## Contents at a Glance

<table>
<thead>
<tr>
<th>Introduction</th>
<th>xvi</th>
</tr>
</thead>
</table>

### Part I: Network Fundamentals

| CHAPTER 1 | Network Fundamentals: Models and Designs | 3 |
| CHAPTER 2 | Network Fundamentals: IPv4 | 33 |
| CHAPTER 3 | Network Fundamentals: IPv6 | 53 |

### Part II: LAN Switching Fundamentals

| CHAPTER 4 | LAN Switching Fundamentals: Switching Concepts | 75 |
| CHAPTER 5 | LAN Switching Fundamentals: VLANs and Interswitch Connectivity | 91 |
| CHAPTER 6 | LAN Switching Fundamentals: Port Security | 111 |

### Part III: Routing Fundamentals

| CHAPTER 7 | Routing Fundamentals: Routing Concepts | 123 |
| CHAPTER 8 | Routing Fundamentals: Inter-VLAN Routing | 137 |
| CHAPTER 9 | Routing Fundamentals: Static and Dynamic Routing | 153 |

### Part IV: Infrastructure Services

| CHAPTER 10 | Infrastructure Services: DNS, DHCP, NTP | 177 |
| CHAPTER 11 | Infrastructure Services: ACLs | 207 |
| CHAPTER 12 | Infrastructure Services: NAT | 225 |

### Part V: Infrastructure Maintenance

| CHAPTER 13 | Infrastructure Maintenance: Syslog and Device Management | 241 |
| CHAPTER 14 | Infrastructure Maintenance: Initial Device Configuration | 257 |
| CHAPTER 15 | Infrastructure Maintenance: Device Hardening | 269 |
| CHAPTER 16 | Infrastructure Maintenance: Device Maintenance | 285 |
| CHAPTER 17 | Infrastructure Maintenance: IOS Troubleshooting Tools | 295 |
Part VI: Command Reference, Practice Exams, and Glossary

<table>
<thead>
<tr>
<th>Command Reference</th>
<th>319</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practice Exam 1</td>
<td>329</td>
</tr>
<tr>
<td>Answer Key to Practice Exam 1</td>
<td>343</td>
</tr>
<tr>
<td>Practice Exam 2</td>
<td>351</td>
</tr>
<tr>
<td>Answer Key to Practice Exam 2</td>
<td>377</td>
</tr>
<tr>
<td>Glossary</td>
<td>385</td>
</tr>
<tr>
<td>Index</td>
<td>403</td>
</tr>
</tbody>
</table>
Contents

Introduction .......................................................... xvi

Part I: Network Fundamentals

CHAPTER 1: Network Fundamentals: Models and Designs .................. 3
  Topic: Compare and contrast OSI and TCP/IP models ................ 5
  Topic: Compare and contrast TCP and UDP protocols ............. 10
  Topic: Describe the impact of infrastructure components in an enterprise network ........................................... 14
  Topic: Compare and contrast collapsed core and three-tier architectures .......................................................... 17
  Topic: Compare and contrast network topologies .................. 20
  Topic: Select the appropriate cabling type based on implementation requirements .............................................. 23
  Topic: Apply troubleshooting methodologies to resolve problems .... 26
  Review Questions ...................................................... 28
  Answers to Review Questions ........................................ 30
  Additional Resources .................................................. 31

CHAPTER 2: Network Fundamentals: IPv4 .................................. 33
  Topic: Configure, verify, and troubleshoot IPv4 addressing and subnetting ........................................................... 34
  Topic: Compare and contrast IPv4 address types .................. 43
  Topic: Describe the need for private IPv4 addressing .......... 46
  Review Questions ...................................................... 48
  Answers to Review Questions ........................................ 50
  Additional Resources .................................................. 51

CHAPTER 3: Network Fundamentals: IPv6 .................................. 53
  Topic: Identify the appropriate IPv6 addressing scheme to satisfy addressing requirements in a LAN/WAN environment .... 54
  Topic: Configure, verify, and troubleshoot IPv6 addressing .......... 58
  Topic: Configure and verify IPv6 Stateless Address Auto Configuration ................................................................. 62
  Topic: Compare and contrast IPv6 address types ................ 65
Part II: LAN Switching Fundamentals

CHAPTER 4:
LAN Switching Fundamentals: Switching Concepts .................... 75
Topic: Describe and verify switching concepts .................. 76
Topic: Interpret Ethernet frame format ......................... 80
Topic: Troubleshoot interface and cable issues (collisions, errors, duplex, speed) ......................... 83
Review Questions ............................................. 88
Answers to Review Questions ........................................... 89
Additional Resources ....................................... 90

CHAPTER 5:
LAN Switching Fundamentals: VLANs and Interswitch Connectivity ............ 91
Topic: Configure, verify, and troubleshoot VLANs (normal range) spanning multiple switches ......................... 92
Topic: Configure, verify, and troubleshoot interswitch connectivity ................. 100
Topic: Configure and verify Layer 2 protocols .................. 104
Review Questions ............................................. 107
Answers to Review Questions ........................................... 108
Additional Resources ....................................... 109

CHAPTER 6:
LAN Switching Fundamentals: Port Security ...................... 111
Topic: Configure, verify, and troubleshoot port security .................. 112
Review Questions ............................................. 117
Answers to Review Questions ........................................... 118
Additional Resources ....................................... 119

Part III: Routing Fundamentals

CHAPTER 7:
Routing Fundamentals: Routing Concepts ...................... 123
Topic: Describe the routing concepts .................. 124
Topic: Interpret the components of routing table .................. 126
Topic: Describe how a routing table is populated by different routing information sources ........................................ 131
Review Questions ........................................................................ 134
Answers to Review Questions ....................................................... 135
Additional Resources ................................................................... 136

CHAPTER 8:
Routing Fundamentals: Inter-VLAN Routing ................................. 137
Topic: Configure, verify, and troubleshoot inter-VLAN routing ........ 138
Review Questions ........................................................................ 149
Answers to Review Questions ....................................................... 150
Additional Resources ................................................................... 151

CHAPTER 9:
Routing Fundamentals: Static and Dynamic Routing ...................... 153
Topic: Compare and contrast static routing and dynamic routing ........ 154
Topic: Configure, verify, and troubleshoot IPv4 and IPv6 static routing ........................................................................ 157
Topic: Configure, verify, and troubleshoot RIPv2 for IPv4 (excluding authentication, filtering, manual summarization, redistribution) ........................................................................ 161
Review Questions ........................................................................ 171
Answers to Review Questions ....................................................... 172
Additional Resources ................................................................... 173

Part IV: Infrastructure Services

CHAPTER 10:
Infrastructure Services: DNS, DHCP, NTP .................................... 177
Topic: Describe DNS lookup operation ............................................ 178
Topic: Troubleshoot client connectivity issues involving DNS .......... 181
Topic: Configure and verify DHCP on a router (excluding static reservations) .................................................................... 186
Topic: Troubleshoot client- and router-based DHCP connectivity issues ........................................................................ 191
Topic: Configure and verify NTP operating in client/server mode .... 200
Review Questions ........................................................................ 203
Answers to Review Questions ....................................................... 204
Additional Resources ................................................................... 205
CHAPTER 11:
Infrastructure Services: ACLs ........................................... 207
  Topic: Configure, verify, and troubleshoot IPv4 standard numbered
  and named access list for routed interfaces ............................ 208
  Review Questions .................................................................. 221
  Answers to Review Questions ............................................. 222
  Additional Resources ......................................................... 223

CHAPTER 12:
Infrastructure Services: NAT ............................................. 225
  Topic: Configure, verify, and troubleshoot inside source NAT ...... 226
  Review Questions .................................................................. 236
  Answers to Review Questions ............................................. 237
  Additional Resources ......................................................... 238

Part V: Infrastructure Maintenance

CHAPTER 13:
Infrastructure Maintenance: Syslog and Device Management .... 241
  Topic: Configure and verify device-monitoring using syslog ....... 242
  Topic: Configure and verify device management ................... 246
  Review Questions .................................................................. 252
  Answers to Review Questions ............................................. 254
  Additional Resources ......................................................... 255

CHAPTER 14:
Infrastructure Maintenance: Initial Device Configuration .......... 257
  Topic: Configure and Verify Initial Device Configuration .......... 258
  Review Questions .................................................................. 265
  Answers to Review Questions ............................................. 266
  Additional Resource ............................................................ 267

CHAPTER 15:
Infrastructure Maintenance: Device Hardening ......................... 269
  Topic: Configure, Verify, and Troubleshoot Basic Device
  Hardening ........................................................................... 270
  Review Questions .................................................................. 282
  Answers to Review Questions ............................................. 283
  Additional Resources ......................................................... 284
Preface

Why is this book so valuable? Why is it an excellent last resource prior to your exam? Let me outline that for you here:

▶ This book balances the two potential areas of expertise you need for each exam topic. You either need to focus on the theory of a technology, or you also need to be able to demonstrate mastery of configuration, verification, and troubleshooting. You can trust this text to guide you through the precise knowledge you need topic by topic.

▶ As alluded to above, this text remains tightly in scope with the exam. Although larger texts might provide background or peripheral information about a topic, this book is laser-focused on just those topics you need to master for success in the exam environment. We certainly encourage the reading and study of larger works for those that require it.

▶ Your author and technical reviewer have specialized in writing about and training candidates in all things CCNA since the inception of the certification in 1998.

▶ Your author and technical reviewer take the actual ICND1 as many times as Cisco permits us in a constant effort to be intimately familiar with the exam itself and Cisco’s testing techniques.

▶ This book is filled with valuable resources to assist you immediately in your passing score—these resources include CramSavers, CramQuizzes, Review Questions, Final Exams, a Command Reference, and even Cram Sheets.
About the Author

Anthony Sequeira (CCIE No. 15626) began his IT career in 1994 with IBM in Tampa, Florida. He quickly formed his own computer consultancy, Computer Solutions, and then discovered his true passion—teaching and writing about Microsoft and Cisco technologies. Anthony has lectured to massive audiences around the world while working for Mastering Computers. Anthony has never been happier in his career than he is now as a full-time trainer for CBT Nuggets. He is an avid tennis player, a private pilot, a semi-professional poker player, and enjoys getting beaten up by women and children at the martial arts school he attends with his daughter.
Dedication

This book is dedicated to my remarkable wife Joette Sequeira. Thank you for your understanding as I worked all those hours in front of the Word Processor. You helped me improve the lives of readers all over the world. I am sure they thank you as well.

Acknowledgments

I cannot thank Keith Barker enough! He helped me acquire this incredible opportunity, and he improved the book dramatically as its technical editor.
About the Technical Reviewer

Keith Barker began as a network technician for Electronic Data Systems (EDS) in 1985 and has had experience in IT and networking for more than 30 years. Keith creates training for CBT Nuggets, is a Cisco CCIE in Route/Switch and Security and has also earned certifications associated with VMware, Palo Alto, Check Point, ITIL, CCISP, and others. He can be reached through his Facebook page: Keith Barker Networking, on YouTube at Keith6783, or on Twitter @KeithBarkerCCIE.
We Want to Hear from You!

As the reader of this book, you are our most important critic and commentator. We value your opinion and want to know what we’re doing right, what we could do better, what areas you’d like to see us publish in, and any other words of wisdom you’re willing to pass our way.

We welcome your comments. You can email or write to let us know what you did or didn’t like about this book—as well as what we can do to make our books better.

*Please note that we cannot help you with technical problems related to the topic of this book.*

When you write, please be sure to include this book’s title and author as well as your name and email address. We will carefully review your comments and share them with the author and editors who worked on the book.

Email: feedback@pearsonitcertification.com
Mail: Pearson IT Certification
      ATTN: Reader Feedback
      800 East 96th Street
      Indianapolis, IN 46240 USA
Reader Services

Register your copy of CCENT ICND1 100–105 Exam Cram at www.pearsonitcertification.com for convenient access to downloads, updates, and corrections as they become available. To start the registration process, go to www.pearsonitcertification.com/register and log in or create an account*. Enter the product ISBN 9780789756732 and click Submit. When the process is complete, you will find any available bonus content under Registered Products.

*Be sure to check the box that you would like to hear from us to receive exclusive discounts on future editions of this product.
Introduction

Welcome to CCENT Exam Cram! This book covers the CCENT certification exam. Whether this is your first or your fifteenth Exam Cram, you'll find information here that will ensure your success as you pursue knowledge, experience, and certification. This introduction covers how the Exam Cram series can help you prepare for the CCENT exam.

This book is one of the Exam Cram series of books and will help by getting you on your way to becoming a CCENT.

This introduction discusses the basics of the CCENT exam. Included are sections covering preparation, how to take an exam, a description of this book's contents, how this book is organized, and, finally, author contact information.

Each chapter in this book contains practice questions. There are also two full-length practice exams at the end of the book. Practice exams in this book should provide an accurate assessment of the level of expertise you need to obtain to pass the test. Answers and explanations are included for all test questions. It is best to obtain a level of understanding equivalent to a consistent pass rate of at least 90 percent or more on the practice questions and exams in this book before you attempt the real exam.

Let's begin by looking at preparation for the exam.

How to Prepare for the Exam

This text follows the official exam objectives letter for letter. These official objective from Cisco Systems can be found here:

https://learningnetwork.cisco.com/community/certifications/ccna/icnd1/exam-topics

Following the exam topics item by item and in their original order allows you to ensure you are ready for the real exam questions that will come your way on your actual test date.
Practice Tests

This book is filled with practice exam questions to get you ready! Enjoy the following:

▶ **CramSaver questions before each and every section**: These difficult, open-ended questions ensure you really know the material. Some readers use these questions in order to “test out” of a particular section.

▶ **CramQuizzes to end each section**: Another chance to demonstrate your knowledge after completing a section.

▶ **Review Questions to end each chapter**: Your final pass-through the material for that chapter.

▶ **Two full final exams**: These exams include explanations and tips for approaching each final exam question.

In addition, the book includes an additional two full practice tests in the Pearson Test Prep software that is available to you either online or as an offline Windows application. To access the practice exams that were developed with this book, please see the instructions in the card inserted in the sleeve in the back of the book. This card includes a unique access code that enables you to activate your exams in the Pearson Test Prep software.

If you are interested in more practice exams than are provided with this book, Pearson IT Certification publishes a Premium Edition eBook and Practice Test product. In addition to providing you with three eBook files (EPUB, PDF, and Kindle) this product provides you with two addition exams worth of questions. The Premium Edition version also offers you a link to the specific section in the book that presents an overview of the topic covered in the question, allowing you to easily refresh your knowledge. The insert card in the back of the book includes a special offer for a 70 percent discount off of this Premium Edition eBook and Practice Test product, which is an incredible deal.

Taking a Certification Exam

When you have prepared for the exam, you must register with Cisco Systems to take the exam. The CCENT (ICND1) exam is given at Pearson VUE testing centers. Check the Pearson VUE website at http://www.pearsonvue.com/ to get specific details.

You can register for an exam done online or by phone. After you register, you will receive a confirmation notice. Some locations may have limited test
Arriving at the Exam Location
As with any examination, arrive at the testing center early. Be prepared! You will need to bring two forms of identification (one with a picture). The testing center staff requires proof that you are who you say you are and that someone else is not taking the test for you. Arrive early because if you are late, you will be barred from entry and will not receive a refund for the cost of the exam.

ExamAlert
You’ll be spending a lot of time in the exam room. Plan on using the full two hours of time allotted for your exam and surveys. Policies differ from location to location regarding bathroom breaks—check with the testing center before beginning the exam.

In the Testing Center
You will not be allowed to take study materials or anything else into the examination room with you that could raise suspicion that you’re cheating. This includes practice test material, books, exam prep guides, or other test aids. The Testing Center will provide you with scratch paper and a pen or pencil. These days, this often comes in the form of an erasable whiteboard.

After the Exam
Examination results are available after the exam. If you pass the exam, you will simply receive a passing grade—your exact score will not be provided. Candidates who do not pass will receive a complete breakdown on their score by domain. This allows those individuals to see what areas they are weak in.

About This Book
The ideal reader for an Exam Cram book is someone seeking certification. However, it should be noted that an Exam Cram book is a very easily readable, rapid presentation of facts. Therefore, an Exam Cram book is also extremely useful as a quick reference manual.
Most people seeking certification use multiple sources of information. Check out the links at the end of each chapter to get more information about subjects you’re weak in.

This book includes other helpful elements in addition to the actual logical, step-by-step learning progression of the chapters themselves. *Exam Cram* books use elements such as examalerts, tips, notes, and practice questions to make information easier to read and absorb. This text also includes a very helpful Command Reference and Glossary to assist you.

**Note**

Reading this book from start to finish is not necessary; this book is set up so that you can quickly jump back and forth to find sections you need to study.

Use the *Cram Sheet* to remember last-minute facts immediately before the exam. Use the practice questions to test your knowledge. You can always brush up on specific topics in detail by referring to the table of contents and the index. Even after you achieve certification, you can use this book as a rapid-access reference manual.

### The Exam Blueprint

The table that follows outlines the CCENT exam domains and objectives and maps the objectives to the chapter(s) in the book that cover them in detail.

<table>
<thead>
<tr>
<th>Exam Domain</th>
<th>Objective</th>
<th>Chapter in Book That Covers It</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Fundamentals</td>
<td>Compare and contrast OSI and TCP/IP models</td>
<td>Chapter 1</td>
</tr>
<tr>
<td>Network Fundamentals</td>
<td>Compare and contrast TCP and UDP protocols</td>
<td>Chapter 1</td>
</tr>
<tr>
<td>Network Fundamentals</td>
<td>Describe the impact of infrastructure components in an enterprise network</td>
<td>Chapter 1</td>
</tr>
<tr>
<td>Network Fundamentals</td>
<td>Compare and contrast collapsed core and three-tier architectures</td>
<td>Chapter 1</td>
</tr>
<tr>
<td>Network Fundamentals</td>
<td>Compare and contrast network topologies</td>
<td>Chapter 1</td>
</tr>
<tr>
<td>Network Fundamentals</td>
<td>Select the appropriate cabling type based on implementation requirements</td>
<td>Chapter 1</td>
</tr>
<tr>
<td>Exam Domain</td>
<td>Objective</td>
<td>Chapter in Book That Covers It</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>Network Fundamentals</td>
<td>Apply troubleshooting methodologies to resolve problems</td>
<td>Chapter 1</td>
</tr>
<tr>
<td>Network Fundamentals</td>
<td>Configure, verify, and troubleshoot IPv4 addressing and subnetting</td>
<td>Chapter 2</td>
</tr>
<tr>
<td>Network Fundamentals</td>
<td>Compare and contrast IPv4 address types</td>
<td>Chapter 2</td>
</tr>
<tr>
<td>Network Fundamentals</td>
<td>Describe the need for private IPv4 addressing</td>
<td>Chapter 2</td>
</tr>
<tr>
<td>Network Fundamentals</td>
<td>Identify the appropriate IPv6 addressing scheme to satisfy addressing requirements in a LAN/WAN environment</td>
<td>Chapter 3</td>
</tr>
<tr>
<td>Network Fundamentals</td>
<td>Configure, verify, and troubleshoot IPv6 addressing</td>
<td>Chapter 3</td>
</tr>
<tr>
<td>Network Fundamentals</td>
<td>Configure and verify IPv6 Stateless Address Auto Configuration</td>
<td>Chapter 3</td>
</tr>
<tr>
<td>Network Fundamentals</td>
<td>Compare and contrast IPv6 address types</td>
<td>Chapter 3</td>
</tr>
<tr>
<td>LAN Switching Fundamentals</td>
<td>Describe and verify switching concepts</td>
<td>Chapter 4</td>
</tr>
<tr>
<td>LAN Switching Fundamentals</td>
<td>Interpret Ethernet frame format</td>
<td>Chapter 4</td>
</tr>
<tr>
<td>LAN Switching Fundamentals</td>
<td>Troubleshoot interface and cable issues (collisions, errors, duplex, speed)</td>
<td>Chapter 4</td>
</tr>
<tr>
<td>LAN Switching Fundamentals</td>
<td>Configure, verify, and troubleshoot VLANs (normal range) spanning multiple switches</td>
<td>Chapter 5</td>
</tr>
<tr>
<td>LAN Switching Fundamentals</td>
<td>Configure, verify, and troubleshoot interswitch connectivity</td>
<td>Chapter 5</td>
</tr>
<tr>
<td>LAN Switching Fundamentals</td>
<td>Configure, verify, and troubleshoot port security</td>
<td>Chapter 6</td>
</tr>
<tr>
<td>Routing Fundamentals</td>
<td>Describe the routing concepts</td>
<td>Chapter 7</td>
</tr>
<tr>
<td>Routing Fundamentals</td>
<td>Interpret the components of routing table</td>
<td>Chapter 7</td>
</tr>
<tr>
<td>Routing Fundamentals</td>
<td>Describe how a routing table is populated by different routing information sources</td>
<td>Chapter 7</td>
</tr>
<tr>
<td>Exam Domain</td>
<td>Objective</td>
<td>Chapter in Book That Covers It</td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>Routing Fundamentals</td>
<td>Configure, verify, and troubleshoot inter-VLAN routing</td>
<td>Chapter 8</td>
</tr>
<tr>
<td>Routing Fundamentals</td>
<td>Compare and contrast static routing and dynamic routing</td>
<td>Chapter 9</td>
</tr>
<tr>
<td>Routing Fundamentals</td>
<td>Configure, verify, and troubleshoot IPv4 and IPv6 static routing</td>
<td>Chapter 9</td>
</tr>
<tr>
<td>Routing Fundamentals</td>
<td>Configure, verify, and troubleshoot RIPv2 for IPv4 (excluding authentication, filtering, manual summarization, redistribution)</td>
<td>Chapter 9</td>
</tr>
<tr>
<td>Infrastructure Services</td>
<td>Describe DNS lookup operation</td>
<td>Chapter 10</td>
</tr>
<tr>
<td>Infrastructure Services</td>
<td>Troubleshoot client connectivity issues involving DNS</td>
<td>Chapter 10</td>
</tr>
<tr>
<td>Infrastructure Services</td>
<td>Configure and verify DHCP on a router (excluding static reservations)</td>
<td>Chapter 10</td>
</tr>
<tr>
<td>Infrastructure Services</td>
<td>Troubleshoot client- and router-based DHCP connectivity issues</td>
<td>Chapter 10</td>
</tr>
<tr>
<td>Infrastructure Services</td>
<td>Configure and verify NTP operating in client/server mode</td>
<td>Chapter 10</td>
</tr>
<tr>
<td>Infrastructure Services</td>
<td>Configure, verify, and troubleshoot IPv4 standard numbered and named access list for routed interfaces</td>
<td>Chapter 11</td>
</tr>
<tr>
<td>Infrastructure Services</td>
<td>Configure, verify, and troubleshoot inside source NAT</td>
<td>Chapter 12</td>
</tr>
<tr>
<td>Infrastructure Maintenance</td>
<td>Configure and verify device-monitoring using syslog</td>
<td>Chapter 13</td>
</tr>
<tr>
<td>Infrastructure Maintenance</td>
<td>Configure and verify device management</td>
<td>Chapter 13</td>
</tr>
<tr>
<td>Infrastructure Maintenance</td>
<td>Configure and verify initial device configuration</td>
<td>Chapter 14</td>
</tr>
<tr>
<td>Infrastructure Maintenance</td>
<td>Configure, verify, and troubleshoot basic device hardening</td>
<td>Chapter 15</td>
</tr>
<tr>
<td>Infrastructure Maintenance</td>
<td>Perform device maintenance</td>
<td>Chapter 16</td>
</tr>
<tr>
<td>Infrastructure Maintenance</td>
<td>Use Cisco IOS tools to troubleshoot and resolve problems</td>
<td>Chapter 17</td>
</tr>
</tbody>
</table>
The Chapter Elements

Each Exam Cram book has chapters that follow a predefined structure. This structure makes Exam Cram books easy to read and provides a familiar format for all Exam Cram books. The following elements typically are used:

▶ Chapter topics
▶ Essential Terms and Components
▶ CramSavers
▶ CramQuizzes
▶ ExamAlerts
▶ Notes
▶ Exam preparation practice questions and answers
▶ An “Additional Resources” section at the end of each chapter

Bulleted lists, numbered lists, tables, and graphics are also used where appropriate. A picture can paint a thousand words sometimes, and tables can help to associate different elements with each other visually.

Now let’s look at each of the elements in detail.

▶ Chapter topics—Each chapter contains details of all subject matter listed in the table of contents for that particular chapter. The objective of an Exam Cram book is to cover all the important facts without giving too much detail; it is an exam cram. When examples are required, they are included.

▶ Essential Terms and Components—The start of every chapter contains a list of terms and concepts you should understand. These are all defined in the book’s accompanying Glossary. They are also highlighted the first time they are encountered in a chapter.

▶ CramSavers—Each major section in the chapter kicks off with a brief short answer question quiz to help you assess your knowledge of the section topic. This chapter element is designed to help you determine if you need to read the whole section in detail or merely skim the material and skip ahead to the CramQuiz at the end of the section.
Introduction

- **CramQuizzes**—Each major section in the chapter concludes with a multiple choice question quiz to help ensure that you have gained a familiarity with the section content.

- **ExamAlerts**—ExamAlerts address exam-specific, exam-related information. An ExamAlert addresses content that is particularly important, tricky, or likely to appear on the exam. An ExamAlert looks like this:

  **ExamAlert**
  Make sure you remember the different ways in which you can access a router remotely. Know which methods are secure, and which are not.

- **Notes**—Notes typically contain useful information that is not directly related to the current topic under consideration. To avoid breaking up the flow of the text, they are set off from the regular text.

  **Note**
  This is a note. You have already seen several notes.

- **Review Questions**—At the end of every chapter is a battery of exam practice questions similar to those in the actual exam. Each chapter contains a list of questions relevant to that chapter, including answers and explanations. Test your skills as you read.

- **Additional Resources section**—This section at the end of each chapter describes other relevant sources of information related to the chapter topics covered.

Other Book Elements

Most of this Exam Cram book on CCENT follows the consistent chapter structure already described. However, there are various, important elements that are not part of the standard chapter format. These elements apply to the entire book as a whole.

- **Practice exams**—In addition to exam-preparation questions at the end of each chapter, two full practice exams are included at the end of the book.
Answers and explanations for practice exams—These follow each practice exam, providing answers and explanations to the questions in the exams.

Command Reference—This valuable study guide appears at the end of the text.

Glossary—The glossary contains a listing of important terms used in this book with explanations.

Cram Sheet—The Cram Sheet is a quick-reference, tear-out cardboard sheet of important facts useful for last-minute preparation. Cram sheets often include a simple summary of facts that are most difficult to remember.

Companion Website—The companion website for your book allows you to access several digital assets that come with your book, including:

- Pearson Test Prep software (both online and Windows desktop versions)
- Key Terms Flash Cards application
- A PDF version of the Command Reference
- A PDF version of the Cram Sheet

To access the book’s companion website, simply follow these steps:

2. Respond to the challenge questions.
3. Go to your account page and select the Registered Products tab.
4. Click on the Access Bonus Content link under the product listing.

Pearson Test Prep Practice Test Software

As noted previously, this book comes complete with the Pearson Test Prep practice test software containing four full exams (the two from the back of the book as well as two additional tests). These practice tests are available to you either online or as an offline Windows application. To access the practice exams that were developed with this book, please see the instructions in the card inserted in the sleeve in the back of the book. This card includes a unique
access code that enables you to activate your exams in the Pearson Test Prep software. Note that this single access code can be used to activate both the online and offline versions of the software.

**Accessing the Pearson Test Prep Software Online**

The online version of this software can be used on any device with a browser and connectivity to the Internet, including desktop machines, tablets, and smartphones. To start using your practice exams online, simply follow these steps:

2. Select **Pearson IT Certification** as your product group.
3. Enter your email/password for your account. If you don’t have an account on PearsonITCertification.com or CiscoPress.com, you will need to establish one by going to PearsonITCertification.com/join.
4. In the **My Products** tab, click the **Activate New Product** button.
5. Enter the access code printed on the insert card in the back of your book to activate your product.
6. The product will now be listed in your **My Products** page. Click the **Exams** button to launch the exam settings screen and start your exam.

**Accessing the Pearson Test Prep Software Offline**

If you wish to study offline, you can download and install the Windows version of the Pearson Test Prep software. There is a download link for this software on the book’s companion web site, or you can just enter this link in your browser:

[http://www.pearsonitcertification.com/content/downloads/pcpt/engine.zip](http://www.pearsonitcertification.com/content/downloads/pcpt/engine.zip)

To access the book's companion web site and the software, simply follow these steps:

2. Respond to the challenge questions.
3. Go to your account page and select the **Registered Products** tab.
4. Click on the **Access Bonus Content** link under the product listing.
5. Click the **Install Pearson Test Prep Desktop Version** link under the Practice Exams section of the page to download the software.
6. After the software finishes downloading, unzip all the files on your computer.
7. Double click the application file to start the installation, and follow the on-screen instructions to complete the registration.
8. When the installation is complete, launch the application and select **Activate Exam** button on the My Products tab.
9. Click the **Activate a Product** button in the Activate Product Wizard.
10. Enter the unique access code found on the card in the sleeve in the back of your book and click the **Activate** button.
11. Click **Next** and then the **Finish** button to download the exam data to your application.
12. You can now start using the practice exams by selecting the product and clicking the **Open Exam** button to open the exam settings screen.

Note that the offline and online versions will synch together, so saved exams and grade results recorded on one version will be available to you on the other as well.

**Customizing Your Exams**

Once you are in the exam settings screen, you can choose to take exams in one of three modes:

- **Study Mode**
- **Practice Exam Mode**
- **Flash Card Mode**

Study Mode allows you to fully customize your exams and review answers as you are taking the exam. This is typically the mode you would use first to assess your knowledge and identify information gaps. Practice Exam Mode locks certain customization options, as it is presenting a realistic exam experience. Use this mode when you are preparing to test your exam readiness.
Flash Card Mode strips out the answers and presents you with only the question stem. This mode is great for late stage preparation when you really want to challenge yourself to provide answers without the benefit of seeing multiple choice options. This mode will not provide the detailed score reports that the other two modes will, so it should not be used if you are trying to identify knowledge gaps.

In addition to these three modes, you will be able to select the source of your questions. You can choose to take exams that cover all of the chapters or you can narrow your selection to just a single chapter or the chapters that make up specific parts in the book. All chapters are selected by default. If you want to narrow your focus to individual chapters, simply deselect all the chapters then select only those on which you wish to focus in the Objectives area.

You can also select the exam banks on which to focus. Each exam bank comes complete with a full exam of questions that cover topics in every chapter. The two exams printed in the book are available to you as well as two additional exams of unique questions. You can have the test engine serve up exams from all four banks or just from one individual bank by selecting the desired banks in the exam bank area.

There are several other customizations you can make to your exam from the exam settings screen, such as the time of the exam, the number of questions served up, whether to randomize questions and answers, whether to show the number of correct answers for multiple answer questions, or whether to serve up only specific types of questions. You can also create custom test banks by selecting only questions that you have marked or questions on which you have added notes.

### Updating Your Exams

If you are using the online version of the Pearson Test Prep software, you should always have access to the latest version of the software as well as the exam data. If you are using the Windows desktop version, every time you launch the software, it will check to see if there are any updates to your exam data and automatically download any changes that were made since the last time you used the software. This requires that you are connected to the Internet at the time you launch the software.

Sometimes, due to many factors, the exam data may not fully download when you activate your exam. If you find that figures or exhibits are missing, you may need to manually update your exams.
To update a particular exam you have already activated and downloaded, simply select the **Tools** tab and select the **Update Products** button. Again, this is only an issue with the desktop Windows application.

If you wish to check for updates to the Pearson Test Prep exam engine software, Windows desktop version, simply select the **Tools** tab and select the **Update Application** button. This will ensure you are running the latest version of the software engine.

**Contacting the Author**

Hopefully, this book provides you with the tools you need to pass the CCENT exam. Feedback is appreciated. You can contact the author at compsolv@me.com.

Thank you for selecting my book; I have worked to apply the same concepts in this book that I have used in the hundreds of training classes I have taught. Spend your study time wisely and you, too, can become a CCENT. Good luck on the exam, although if you carefully work through this text, you will certainly minimize the amount of luck required!
PART I

Network Fundamentals

This part of the text deals with one of five overall sections you must master for the ICND1 exam. There are three chapters total that make up Part 1. These three chapters, taken as a whole, represent 20 percent of the exam questions you face in your exam. This means that the Network Fundamentals area is the third-most important section of the five overall sections that you deal with on your testing day.

Here you master important models and designs, as well as key fundamentals of networking such as transport protocols and cabling. You also dig deep into the worlds of TCP/IP version 4 and TCP/IP version 6. Both of these protocol suites are already popular today. Version 4 should gradually fade away from usage (although perhaps never completely), whereas IPv6 installations should become more and more predominant.

Part 1 includes the following chapters:

CHAPTER 1 Network Fundamentals: Models and Designs
CHAPTER 2 Network Fundamentals: IPv4
CHAPTER 3 Network Fundamentals: IPv6
CHAPTER 2

Network Fundamentals: IPv4

This chapter covers the following official ICND1 100-105 exam topics:

▶ Configure, verify, and troubleshoot IPv4 addressing and subnetting
▶ Compare and contrast IPv4 address types
▶ Describe the need for private IPv4 addressing

This chapter ensures you are ready for the above topics from the Network Fundamentals section of the overall exam blueprint from Cisco Systems. Remember, this is just a section of the Network Fundamentals area. Chapters One and Three also make up this grouping. Those chapters deal with networking models and IPv6 respectively.

Essential Terms and Components

▶ IPv4 Addressing
▶ IPv4 Address Classes
▶ Subnet Masks
▶ IPv4 Subnetting
▶ IPv4 Address Configuration
▶ Broadcasts
▶ Unicasts
▶ Multicasts
▶ Private IPv4 Addressing
▶ Network Address Translation (NAT)
CHAPTER 2: Network Fundamentals: IPv4

Topic: Configure, verify, and troubleshoot IPv4 addressing and subnetting

CramSaver

If you can correctly answer these CramSaver questions, save time by skimming the ExamAlerts in this chapter and then completing the CramQuiz at the end of each section and the Review Questions at the end of the chapter. If you are in doubt at all—read EVERYTHING in this chapter!

1. What is 187 converted to binary?
   _______

2. What is 10010011 in decimal?
   _______

3. What class of address is 239.1.2.3?
   _______

4. You are using 5 mask bits in an octet. What is the decimal value in this octet of the subnet mask?
   _______

5. How many hosts can this network support: 10.0.0.0 255.255.255.128?
   _______

6. How many subnets can you create if you borrow 6 bits?
   _______

7. What is the broadcast address for the subnet 10.15.2.0 255.255.254.0?
   _______

8. What is the usable host range for 10.15.0.224/27?
   _______
Remember, an IPv4 address is a 32-bit number that we like to represent in dotted decimal notation. Consider using a conversion chart for the 8 bits that exist in an octet to help you with the various subnetting exercises you might encounter in the exam. Figure 2.1 is the simple chart I build on scratch paper before starting the exam:

![Conversion Chart for IPv4 Addressing and Subnetting Questions](image)

One task that is simple using this chart is converting a number from decimal to binary or vice versa. For example, to convert 186 to binary, we first note that you can successfully subtract 128 from this number, so the first bit is on (1). The remainder is 58 after this subtraction. Note we cannot subtract 64 from this number (without having a negative number), so we move to the next number after setting the 64 value to off (0). We then subtract 32 from 58. This places a 1 in the 32 column and leaves us with 26. We can subtract 16 from 26 so there is a 1 in that column. Continuing with this method, we easily calculate that 186 in binary is:

10111010

Converting from binary to decimal is even easier. Just examine what bit positions are on (1) and add those decimal values together. So for example, 11101111 equals:

239
Early on in the development of TCP/IP, the designers created address classes to attempt to accommodate networks of various sizes. Notice they did this by setting the initial bit values. Table 2.1 shows these classes.

**TABLE 2.1 The TCP/IP Version 4 Address Classes**

<table>
<thead>
<tr>
<th>Address Class</th>
<th>High-Order Bit Setting</th>
<th>1st Octet Range in Decimal</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>1–127</td>
</tr>
<tr>
<td>B</td>
<td>10</td>
<td>128–191</td>
</tr>
<tr>
<td>C</td>
<td>110</td>
<td>192–223</td>
</tr>
<tr>
<td>D</td>
<td>1110</td>
<td>224–239</td>
</tr>
</tbody>
</table>

ExamAlert

It is an important skill to be able to recognize the class of address using the decimal value in the first octet. Note that addresses beginning with 127 are reserved for local loopback purposes. Also memorize that class D addresses are for multicasting. Multicast can be used to send a message to multiple devices across multiple networks and subnetworks.

Another critical memorization point here is the default subnet masks for these address classes. Remember, it is the job of the subnet mask to define what portion of the 32-bit address represents the network portion versus the host portion. Table 2.2 defines the default masks.

**TABLE 2.2 Default IPv4 Subnet Masks**

<table>
<thead>
<tr>
<th>Address Class</th>
<th>Default Mask</th>
<th>Prefix Notation</th>
<th>Mask Bits</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>255.0.0.0</td>
<td>/8</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>255.255.0.0</td>
<td>/16</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>255.255.255.0</td>
<td>/24</td>
<td></td>
</tr>
</tbody>
</table>

Note that subnet masks must use continuous on bits (1). This results in the only possible values in a subnet mask octet shown in Table 2.3.
TABLE 2.3  The Possible Values in an IPv4 Subnet Mask Octet

<table>
<thead>
<tr>
<th>On Bits</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>255</td>
</tr>
<tr>
<td>7</td>
<td>254</td>
</tr>
<tr>
<td>6</td>
<td>252</td>
</tr>
<tr>
<td>5</td>
<td>248</td>
</tr>
<tr>
<td>4</td>
<td>240</td>
</tr>
<tr>
<td>3</td>
<td>224</td>
</tr>
<tr>
<td>2</td>
<td>192</td>
</tr>
<tr>
<td>1</td>
<td>128</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

ExamAlert

Some students will write out this table on scratch paper, as well as other tables in this chapter before they begin their exam. I do not do so, as I find I can pretty quickly calculate these facts on an as-needed basis during the exam.

Remember, subnetting is the process of “stealing” or “borrowing” bits from the host portion of the IPv4 address in order to create additional subnets. Think of using the following IP address and subnet mask combination in your network:

10.0.0.0/8 or 10.0.0.0 255.0.0.0

This allows you to only create one giant network. Sure, this network can have many host systems (specifically $2^{24} - 2$), but they all must exist in the same network. With broadcast traffic and other potential issues, this would be terrible for efficient communications. Today, we like to divide networks into small sections (subnetworks) of about 100 computers or less.

ExamAlert

Notice that the formula for calculating the number of hosts a subnet can support is to take the number of bits remaining for host addressing (h), make this the exponent for the number 2, and then subtract 2 from this amount. Thus, the formula is $2^h - 2$. We subtract two in this formula because we cannot assign a host an IP address with all zeroes in the host bits or all ones in the host bits. These are reserved for the identification of the network itself (all zeroes), and the broadcast address (all ones) for that subnet.
In the preceding example, we might decide to borrow 4 bits for subnetting. Now the identifications look like this:

\[ 10.0.0.0 \ 255.240.0.0 \text{ or } 10.0.0.0/12 \]

How many bits are left for host identification? The subnet mask now contains 12 bits, leaving 20 bits available for host identification. Note that our calculation \(2^{20} - 2\) requires a calculator. As a result, you would not see this question in your exam. The answer is an astounding 1,048,574 hosts per subnet.

**ExamAlert**

But how many subnets can we create? The answer is the formula \(2^s\) where \(s\) is the number of subnet bits we are borrowing. So in this case, we have \(2^4\). Examining my scratch paper chart from Figure 2.1, I quickly see the answer is 16 subnets. Note that as we borrow more and more host bits, we can create more and more subnets, but each subnet supports fewer and fewer hosts.

Also important is to establish the exact subnets we create given a bit-borrowing scenario. The great news is: We once again rely on Figure 2.1 for assistance!

Using the preceding scenario, we have:

\[ 10.0.0.0 \ 255.240.0.0 \text{ or } 10.0.0.0/12 \]

To determine the subnets—we determine our block size. The block size is the least significant bit (rightmost) decimal value that the mask extends in to. So, in our example here, we extend four bits into the second octet. The decimal value here from Figure 2.1 is 16. We start at 0 and then each new subnet increments by 16! So we have subnets numbered 0, 16, 32, 48, 64, 80, and so on. Plugging these values into our IP address, we have:

\[ 10.0.0.0/12 \]
\[ 10.16.0.0/12 \]
\[ 10.32.0.0/12 \]
\[ 10.48.0.0/12 \]
\[ 10.64.0.0/12 \]
\[ 10.80.0.0/12 \]

Etc.
What if we begin with 10.46.0.0/16 and we want to borrow 4 additional bits to create new subnets? No problem. We have:

- 10.46.0.0/20
- 10.46.16.0/20
- 10.46.32.0/20
- 10.46.48.0/20
- 10.46.64.0/20
- 10.46.80.0/20

Etc.

What if we begin with 192.168.1.0/24 and we need to create 6 subnets? Borrowing 3 bits does the job with some to spare ($2^3 = 8$). So we have subnets of:

- 192.168.1.0/27
- 192.168.1.32/27
- 192.168.1.64/27
- 192.168.1.96/27
- 192.168.1.128/27
- 192.168.1.160/27

There are two more subnets of course, but we do not care here because we only needed six.

**Note**

You can take unused subnets and further subnet them! This is known as variable length subnet masking (VLSM).

What about usable addresses for hosts on a subnet? Look at 192.168.1.0/27 above. That is a reserved address—it is the subnet ID itself. Add 1 to this and you have the first usable host address on this subnet—so it would be 192.168.1.1/27. The last address before we get to the next subnet is 192.168.1.31/27. This is reserved as well. It is for the subnet broadcast. Remember from our earlier discussion these two reserved addresses are why we have the $-2$ in the hosts calculation formula. So the last usable address on the subnet is 192.168.1.30/27. The last usable address is always the next subnet ID minus two.
Here is one more example for you. If we have 10.10.0.0/16 and we want at least 15 new subnets, we create the scheme 10.10.0.0/20. Here are the usable host ranges for the first four subnets:

- Subnet 10.10.0.0/20—First Usable 10.10.0.1—Last Usable 10.10.15.254
- Subnet 10.10.16.0/20—First Usable 10.10.16.1—Last Usable 10.10.31.254
- Subnet 10.10.32.0/20—First Usable 10.10.32.1—Last Usable 10.10.47.254
- Subnet 10.10.48.0/20—First Usable 10.10.48.1—Last Usable 10.10.63.254

Be ready to implement all of the above skills in the exam environment. Obviously there are a variety of ways in which questions can be asked of you, and this chapter provides plenty of examples through CramSavers, CramQuizzes, and Review Questions. Although initially these questions might seem like a lot of work, you eventually crave questions like this in the exam because they are just math. Math questions don’t have the challenging gray areas other multiple-choice questions have.

**CramQuiz**

1. What is 203 converted to binary?
   - A. 11001011
   - B. 11101011
   - C. 10101100
   - D. 11001000

2. What is 01101111 in decimal?
   - A. 112
   - B. 111
   - C. 120
   - D. 110

3. What is the default subnet mask for a class B network?
   - A. 255.255.255.0
   - B. 255.0.0.0
**Topic: Configure, verify, and troubleshoot IPv4 addressing and subnetting**

- C. 255.255.0.0
- D. 255.255.255.255

4. If your mask uses three bits in an octet, what is the decimal value?
   - A. 192
   - B. 224
   - C. 240
   - D. 252

5. If you have a mask of 255.255.255.240—how many hosts can you support?
   - A. 32
   - B. 62
   - C. 14
   - D. 6

6. Your network needs to support 30 subnets. How many bits should you “borrow” in order to create the least waste in address space?
   - A. 4
   - B. 5
   - C. 6
   - D. 7

7. What is the last usable host on a subnet where your computer has been given the address of 172.16.7.1 255.255.254.0?
   - A. 172.16.7.255
   - B. 172.16.6.1
   - C. 172.16.7.128
   - D. 172.16.7.254

**CramQuiz Answers**

1. A is correct. Using the chart in Figure 2.1, you arrive at these decimal values: $128 + 64 + 8 + 2 + 1 = 203$.
2. B is correct. The bits we add here are $64 + 32 + 8 + 4 + 2 + 1 = 111$.
3. C is correct. 255.255.0.0 or 16 bits is the default mask for a Class B address.
4. B is correct. Three bits would mean $128 + 64 + 32 = 224$. 
5. C is correct. With this mask, there are only 4 bits left for host addressing. Using the chart in Figure 2.1, we learn that 2 raised to the 4th power is 16. We subtract two from this number to arrive at 14 hosts.

6. B is correct. Borrowing 5 bits permits the creation of 32 subnets. You have the 30 you need, plus 2 additional subnets.

7. D is correct. The usable host range here is 172.16.6.1 through 172.16.7.254.
Modern networking systems use three main forms of addressing in order to communicate in the network:

- **Unicast**
- **Broadcast**
- **Multicast**

Unicast transmission is most likely what you think of first. For example, you are in a home network with an IP address of 192.168.2.1, and you want to send data to print to a printer located at 192.168.1.10. You do not intend for any other system to receive this traffic. This is a classic example of unicast IPv4 traffic.

When you have a system that must send a frame to all members of the network, this is termed a *broadcast*. At Layer 2, the destination broadcast address is FF:FF:FF:FF:FF:FF. At Layer 3, an example of a broadcast IPv4 address is
255.255.255.255. Remember, there is another type of broadcast, however. This is when a packet is destined for all of the members of a subnet. You and I calculated the broadcast address for subnets in this chapter. So, for example, the broadcast address for Subnet 10.10.0.0/20 is 10.10.15.255.

**Note**

Because a directed broadcast to a remote subnet can introduce many potential security issues, most routers give you the opportunity to enable or disable directed broadcast capabilities.

What if you want your device to “tune into” traffic in much the same way we tune into a television station in order to enjoy a broadcast of some show? The network equivalent of this is multicasting. Remember, the multicast address range is 224–239 in the first octet. Computers can “subscribe” to or “join” the multicast group by participating in this address scheme (in addition to their unicast address). Multicast is a way of sending one message (or set of packets) to multiple hosts across multiple networks and subnetworks. Some routing protocols use multicast addressing. When you enable RIP on your router, it starts listening for traffic destined for its 224.0.0.9 address as this is the address used to send traffic to all RIPv2 routers.

### CramQuiz

1. Your system is sending email to the local SMTP server. What type of IPv4 traffic is this most likely given that these two systems have communicated seconds ago?
   - **A.** Broadcast
   - **B.** Multicast
   - **C.** Unicast
   - **D.** Anycast

2. EIGRP uses 224.0.0.10 in its operation. What type of address is this?
   - **A.** Unicast
   - **B.** Broadcast
   - **C.** Multicast
   - **D.** Anycast
Topic: Compare and contrast IPv4 address types

3. What does it mean when you see FF:FF:FF:FF:FF as the destination address in an Ethernet frame?
   - A. It means the frame is a multicast.
   - B. It means the frame is a unicast.
   - C. It means the frame should be dropped.
   - D. It means the frame is a broadcast.

CramQuiz Answers

1. C is correct. Although an ARP broadcast may initially be needed, because these systems have already communicated, the traffic can be sent unicast.

2. C is correct. 224.0.0.10 is the all-EIGRP-routers multicast address.

3. D is correct. The destination address of FF:FF:FF:FF:FF:FF is a reserved MAC address to indicate a broadcast.
CHAPTER 2: Network Fundamentals: IPv4

Topic: Describe the need for private IPv4 addressing

The designers of IPv4 created private address space to help alleviate the depletion of IPv4 addresses. This address space is not routable on the public Internet. This address space can be used as needed inside corporations. This address space would then be translated using Network Address Translation (NAT) to allow access to and through the public Internet. Of course, this is why you tend to see the same addresses used in homes today (typically in the 192.168.1.X range). Table 2.4 shows you the private address space.

<table>
<thead>
<tr>
<th>Address Class</th>
<th>Range of Private Addresses</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10.0.0.0 to 10.255.255.255</td>
</tr>
<tr>
<td>B</td>
<td>172.16.0.0 to 172.31.255.255</td>
</tr>
<tr>
<td>C</td>
<td>192.168.0.0 to 192.168.255.255</td>
</tr>
</tbody>
</table>
Topic: Describe the need for private IPv4 addressing

ExamAlert
Clearly a skill you must possess is to memorize these ranges. Although it is normally not important to memorize Request for Comment numbers, the RFC that defined these ranges is so famous you should know it. The above ranges are often termed RFC 1918 addresses.

CramQuiz
1. What technology permits many private addresses to communicate on the public Internet?
   - A. SMTP
   - B. POP3
   - C. SNMP
   - D. NAT

2. Which of the following is not a private address?
   - A. 10.10.10.1
   - B. 12.34.100.1
   - C. 172.16.1.10
   - D. 192.168.1.10

3. What famous RFC defined the private use only IP address space?
   - A. RFC 2020
   - B. RFC 2191
   - C. RFC 2001
   - D. RFC 1918

CramQuiz Answers
1. D is correct. Network Address Translation permits these private addresses to communicate.
2. B is correct. 12.X.X.X is part of the public IP address space.
3. D is correct. RFC 1918 defined the private address space.
Review Questions

1. What is two raised to the seventh power?
   - A. 64
   - B. 128
   - C. 32
   - D. 16

2. What is the meaning of this IP address—127.0.0.1?
   - A. This is a multicast address
   - B. This is a Class A unicast address
   - C. This is a loopback address
   - D. This is an invalid IP address

3. What is the subnet mask if you began with the default Class A mask and then “borrowed” four bits for subnetting?
   - A. 255.255.128.0
   - B. 255.255.240.0
   - C. 255.240.0.0
   - D. 255.255.255.240

4. If you need to create six subnets, and want to waste as little IP address space as possible, how many bits should you “borrow”?
   - A. 2
   - B. 3
   - C. 4
   - D. 5

5. Examine the following diagram. What is the most likely reason HostA is unable to ping HostB?

   ![Diagram](image-url)
Review Questions

- A. The subnet masks are incorrect for the link between R1 and R2.
- B. HostA has an invalid IP address.
- C. HostB is attempting to use the subnet ID as an IP address.
- D. The R2 interface to R1 is attempting to use a subnet broadcast IP address.

6. What is the Layer 3 broadcast address?
   - A. 127.255.255.255
   - B. 0.0.0.0
   - C. 1.1.1.1
   - D. 255.255.255.255

7. What is the range of Class B private addresses?
   - A. 172.16.0.0 to 172.16.255.255
   - B. 172.0.0.0 to 172.255.255.255
   - C. 172.16.0.0 to 172.31.255.255
   - D. 172.32.0.0 to 172.36.255.255
Answers to Review Questions

1. B is correct. Two raised to the seventh power is on our quick reference sheet shown in Figure 2.1. The value is 128.

2. C is correct. 127.0.0.1 is a loopback address.

3. C is correct. The default Class A subnet mask is 255.0.0.0. Borrowing four bits from the next octet creates a new mask of 255.240.0.0.

4. B is correct. Borrowing three bits permits the creation of eight subnets.

5. C is correct. The HostB IP address is the subnet identifier for that subnet and is reserved.

6. D is correct. The Layer 3 broadcast address is simply 255.255.255.255.

7. C is correct. The RFC 1918 range is 172.16.0.0 to 172.31.255.255 for Class B.
Additional Resources

Reverse Engineering an IPv4 Host Address—
http://www.ajsnetworking.com/reverse-ipv4

Online IP Subnet Calculator—http://www.subnet-calculator.com
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Index

Numbers
802.1Q, 100–103

A
aaa new-model command, 273
access points (APs), 15
ACE (Access Control Entry), 216
ACL (Access Control List), 208–220
address classes, IPv4, 36
address configuration, IPv4, 43–45
addressing
IPv4
configuring, verifying, troubleshooting, 34–42
conversion chart, 35
private addressing, 46–47
IPv6
comparison of address types, 65–67
configuring, verifying, troubleshooting, 58–61
formats for, 54–57
SLAAC, 62–64
administrative distance, 129, 131–132
anycast, IPv6, 66
APs (access points), 15
archive command, 290
authentication, local, 273–274

B
baby giant frames, 85
backup configurations, 247
banner login # command, 279
banner motd command, 279
bidirectional NAT, 229
binary conversion, 35
broadcasts, IPv4, 43–45
buffer logging, 243
cabling. See network cabling
carrier sense multiple access with
collision avoidance (CSMA/CA), 15
carrier sense multiple access with
collision detection (CSMA/CD), 15
CDP (Cisco Discovery Protocol), 104,
247–248
clear logging command, 308
client DNS configurations,
troubleshooting, 181–185
collapsed core network design,
three-tier network design versus,
17–19
collisions, 84
configure replace command, 290
configure terminal command, 262
configuring
device hardening, 270–281
device management, 246–251
device monitoring, 242–245
DHCP, 186–190
DHCP Relay Agent, 189
DNS clients, troubleshooting,
181–185
initial device configuration, 258–264
interswitch links, 100–103
inter-VLAN routing, 138–148
IPv4 addressing and sub-netting,
34–42
IPv6 addressing, 58–61
Layer 2 protocol, 104–106
NAT, 226–235
NTP, 200–202
Port Security, 112–116
RIPv2 for IPv4, 161–170
SLAAC, 62–64
static routing, 157–160
VLANs, 92–99
Voice VLANs, 96
console, 262
console logging, 243
copy command, 287
copy running-config startup-config
command, 247, 290
copy startup-config usbflash1:
copy_config command, 290
crypto key generate rsa command, 278
CSMA/CA (carrier sense multiple
access with collision avoidance), 15
CSMA/CD (carrier sense multiple
access with collision detection), 15
data access ports, 95
debug ip rip command, 307
debug messages, 307–310
decimal conversion, 35
default routes, 154–155
default VLAN, 95
default-router 10.1.1.1 command, 187
deny any log entry, 217
device access (physical security), 276
device hardening, 270–281
device maintenance, 286–291
device management, configuring and
verifying, 246–251
device monitoring, configuring and
verifying, 242–245
DHCP (Dynamic Host Configuration
Protocol)
clients, configuring and verifying,
186–190
configuring and verifying, 186–190
servers, configuring and verifying,
186–190
troubleshooting, 191–199
DHCP Relay Agent, configuring, 189
DNS (Domain Name System),
178–180
DNS lookups, 178–180
dns-server 8.8.8.8 4.2.2.2
command, 187
documentation, 26
duplex mismatches, 85
dynamic NAT, 231–232
Dynamic Port Security, 113

dynamic routing, static routing versus, 154–156

enable command, 262
enable password command, 275
enable secret command, 275
capsulation dot1q 10 command, 140
capsulation dot1q 20 command, 140
d command, 263
errdisable recovery command, 113–114
errors, 85
escalation, 26
Ethernet
cabling types, 24
frame format, 80–82
technology types, 23

Ethernet switching
terminology, 76–79
troubleshooting, 83–87

examples, 217
assigning standard ACLs to interfaces, 218
backing up router configuration to NVRAM, 247
building standard numbered ACL, 216
checking DNS functionality by using PING, 183
configuring
DHCP client, 188
DHCP Relay Agent, 189
DHCP server, 186
floating static route, 159
inside source dynamic NAT, 232
inside source static NAT, 230
local authentication for console line, 273
NTP client, 201
NTP master in network, 200
SSH, 277
standard named ACL, 217
static default route, 154

static network routes and host routes in IPv4, 157
Static Port Security, 114
static route in IPv6, 158
sticky MAC address learning, 115
telnet, 276
configuring and verifying interface for VLAN, 95
login banner message, 278
loopback interfaces, 250
Port Security, 112
service password-encryption feature, 274
trunking, 101
VLAN, 94
Voice VLAN, 96
controlling debug messages, 308
copy command usage to upgrade IOS, 287
creating VLAN on Cisco switch, 94
default logging configuration of Cisco router, 242
authorizing
CDP on interface or entire device, 248
debug of ICMP traffic, 308
ensuring
CDP is running on device and interface, 104
LLDP is running globally and on interface, 105
examining
DNS settings on Windows client, 181
real MAC address table, 78
extended traceroute options usage, 304
initial configuration of R1 router, 261
initial factory default configuration of Cisco router, 259
inside source dynamic PAT configuration, 233
IP routing table on Cisco router, 127
modified EUI 64 host portion assignment and verification, 60
Native VLAN
  on physical interface, 143
  on subinterface, 143
NSLOOKUP usage to verify DNS, 184
performing
debug of ICMP traffic, 307
  simple ping test, 298
trace route on Windows system to
  Internet destination, 304
ping with failures in network, 300
RIP version 2 configuration, 161
ROAS configuration of R1, 139
running
  extended ping in network, 301
  ping test with more packets, 299
  sample IPv6 address, 58
  sample IPv6 address verifications, 59
  sample syslog configuration on Cisco
  router, 244
setting clock and time settings on
  Cisco device, 249
setting source address for network
  communications, 276
show access-list usage for verification
  of matches, 219
show flash command usage, 287
show interface output on Cisco
  switch, 84
show IP protocols usage to verify
  RIP, 163
show ip route usage to verify
  RIP, 164
show NTP status usage to verify
  NTP, 202
simple traceroute usage, 303
SLAAC usage for address assignment
  on Cisco router, 63
terminal monitor feature usage, 306
testing loopback connectivity using
  ping, 298
Verify MD5 feature usage, 289
verifying
  ACL interface assignment, 218
  DHCP client, 189
  DHCP server, 188
  inside source dynamic PAT
    configuration, 233
  inside source static NAT
    configuration, 231
  local authentication configuration, 274
  NTP configuration with show
    NTP associations, 201
  R1 configuration, 141
  standard ACL, 217
  static IPv4 and IPv6 routes, 158
  on SW1, 142
viewing running configuration on
  Cisco router, 246
VTP status of default configuration
  for Cisco switch, 93
examples obtaining information about
  neighboring Cisco device, 247
exec-timeout 0 0 command, 262
exit command, 262
extended ACL, 215–216
extended options
  for ping command, 300–302
  for traceroute command, 304–305

F
file system management, 290
File Transfer Protocol (FTP), 289
firewalls, 15
floating static routes, 159
frame flooding, 78
frame rewrite, 125
frame switching, 77–78
frames, Ethernet frame format, 80–82
FTP (File Transfer Protocol), 289

G
gateway of last resort, 129
giants, 85
global unicast, IPv6, 65
**H**
- host routes, 157
- hostname R1 command, 262
- hosts
  - naming conventions, 263
  - subnets and, 37–38
- hybrid topologies, 20–22

**I**
- implicit deny all entry, 217
- initial device configuration,
  configuring and verifying, 258–264
- inside source NAT, 226–235
- interface lo1 command, 263
- interfaces, 263
- interswitch links, 100–103
- inter-VLAN routing, 138–148
- IOS recovery, 288
- IOS tools, troubleshooting with,
  296–311
- IOS upgrade, 286–288
- ip access-group command, 218
- ip address 1.1.1.1 255.255.255.255
  command, 263
- ip address dhcp command, 188
- ip dhcp excluded-address 10.1.1.1
  10.1.1.10 command, 187
- ip dhcp pool ICND1EXAMCRAM
  command, 187
- ip domain-lookup command, 184
- ip domain-name command, 184
- ip domain-name lab.cbtnuggets.com
  command, 278
- IP header, protocol identifiers in, 11
- ip helper-address command, 189
- ip name-server command, 184
- ip nat inside command, 230
- ip nat inside source command, 233
- ip nat inside source static 10.2.2.1
  10.1.1.100 command, 230
- ip nat outside command, 230
- ip route command, 158

**IPv4**
- address classes, 36
- address configuration, comparison of
  address types, 43–45
- addressing
  - configuring, verifying,
    troubleshooting, 34–42
  - conversion chart, 35
  - private addressing, 46–47
- static routing, 157–160
- subnetting
  - configuring, verifying,
    troubleshooting, 34–42
  - subnet masks, 36–40

**IPv6**
- addressing
  - comparison of address types, 65–67
  - configuring, verifying,
    troubleshooting, 58–61
  - formats for, 54–57
  - subnet masks, 55–56
  - anycast, 66
  - autoconfiguration, 66
  - multicast, 66
  - SLAAC, configuring and verifying,
    62–64
  - static routing, 157–160
- ipv6 enable command, 66
- ipv6 unicast-routing command, 59, 63

**J**
- jumbo frames, 85

**L**
- Layer 2 protocol, configuring and
  verifying, 104–106
- license install command, 249
- licensing, 248
- line console 0 command, 262
- line vty 0 4 command, 263
- line vty 5 10 command, 277
link local

link local, IPv6, 65
LLDP (Link Layer Discovery Protocol), 105, 248
lldp receive command, 248
lldp run command, 248
lldp transmit command, 248
local authentication, 273–274
log events, debug messages, 307–310
logging, 249
with syslog, 242–245
with terminal monitor, 305–307
logging buffered 4 command, 245
logging conls 6 command, 244
logging host 10.1.1.3 command, 245
logging monitor warning command, 245
logging synchronous command, 262
login banners, 278–279
login command, 263
login local command, 273
loopbacks, 250, 263

M
MAC address table, 78
MAC aging, 77
MAC learning, 77
Maximum MAC Addresses, 114
MD5 Verify, 289–290
mesh topologies, 20–22
metric, 129
modified EUI 64, 59, 66
monitor logging, 243
multicasts
IPv4, 43–45
IPv6, 66

N
named ACL, 208–220
NAT (Network Address Translation), 46
configuring, verifying, troubleshooting, 226–235
overloading, 232–234
pools, 232
Native VLAN, 102, 142–143
network 10.0.0.0 command, 162
network 10.1.0.0/24 command, 187
network cabling
selecting, 23–25
troubleshooting, 83–87
network masks, 127
network routes, 157
network topologies, comparison of, 20–22
next hop, 127
no auto-summary command, 162
no debug all command, 308
no service password-encryption command, 275
no shutdown command, 263
nslookup command, 184
NTP (Network Time Protocol)
clients, configuring and verifying, 200–202
configuring and verifying, 200–202
servers, configuring and verifying, 200–202
ntp master command, 201
ntp server command, 201
numbered ACL, 208–220

O
option 150 ip 10.10.10.2 command, 187
OSI (Open Systems Interconnection) model
layers in, 7–8
protocols in, 9
TCP/IP model versus, 5–9
in troubleshooting, 27

P
packet handling, 124
passive-interface command, 162
password cisco command, 263
password recovery, 288–289
passwords, security of, 274–275
PAT (Port Address Translation), 232–234
PDUs (Protocol Data Units) in OSI model, 8
physical security (device access), 276
ping command, 183, 231, 297–302
  extended options, 300–302
  return codes, 300
populating routing tables, 131–133
Port Address Translation (PAT), 232–234
port numbers, well-known, 11–12
Port Security
  configuring, verifying, troubleshooting, 112–116
  Violation Actions, 113–114
prefix, 127
private IPv4 addressing, 46–47
privilege levels, 274
problem isolation, 26
Protocol Data Units (PDUs) in OSI model, 8
protocol identifiers in IP header, 11
protocols in OSI model layers, 9.
  See also names of specific protocols
Routing
  Relay Agent, configuring, 189
  resolution monitoring, 26
  return codes for ping command, 300
  RIPv2 for IPv4, 161–170
  route lookups, 124
  router on a stick (ROAS), 138–139
  router rip command, 162
  routing
    dynamic routing, static routing versus, 154–156
    explained, 124–125
    inter-VLAN routing, 138–148
    static routing
      configuring, verifying, troubleshooting, 157–160
      dynamic routing versus, 154–156
  routing protocol code, 128
  routing tables
    components of, 126–130
    populating, 131–133
  running configuration, 246
  runts, 85
SCP (Secure Copy Protocol), 289
secure passwords, 274–275
Secure Shell (SSH), 277–278
security levels in syslog, 244
serial connections, 24
service password-encryption command, 274, 275, 276
show access-list command, 219
show controllers command, 24
show flash command, 287
show interface command, 83, 86
show interface switchport command, 97
show interface trunk command, 142
show ip dhcp binding command, 188, 196
show ip interface brief command, 142, 189, 196
show ip interface command, 219
show ip nat translation command, 231
show ip protocols command, 163
show ip route command, 132, 158, 163, 298
show ipv6 route command, 158
show license command, 249
show license feature command, 249
show lldp entry R2 command, 248
show lldp neighbors command, 248
show ntp associations command, 201
show ntp status command, 201
show port-security interface command, 113
show run | include nat command, 231

Secure Copy Protocol, 289
secure passwords, 274–275
Secure Shell (SSH), 277–278
security levels in syslog, 244
serial connections, 24
service password-encryption command, 274, 275, 276
show access-list command, 219
show controllers command, 24
show flash command, 287
show interface command, 83, 86
show interface switchport command, 97
show interface trunk command, 142
show ip dhcp binding command, 188, 196
show ip interface brief command, 142, 189, 196
show ip interface command, 219
show ip nat translation command, 231
show ip protocols command, 163
show ip route command, 132, 158, 163, 298
show ipv6 route command, 158
show license command, 249
show license feature command, 249
show lldp entry R2 command, 248
show lldp neighbors command, 248
show ntp associations command, 201
show ntp status command, 201
show port-security interface command, 113
show run | include nat command, 231
show running-config command, 246, 247
show startup-config command, 247
show version command, 249
show vlans command, 142
SLAAC (IPv6 stateless address auto configuration), configuring and verifying, 62–64
source addressing, 276
source NAT, 226–235
speed mismatches, 85
SSH (Secure Shell), 277–278
standard ACL, 215
  configuring, verifying, troubleshooting, 208–220
star topologies, 20–22
startup configuration, 247
static NAT, 230–231
Static Port Security, 114
static routing
  configuring, verifying, troubleshooting, 157–160
  dynamic routing versus, 154–156
Sticky Learning, 115
stratum, 200
subinterfaces, 140
subnet masks
  IPv4, 36–40
  IPv6, 55–56
subnetting, IPv4, 34–42
switching. See Ethernet switching
switchport mode access command, 113
switchport port-security command, 113
syslog, 242–245
TCP/IP (Transmission Control Protocol/Internet Protocol) model, OSI model versus, 5–9
telnet, 276–277
terminal monitor, 305–307
terminal no monitor command, 307
TFTP (Trivial File Transfer Protocol), 289
three-tier network design
  collapsed core network design versus, 17–19
  layers in, 17–18
Time to Live (TTL), 302–303
timezones, 249
topologies. See network topologies
traceroute command, 302–305
  extended options, 304–305
tracet command, 303
Transmission Control Protocol (TCP)
  applications relying on, 11
  port numbers, 11–12
  UDP versus, 10–13
Transmission Control Protocol/Internet Protocol (TCP/IP) model, OSI model versus, 5–9
transport input ssh command, 278
transport input ssh telnet command, 278
transport input telnet command, 263
Trivial File Transfer Protocol (TFTP), 289
troubleshooting
  client DNS configurations, 181–185
  device hardening, 270–281
  DHCP, 191–199
  Ethernet switching, 83–87
  interswitch links, 100–103
  inter-VLAN routing, 138–148
  with IOS tools, 296–311
  IPv4 addressing and subnetting, 34–42
  IPv6 addressing, 58–61
  methodology for, 26–27
NAT, 226–235
network cabling, 83–87
Port Security, 112–116
RIPv2 for IPv4, 161–170
static routing, 157–160
VLANs, 92–99
trunks, 93, 100–103
TTL (Time to Live), 302–303

UDP (User Datagram Protocol)
applications relying on, 11
port numbers, 11–12
TCP versus, 10–13
undebug all command, 308
unicasts, IPv4, 43–45
unidirectional NAT, 229
unique local, IPv6, 65
username JOHNS secret privilege 15
1L0v3C1sc0Systems command, 273

variable length subnet masking, 39
verify /md5 command, 289
verifying
device hardening, 270–281
device management, 246–251
device monitoring, 242–245
DHCP, 186–190
initial device configuration, 258–264
interswitch links, 100–103
inter-VLAN routing, 138–148
IPv4 addressing and subnetting, 34–42
IPv6 addressing, 58–61
Layer 2 protocol, 104–106
NAT, 226–235
NTP, 200–202
Port Security, 112–116
RIPv2 for IPv4, 161–170
SLAAC, 62–64
static routing, 157–160
VLANs, 92–99
version 2 command, 162
virtual terminal lines (VTY), 263
VLAN Trunking Protocol (VTP), 93
VLANs (virtual local area networks)
configuring, verifying, troubleshooting, 92–99
default VLAN, 95
inter-VLAN routing, 138–148
Native VLAN, 102, 142–143
Voice VLANs, configuring, 96
VTP (VLAN Trunking Protocol), 93
voice access ports, 96
Voice VLANs, configuring, 96
VTP (VLAN Trunking Protocol), 93
VTY (virtual terminal lines), 263

well-known port numbers, 11–12
wildcard (inverse) mask, 216
wireless networks
access points (APs), 15
CSMA/CA and CSMA/CD, 15
WLCs (Wireless LAN Controllers), 15–16