prep courses for these exams, described shortly. While the published exam objectives are accurate, the prep course syllabi provide additional information. Each Red Hat prep course provides an excellent grounding in systems administration, network administration, security, and more. To that end, this book also includes coverage based on the public syllabi of Red Hat courses RH124 and RH134, described later.

Nevertheless, this book is not intended to be a substitute for any Red Hat course.

Leaping Ahead of the Competition!

Red Hat's RHCSA certification exam is a hands-on exam. As such, it is respected throughout the industry as a sign of genuine practical knowledge. If you pass, you will be head and shoulders above the candidate who has passed only a "standard" multiple-choice certification exam.

Red Hat has offered its hands-on exams since 1999. They've evolved over the years. As detailed in Chapter 1, the RHCSA is a three-hour exam. The requirements are detailed in the Exam Readiness Checklist later in this Introduction.

Why a Hands-On Exam?

Most certifications today are based on multiple-choice exams. These types of exams are relatively inexpensive to set up and easy to proctor. Unfortunately, many people without real-world skills are good at taking multiple-choice exams. In some cases, the answers to these multiple-choice exams are already available online. This results in problems on the job with "certified" engineers who have an image as "paper tigers" and do not have any real-world skills.

INSIDE THE EXAM

The RHCSA exam is a Red Hat exam. Knowledge of Unix or a Linux distribution such as Ubuntu is certainly helpful, as well as real-world experience with Linux and

containers. However, it is important to know how to set up, configure, install, and perform tasks using Red Hat Enterprise Linux.

In response, Red Hat wanted to develop a certification program that matters. In our opinion, they have succeeded with the RHCSA, the RHCE, and their other advanced certifications.

Linux administrators sometimes have to install Linux on a computer or virtual machine. In fact, the RHCSA includes several objectives on this subject. Depending on the configuration, they may need to install Linux from a central source through a network. Installing Linux is not enough to make it useful. Administrators need to know how to configure Linux: add users, install and configure services, set up firewalls, and more.

Red Hat Certification Program

Red Hat offers several courses that can help you prepare for the RHCSA exam. Most of these courses are four or five days long. In some cases, the courses are offered electronically.

These aren't the only Red Hat courses available; there are a number of others related to the Red Hat Certified Engineer (RHCE), Red Hat Certified Architect (RHCA), Red Hat Certified OpenShift Administrator, and several Certificates of Expertise in specific areas such as server hardening and performance tuning. But focus on passing the RHCSA exam first; the RHCSA is a prerequisite for more advanced certifications such as the RHCE and RHCA.

Should You Take an RHCSA Course?

This book is *not* intended as a substitute for any particular Red Hat RHCSA prep course. However, the topics in this book are based in part on the topics listed in course outlines provided at www.redhat.com/en/services/training/all-courses-exams. By design, these topics may help Linux users qualify as real-world administrators and can also be used as such. Red Hat can change these topics and course outlines at any time, so monitor www.redhat.com for the latest updates. Table 1 describes those courses associated with the RHCSA exam.

The courses given by Red Hat are excellent. The Red Hat instructors who teach these courses are highly skilled. If you have the resources, it is the best way to prepare for the RHCSA exam. If you feel the need for classroom instruction, read this book and then take the appropriate course.

TABLE 1 Red Hat RHCSA-Related Courses

Course	Description
RH024	A free, on-demand video course that provides an introduction to Red Hat Enterprise Linux
RH124	System Administration I: Core system administration skills
RH134	System Administration II: Command line skills for Linux administrators (RH135 without the RHCSA exam)
RH135	System Administration II with the RHCSA exam
RH199	RHCSA rapid-track course for experienced administrators
RH200	RH199 + RHCSA exam
EX200	Just the RHCSA exam

If you're not sure you're ready for the course or book, read Chapter 1. It includes a rapid overview of the requirements associated with the RHCSA certification. If you find the material in Chapter 1 to be overwhelming, consider one of the books noted near the start of the chapter or one of the other lower-level Red Hat courses. In addition, Chapter 1 includes a lab that prompts you to examine the requirements of the Linux Professional Institute for its Level 1 certification (LPIC-1). Linux geeks like yourself who are ready to study for the Red Hat exams often take the LPIC-1 exams first.

Alternatively, you may already be familiar with the material in this book. You may have the breadth and depth of knowledge required to pass the RHCSA exam. In that case, use this book as a refresher to help you focus on the skills and techniques needed to pass the exam.

Signing Up for the RHCSA Course and/or Exam

Red Hat provides convenient web-based registration systems for the courses and tests. To sign up for any of the Red Hat courses or exams, navigate to www.redhat.com, click the link for Training & Services | All Courses and Exams, and select the desired course or exam. As shown back in Table 1, exams may be taken independently from a course. For example, the RHCSA exam is associated with exam codes EX200. Exams may also be taken as part of an online or instructor-led course. Alternatively, contact Red Hat Enrollment Central at training@redhat.com or (866) 626-2994.

Discounts may be available for a limited time for candidates who have been previously certified as an RHCSA. Current discounts are shown at <https://www.redhat.com/en/services/training/specials/>.

RHCSA Exam Readiness Checklist

Certification Objective	Study Guide Coverage	Ch #	Pg #	Exam Ready?
Category: Understand and Use Essential Tools				
Access a shell prompt and issue commands with correct syntax	Shells	2	46	
Use input-output redirection (>, >>, , 2>, etc.)	Shells	2	46	
Use grep and regular expressions to analyze text	Managing Text Files	2	68	
Access remote systems using SSH	Administration with Secure Shell and Secure Copy	3	73	
Log in and switch users in multiuser targets	User and Shell Configuration	6	236	
Archive, compress, unpack, and uncompress files using tar, star, gzip, and bzip2	Archives and Compression	9	367	
Create and edit text files	Managing Text Files	2	68	
Create, delete, copy, and move files and directories	Standard Command-Line Tools	2	51	
Create hard and soft links	Standard Command-Line Tools	2	51	
List, set, and change standard ugo/rwx permissions	File Permissions	2	60	
Locate, read, and use system documentation including man, info, and files in /usr/share/doc	Accessing the Documentation	2	78	
Category: Create Simple Shell Scripts				
Conditionally execute code (use of: if, test, [], etc.)	Bash Scripts	9	377	
Use Looping constructs (for, etc.) to process file, command line input	Bash Scripts	9	377	
Process script inputs (\$1, \$2, etc.)	Bash Scripts	9	377	
Processing output of shell commands within a script	Bash Scripts	9	377	
Category: Operate Running Systems				
Boot, reboot, and shut down a system normally	Bootloaders and GRUB 2, Between GRUB 2 and Login	5	177, 189	
Boot systems into different targets manually	Between GRUB 2 and Login	5	189	
Interrupt the boot process in order to gain access to a system	Bootloaders and GRUB 2	5	177	
Identify CPU/memory-intensive processes and kill processes	Resource Management and System Tuning	9	355	

Certification Objective	Study Guide Coverage	Ch #	Pg #	Exam Ready?
Adjust process scheduling	Resource Management and System Tuning	9	355	
Manage tuning profiles	Resource Management and System Tuning	9	355	
Locate and interpret system log files and journals	Local Log Files	9	388	
Preserve system journals	Local Log Files	9	388	
Start, stop, and check the status of network services	Network Configuration and Troubleshooting	3	59	
Securely transfer files between systems	Administration with Secure Shell and Secure Copy	3	73	
Category: Configure Local Storage				
List, create, and delete partitions on MBR and GPT disks	Storage Management and Partitions	7	255	
Create and remove physical volumes	Logical Volume Manager (LVM)	7	282	
Assign physical volumes to volume groups	Logical Volume Manager (LVM)	7	282	
Create and delete logical volumes	Logical Volume Manager (LVM)	7	282	
Configure systems to mount file systems at boot by universally unique ID (UUID) or label	Filesystem Management	7	288	
Add new partitions and logical volumes, and swap to a system non-destructively	Basic Linux Filesystems and Directories, Filesystem Management	7	279, 288	
Category: Create and Configure File Systems				
Create, mount, unmount, and use vfat, ext4, and xfs filesystems	Filesystem Formats, Filesystem Management	7	274, 288	
Mount and unmount network file systems using NFS	Filesystem Management	7	288	
Configure autofs	The Automounter	7	296	
Extend existing logical volumes	Logical Volume Manager (LVM)	7	282	
Create and configure set-GID directories for collaboration	Special Groups	6	240	
Diagnose and correct file permission problems	File Permissions	2	60	

Certification Objective	Study Guide Coverage	Ch #	Pg #	Exam Ready?
Category: Deploy, Configure, and Maintain Systems				
Schedule tasks using at and cron	Running Tasks on a Schedule: cron and at	9	369	
Start and stop services and configure services to start automatically at boot	Control by Target	5	200	
Configure systems to boot into a specific target automatically	Between GRUB 2 and Login	5	189	
Configure time service clients	Time Synchronization	5	204	
Install and update software packages from Red Hat Network, a remote repository, or from the local file system	The RPM Package Manager, More RPM Commands, Dependencies and the dnf Command	4	87, 94, 99	
Modify the system bootloader	The Boot Process, Bootloaders and GRUB 2	5	175, 177	
Category: Manage Basic Networking				
Configure IPv4 and IPv6 addresses	A Networking Primer, Network Configuration and Troubleshooting, An Introduction to IPv6	3	51, 59, 69	
Configure hostname resolution	Network Configuration and Troubleshooting	3	59	
Configure network services to start automatically at boot	Network Configuration and Troubleshooting	3	59	
Restrict network access using firewall-cmd/firewall	Basic Firewall Control	8	313	
Category: Manage Users and Groups				
Create, delete, and modify local user accounts	User Account Management	6	216	
Change passwords and adjust password aging for local user accounts	User Account Management	6	216	
Create, delete, and modify local groups and group memberships	User Account Management	6	216	
Configure superuser access	Administrative Control	6	232	
Category: Manage Security				
Configure firewall settings using firewall-cmd/firewalld	Basic Firewall Control	8	313	
Manage default file permissions	File Permissions	2	60	

Certification Objective	Study Guide Coverage	Ch #	Pg #	Exam Ready?
Configure key-based authentication for SSH	Securing SSH with Key-Based Authentication	8	324	
Set enforcing and permissive modes for SELinux	A Security-Enhanced Linux Primer	8	329	
List and identify SELinux file and process context	A Security-Enhanced Linux Primer	8	329	
Restore default file contexts	A Security-Enhanced Linux Primer	8	329	
Manage SELinux port labels	A Security-Enhanced Linux Primer	8	329	
Use boolean settings to modify system SELinux settings	A Security-Enhanced Linux Primer	8	329	
Diagnose and address routine SELinux policy violations	A Security-Enhanced Linux Primer	8	329	
Category: Manage Containers				
Find and retrieve container images from a remote registry	Building and Using Container Images	10	416	
Inspect container images	Building and Using Container Images	10	416	
Perform container management using commands such as podman and skopeo	Managing Containers	10	422	
Build a container from a Containerfile	Building and Using Container Images	10	416	
Perform basic container management such as running, starting, stopping, and listing running containers	Fundamentals of Container Technology, Getting Started with Containers	10	407, 412	
Run a service inside a container	Getting Started with Containers	10	412	
Configure a container to start automatically as a systemd service	Managing Containers	10	422	
Attach persistent storage to a container	Managing Containers	10	422	

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Chapter 1

Prepare for the Red Hat RHCSA Certification

CERTIFICATION OBJECTIVES

- | | | | |
|------|----------------------------------|------|---------------------|
| 1.01 | The RHCSA Exam | 1.05 | RHEL 9 Installation |
| 1.02 | Basic Hardware Requirements | ✓ | Two-Minute Drill |
| 1.03 | Get Red Hat Enterprise Linux | Q&A | Self Test |
| 1.04 | An Environment for Practice Labs | | |

The Red Hat exams are an advanced challenge. This book covers the Red Hat Certified System Administrator (RHCSA) exam, a practical lab test that evaluates an individual's proficiency in Red Hat Enterprise Linux. Successfully passing it not only boosts one's professional appeal but also demonstrates their mastery of Linux. The RHCSA certification also is the foundation for those who want to earn the Red Hat Certified Engineer (RHCE) and serves as the initial step toward more advanced Red Hat certifications. Red Hat offers several courses to help prepare for these exams, as described in the front matter and in this chapter.

2 Chapter 1 Prepare for the Red Hat RHCSA Certification

The focus of this chapter is installation, to create a lab environment as a test bed for the lab exercises in subsequent chapters. We assume that you have a PC available, either a desktop or a laptop, running Linux or a Windows operating system. On your PC, you will install two virtual machines (VMs) running Red Hat Enterprise Linux 9 (RHEL 9). Alternatively, you can use a “rebuild” distribution such as AlmaLinux, as it’s built from the same source code as RHEL 9. We discuss the only relevant differences in Chapter 4.

Today, containers have become a key part of IT systems because of their unique ability to neatly pack up an application in its own box with everything it needs to run. This makes moving and running applications much easier and quicker. Plus, with containers, you can easily add or reduce resources based on the demand for your app, a feature known as *scalability*. Because containers play such a big role in modern IT operations, the RHCSA exam now includes a whole section about them. We’ll go into all the details in Chapter 10 of this book.

If you are new to Linux or Unix, this book may not be enough for you. Red Hat suggests that RHCSA candidates have one to three years of experience with the bash shell, user administration, system monitoring, basic networking, software updates, and more. In this book it’s not possible to provide sufficient detail, at least in a way that can be understood by newcomers to Linux and other Unix-based operating systems. Nevertheless, we tried to keep the topics easy to follow even for the reader who has very little experience with Linux. If after reading the first chapters of this book you find gaps in your knowledge, you can refer to one of the following guides:

- *Linux Administration: A Beginner’s Guide, Eighth Edition*, by Wale Soyinka (McGraw Hill, 2020), provides a step-by-step guide to Linux.
- *LPIC-1 in Depth* by Michael Jang (Course Technology PTR, 2009) covers the certification many Linux professionals qualify for prior to working for the RHCSA. The book dates back to 2009, but the fundamentals of Linux are still the same.

Before installing RHEL 9, you need to ensure that your system has the right hardware. The installation of RHEL 9 is supported on systems with 64-bit CPUs. In addition, to set up a lab environment with virtual machines, you need a CPU that supports hardware virtualization. Details are discussed in this chapter. As such, while the RHCSA exam is, by and large, not a hardware exam, some basic hardware knowledge is a fundamental requirement for any Linux administrator. As for the operating system itself, you can purchase a subscription to RHEL, or you can use a “rebuild” distribution such as AlmaLinux, where the operating system software is compiled by the open-source community from source code publicly released by Red Hat.

If you’re experienced with other Unix-type operating systems such as Solaris, AIX, and HP-UX, prepare to leave some defaults at the door. There are even significant differences between the Ubuntu and Red Hat distributions. When Red Hat developed

its Linux distribution, the company made some choices that differed from other Unix implementations. When one of the authors of this *Study Guide* took one of Red Hat's System Administration courses, some students with these backgrounds had difficulties with the course and the RHCSA exam.

For the purposes of this book, we'll be running most commands as the Linux administrative user, root. Logging in as the root user is normally discouraged for security reasons. Also, if you make a mistake on the command line as the root user, you could potentially harm your system very seriously. However, since the RHCSA is a time-based exam, you may find that running commands as the root user is appropriate, because it is quicker and requires less typing than using a normal user account for administrative purposes. Just remember that out of the exam room, this is not recommended.

INSIDE THE EXAM

OS Installation and Virtualization

This chapter does not cover any RHCSA exam objectives. While the previous versions of the RHCSA exam included skills related to the installation of Red Hat Enterprise Linux and to the management of virtual guests, the current version of the RHCSA exam does not.

For RHEL 9, the installation process of RHEL is relatively simple. Automated installations (using Kickstart) and virtualization management are now covered in other certification exams: specifically, in the Red Hat Certified Specialist in Deployment and System Management exam (EX403) and in the Red Hat Certified Specialist in Virtualization exam (EX318).

Nevertheless, to set up the lab environment that we will use in the rest of the book, you will need to go through the installation of RHEL and the basic configuration of virtual machines.

These procedures will not be tested in the RHCSA exam, but are essential skills that you must be very familiar with.

Using Other Versions of Red Hat

For the purposes of this chapter, you can install RHEL 9 using a no-cost developer subscription provided by the Red Hat Developer Program. You can also use AlmaLinux. However, whereas RHEL 9 is based in part on the work done by many open-source contributors, it's also based on the Fedora Linux 34 release. Don't use Fedora to study for the Red Hat exams. If you use Fedora, some configuration settings and commands may differ from RHEL 9. Later versions of Fedora are likely to have features not found in RHEL 9.

CERTIFICATION OBJECTIVE 1.01

The RHCSA Exam

Red Hat first started giving certification exams in 1999. Since that time, its exams have evolved. The former Red Hat Certification Technician (RHCT) was a complete subset of the RHCE.

In addition, Red Hat has focused the exams more on hands-on configuration. Multiple-choice questions were removed from the exam in 2003. Later, in 2009, Red Hat simplified the exam by removing the requirement to install Linux on a “bare-metal” system.

Then, the RHCSA certification was introduced as a replacement for the RHCT certification to better align with industry demands and to reflect the evolving role of a Linux system administrator.

Today, the RHCSA exam tests your ability to configure live physical and virtual systems for networking, security, custom filesystems, package updates, user management, and more. In essence, the RHCSA exam covers those skills required to configure and administer a Linux system in the enterprise.



For those keen on progressing their Red Hat credentials, the RHCE certification is the next logical step. The RHCE exam tests your ability to manage multiple systems using Ansible and evaluates your expertise in system automation and administration. Achieving this certification augments one’s professional standing and underscores their expertise in Linux.

The Exam Experience

Red Hat’s certification tests are hands-on exams. As a result of this, they are respected throughout the industry as a sign of genuine practical knowledge. When you pass a Red Hat exam, you will stand head and shoulders above the candidate who has passed only a “standard” multiple-choice certification exam.

When the RHCSA exam starts, you’ll be faced with a live RHEL 9 system. You’ll be given actual configuration problems associated with the items listed in the RHCSA EX200 exam objectives, shown at the following (click the Objectives tab):

<https://www.redhat.com/en/services/training/ex200-red-hat-certified-system-administrator-rhcsa-exam>

Naturally, this book is dedicated to helping you gain the skills described on those web pages.

exam

watch

An overview of this book’s coverage of the items listed in the RHCSA exam objectives can be found in the introduction for this book.

The RHCSA exam lasts three hours. Any changes that you make must survive a reboot. When you've completed the given tasks, the person grading the exam will check if the system is configured to meet the requirements. For example, if you are told to “create, delete, and modify local user accounts,” it doesn't matter whether you modify the associated configuration files with the `vi` editor or by using other command-line tools. As long as you don't cheat, it's the results that count.

While you won't have Internet access during the exam, you will have access to online documentation such as `man` and `info` pages, as well as documentation in the `/usr/share/doc/` directories, assuming appropriate packages are installed.

In addition, Red Hat provides the exams in electronic format. Although the basic instructions may be in a local language such as English, the RHCSA exam is available in several different languages. If you prefer to take the exam in a language other than English, you should contact Red Hat training to be sure the exam is available in that language at training@redhat.com or 1-866-626-2994.

Red Hat also has prep courses for the RHCSA exam. The outlines for those courses are available from <https://www.redhat.com>. Although this book is not intended as a substitute for such courses, it is consistent with their outlines. This book covers the objectives associated with the RHCSA exam.

exam

Watch

Red Hat provides “pre-assessment” tests for its exam prep courses. These tests are available at <https://rhtapps.redhat.com/assessment>

Evolving Requirements

Red Hat regularly updates the RHCSA exam to keep up with the changing landscape of Linux system administration and technology trends. This ensures that certified professionals remain current and relevant in their skills and knowledge.

Future changes to the RHCSA exam may be based on topics covered in the Red Hat RHCSA Rapid Track course, RH199/RH200. So if you are not planning to take the RHCSA exam within the next few months, watch the outline for that course. It may, in effect, be a preview of where Red Hat wants to take the RHCSA exam in the future.

CERTIFICATION OBJECTIVE 1.02

Basic Hardware Requirements

Now it is time to explore in detail the hardware that a computer requires to support Red Hat Enterprise Linux. Although some manufacturers include their own Linux hardware drivers, most Linux hardware support comes from third parties, starting with the work

of volunteers. Fortunately, there is a vast community of Linux developers, many of whom produce drivers for Linux and distribute them freely on the Internet. If a certain piece of hardware is popular, you can be certain that Linux support for that piece of hardware will pop up somewhere on the Internet and will be incorporated into various Linux distributions, including Red Hat Enterprise Linux.

Hardware Compatibility

RHEL 9 can be installed only on 64-bit systems. Fortunately, all PCs and servers sold today are 64-bit systems. Even the lowly Intel i3 CPU can handle 64-bit operating systems. There are even 64-bit versions of the Intel Atom CPU, common on netbook systems and tablets. Similar comparisons can be made for CPUs from Advanced Micro Devices.

Be careful when purchasing a new computer to use with Linux. Although Linux hardware compatibility has come a long way the last few years, and you should have little problem installing it on most modern servers or PCs, you shouldn't assume Linux will install

or run flawlessly on *any* computer, especially if the system in question is a state-of-the-art laptop computer. Laptops are sometimes designed with proprietary configurations that work with Linux only after some reverse engineering.

If you want hardware compatible with and supported by Red Hat, consult the hardware compatibility list at <https://catalog.redhat.com/hardware>.

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While it is important to know how Linux interacts with your hardware, the RHCSA exam is not a hardware exam.

Architectures

The architecture of a server or PC defines the components it uses as well as the way those components are connected. In other words, the architecture describes much more than just the CPU. It includes standards for other hardware such as memory, data paths such as computer buses, general system design, and more. All software is written for a specific computer architecture.

Although RHEL 9 has been built for a variety of architectures, you can focus on the Intel/AMD 64-bit or x86_64 architecture for the RHCSA exam. As of this writing, this exam is offered only on computers with such CPUs, so you need not worry about special architecture-specific issues such as specialty bootloaders or custom proprietary drivers. Nevertheless, customized Red Hat distributions are available for a variety of platforms.

You can install RHEL 9 on systems with a wide variety of CPUs. Red Hat supports four different basic 64-bit CPU architectures:

- Intel/AMD64 (x86_64)
- 64-bit ARM

- IBM Power Systems, Little Endian
- IBM System Z

To identify the architecture of a running RHEL system, run the following command:

```
# uname -p
```

To practice with the labs in this book, you need to configure virtual machines. Be sure to choose a system that supports hardware-assisted virtualization, along with Basic Input/Output System (BIOS) or Unified Extensible Firmware Interface (UEFI) menu options that allow you to activate hardware-assisted virtualization. All new PCs will meet these requirements today. However, if you are running an old system, look at the processor specifications on the vendor’s website.

RAM Requirements

Although it’s possible to run RHEL 9 on less, the RAM requirements are driven by the needs of the Red Hat installer. For basic Intel/AMD-based 64-bit architectures, Red Hat officially requires 1.5GiB of RAM.

Of course, actual memory requirements depend on the load from every program that may be run simultaneously on a system. That can also include the memory requirements of any virtual machine that you might run on a physical RHEL 9 system. There is no practical maximum RAM because, theoretically, you could run 64TB of RAM on RHEL 9. But that’s just theory. The maximum RAM supported and tested on RHEL 9 for 64-bit Intel/AMD-based systems is 48TB, which is still twice than the 24TB supported on RHEL 8.



If you’re setting up Linux as a server, RAM requirements increase with the number of applications that may need to run simultaneously. The same may be true if you’re running several different VMs on a single system. However, administrators typically “overcommit” RAM on VMs configured with different functionality. VMs can also transparently share memory pages to further improve efficiency.

Storage Options

Before a computer can load Linux, the BIOS or UEFI firmware has to recognize the active primary partition on the disk drive. This partition should include the Linux boot files. The BIOS or UEFI can then set up and initialize that disk drive, and then load Linux boot files from that active primary partition. You should know the following about disk drives and Linux:

- The number of drives that can be installed on modern computers has increased. On commodity hardware it’s relatively easy to get 16 or 24 Serial Advanced Technology Attachment (SATA) or Serial Attached SCSI (SAS) internal drives on a system. Moreover, the use of Non-Volatile Memory Express (NVMe) drives is steadily growing, particularly in applications requiring high performance.

- You need both a UEFI firmware and a GPT-partitioned disk to boot from a drive larger than 2TB. UEFI is a firmware interface that is meant to replace the traditional BIOS, and today is available on many PCs on the market. The GUID Partition Table (GPT) is a partitioning format that supports drives larger than 2TB, but you also require a UEFI firmware (rather than a traditional BIOS firmware) to boot from such device.
- You can install RHEL 9 on a storage area network (SAN) volume. RHEL 9 supports more than 10,000 storage device paths.

Networking

As Linux was originally designed as a clone of Unix, it retains the advantages of Unix as a network operating system. However, not every network component works with Linux. As an example, several manufacturers of wireless network devices have not built Linux drivers. In most such cases, Linux developers have been working endlessly to develop appropriate drivers and to get those drivers incorporated into the major distributions, including RHEL.

Virtual Machine Options

Virtualization makes it relatively easy to set up a large number of systems, so it can help you configure machines, each dedicated to a specific service. To that end, virtualization can be classified into different categories. Some solutions can belong to more than one category. As an example, VMware ESXi is a bare-metal, hypervisor-based virtualization solution that supports hardware-assisted virtualization and provides optional paravirtual drivers to be installed on the guest OS.

- **Application level vs. VM level** Software tools such as Wine (originally an acronym for Wine Is Not an Emulator) support the installation of a single application. In this case, Wine allows an application built for Microsoft Windows to be running on Linux. On the other end, VM-level virtualization emulates a number of complete computer systems for the installation of separate guest OSs.
- **Hosted vs. bare-metal hypervisor** Applications such as VMware Player and VirtualBox are hosted hypervisors (“type-2” hypervisors) because they run on a conventional OS such as Microsoft Windows 11. Conversely, bare-metal virtualization systems, such as VMware ESXi and Citrix Hypervisor (“type-1” hypervisors), include a minimal OS dedicated to VM operations.
- **Paravirtualization vs. full virtualization** Full virtualization allows a guest OS to run unmodified on a hypervisor, whereas paravirtualization requires specialized drivers to be installed in the guest OS.

The KVM (Kernel-based Virtual Machine) solution that comes with RHEL 9 is known as a hypervisor—a VM monitor that supports the running of multiple operating systems concurrently on the same CPU.



KVM replaced Xen as the default hypervisor starting in RHEL 5 and has replaced Xen in many open-source distributions. Citrix Hypervisor (formerly XenServer) is owned by Citrix.

Another virtualization approach that is very popular today is Linux containers, such as those provided by Docker or Podman. This solution is not hypervisor-based but rather relies on the process and filesystem isolation techniques available in the Linux kernel (that is, cgroups and namespaces) to run multiple isolated Linux systems on the same physical host. Kubernetes (and OpenShift, which is based on it) provides an orchestration platform for the management and deployment of containers.

CERTIFICATION OBJECTIVE 1.03

Get Red Hat Enterprise Linux

The RHCSA exam is based on your knowledge of RHEL. To get an official copy of RHEL, you typically need a subscription. However, for development purposes Red Hat also offers a subscription at no cost as part of the Red Hat Developer Program. As an alternative, third-party rebuilds such as AlmaLinux are available. AlmaLinux uses the same source code as RHEL and, except for the trademarks and the connection to the Red Hat Customer Portal, is essentially functionally identical to RHEL.

Once you get a subscription, you'll be able to download RHEL 9 from the Red Hat Customer Portal at <https://access.redhat.com/downloads>. Downloads are available for the operating system in a format appropriate for a DVD. There's also a download available for a network boot ISO image. You'll even be able to download files with the source code

for associated packages. These downloads are in ISO image format, with an **.iso** extension. Such files can be burned to appropriate media, using standard tools such as balenaEtcher, K3b, Brasero, and even corresponding tools on Microsoft systems. Alternatively, you can set up a VM where the virtual CD/DVD drive hardware points directly to the ISO file.

exam

Watch

Although it is important to know how to get RHEL, that skill is not a part of the objectives for the RHCSA exam.