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CompTIA A+ 220-801 and 220-802 Authorized Cert Guide
Third Edition

Mark Edward Soper
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Contents at a Glance

Introduction xxxvii

CHAPTER 1 Technician Essentials and PC Anatomy 101 3
CHAPTER 2 Motherboards and Processors 29
CHAPTER 3 BIOS 85
CHAPTER 4 Power Supplies and System Cooling 129
CHAPTER 5 RAM 177
CHAPTER 6 I/O and Input Ports and Devices 207
CHAPTER 7 Video Displays and Video Cards 273
CHAPTER 8 Customized PCs and Multimedia Devices 313
CHAPTER 9 Laptop and Notebook Computers 345
CHAPTER 10 Mobile Devices 397
CHAPTER 11 Printers 449
CHAPTER 12 Storage Devices 501
CHAPTER 13 Installing and Upgrading Windows 565
CHAPTER 14 Using and Managing Windows 605
CHAPTER 15 Troubleshooting and Maintaining Windows 705
CHAPTER 16 Networking 769
CHAPTER 17 Security 869
CHAPTER 18 Operational Procedures and Communications Methods 929
GLOSSARY 953
Index 995

CD Only:
APPENDIX A Memory Tables
APPENDIX B Memory Tables Answer Key

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# Table of Contents

**Introduction**  xxxvii

**Chapter 1  Technician Essentials and PC Anatomy 101**  3

- The Essential Parts of Any Computer  4
- Front and Rear Views of a Desktop PC  5
- All Around a Notebook (Laptop) Computer  7
- Quick Reference to PC Components  8

**Hardware, Software, and Firmware**  9

- Hardware  10
- Software  10
- Firmware  11

- Why Hardware, Software, and Firmware Are Important to Understand  11

**Points of Failure**  11

- Points of Failure on a Desktop Computer  12
- Points of Failure on a Notebook Computer  13

**The CompTIA Six-Step Troubleshooting Process**  14

**PC Tools**  15

- Basic Tools for Assembly/Disassembly of Computers  15
- ESD Protection  16
- System and Electrical Testing Tools  16
- Network Installation and Configuration Tools  17
- Printer Maintenance Tools  18

**Important Websites**  18

**Review All the Key Topics**  19

**Complete the Tables and Lists from Memory**  19

**Define Key Terms**  19

**Complete Hands-On Labs**  19

- Lab 1-1: Determine the External Equipment Available on a Desktop or Laptop Computer  20
- Lab 1-2: Determine the Tool(s) to Use for Performing Specified Service on a PC  21

**Answer Review Questions**  21

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www.allitebooks.com
Answers to Hands-On Labs 24
Lab 1-1: Determine the external equipment available on a desktop or laptop computer. 24
Lab 1-2: Determine the tool(s) to use for performing specified service on a PC. 26

Answers and Explanations to Review Questions 26

Chapter 2  Motherboards and Processors 29
Motherboards and Their Components 30
Form Factors 31
Integrated I/O Ports 33
Memory Slots 35
Expansion Slots 36
Chipset Components 42
Jumpers and Jumper Blocks 44
Fan Connectors 44
Audio Connectors 45
Front-Panel Connectors 46
Installing Motherboards 48
Step-by-Step Motherboard Removal 48
Preparing the Motherboard for Installation 50
Step-by-Step Motherboard Installation 51
Troubleshooting Motherboards 52
Unexpected Shutdowns 52
Continuous Reboots (Power Supply and BSOD Problems) 53
BIOS Time and Settings Resets 53
System Lockups 54
POST Code Beeps at Startup 54
Blank Screen on Bootup 54
Smoke or Burning Smells 55
System Will Not Start 55
Processors and CPUs 58
Overview of Processor Differences 58
Intel Processors 58
AMD Processors 64

www.allitebooks.com
CPU Technologies 69
   Hyperthreading (HT Technology) 70
   Multicore 70
   Cache 70
   Bus Speeds 71
   Overclocking 72
   32-bit Versus 64-bit Architecture 73
   Virtualization Support 73
   Integrated GPU 74
CPU Cooling 74
   Passive and Active Heat Sinks 75
   Liquid Cooling Systems 76
Review All the Key Topics 78
Complete the Tables and Lists from Memory 79
Define Key Terms 79
Complete Hands-On Lab 79
   Lab 2-1: Determine Available USB Ports, Locations, and Types 79
   Lab 2-2: Determine Smallest Form Factor Suitable for a New PC 80
Answer Review Questions 80
Answers to Hands-On Lab 82
   Lab 2-1: Determine Available USB Ports, Locations, and Types 82
   Lab 2-2: Determine Smallest Form Factor Suitable for a New PC 83
Answers and Explanations to Review Questions 83

Chapter 3 BIOS 85
Understanding BIOS, CMOS, and Firmware 86
Configuring the System BIOS 89
   Accessing the BIOS Setup Program 89
   UEFI and Traditional BIOS 91
   BIOS Settings Overview 92
   Automatic Configuration of BIOS/CMOS Settings 95
Main Menu 96
   Standard Features/Settings 96
   System Information 98
   Boot Settings and Boot Sequence 98

www.allitebooks.com
Contents vii

Integrated Ports and Peripherals 100
Power Management 104
PnP/PCI Configurations 105
Hardware Monitor 105
Processor and Memory Configuration 106
Virtualization Support 106
Security Features 108
Exiting the BIOS and Saving/Discarding Changes 109
Power-On Self Test (POST) and Error Reporting 110
   Beep Codes 111
   POST Error Messages 112
   POST Hex Codes 112
BIOS Updates 114
   Flash BIOS Update 115
   BIOS Chip Replacement 118
Review All the Key Topics 120
Complete the Tables and Lists from Memory 120
Define Key Terms 121
Complete Hands-On Labs 121
   Lab 3-1: Disable Onboard Audio 121
   Lab 3-2: Check Fan and Voltage Levels 121
Answer Review Questions 122
Answers to Hands-On Labs 125
   Lab 3-1: Disable Onboard Audio 125
   Lab 3-2: Check Fan and Voltage Levels 125
Answers and Explanations to Review Questions 125

Chapter 4 Power Supplies and System Cooling 129
Power Supplies 130
   Power Supply Ratings 130
   Multivoltage Power Supplies 133
   Power Supply Form Factors and Connectors 135
   Removing and Replacing the Power Supply 139

www.allitebooks.com
Troubleshooting Power Supplies 141
  Overloaded Power Supplies—Symptoms and Solutions 141
  Loud Noises from the Power Supply 142
  Finding Solutions to a “Dead” System 143
  Overheating 144
  Fans Turn But System Doesn’t Start 149
  Testing Power Supplies and Other Devices with a Multimeter 149

Avoiding Power Supply Hazards 154

Power Protection Types 155
  Surge Suppressors 156
  Battery Backup Units (UPS and SPS) 158
  Buying the Correct-Sized Battery Backup System 159
  Power-Conditioning Devices 160

System Cooling 161
  Northbridge and Southbridge Chips and Voltage Regulators 161
  Video Card Cooling 163
  Case Fans 163
  Thermal Compound 164

Review All the Key Topics 167

Complete the Tables and Lists from Memory 168

Define Key Terms 168

Complete Hands-On Lab 168
  Lab 4-1: Check Power Supply Voltages 168
  Lab 4-2: Check for Airflow Problems Inside the System 168

Answer Review Questions 169

Answers to Hands-On Lab 172
  Lab 4-1: Check Power Supply Voltages 172
  Lab 4-2: Check for Airflow Problems Inside the System 172

Answers and Explanations to Review Questions 173

Chapter 5  RAM 177

RAM Basics 178

Memory Modules 180
  DRAM 180
  SRAM 181
Chapter 6  I/O and Input Ports and Devices  207
Introduction to I/O Ports  208
USB  209
   USB Port Types, Speeds, and Technical Details  209
   Adding USB Ports  213
   Troubleshooting USB Ports and Devices  215
IEEE-1394 (FireWire)  218
   IEEE 1394 Ports and Cables  218
   IEEE 1394–Compatible Devices  219
   Installing an IEEE 1394 Card  220
   Troubleshooting IEEE 1394 Ports and Devices  220
SCSI  221
   Multiple Device Support with SCSI Host Adapters  222
   Jumper Block and DIP Switch Settings for Device IDs  223
   SCSI Standards  225
   SCSI Cables  225
   SCSI Signaling Types  227
   Daisy-Chaining SCSI Devices  227
   SCSI Host Adapter Card Installation  228
   SCSI Daisy-Chain Maximum Length  229
   SCSI Termination Methods  229
COM (Serial)  231
   Serial Port Pinouts  233
   Types of Serial Cables  235
   How to Configure or Disable Serial Ports  236
   Serial Port Software Configuration  236
   Adding Additional Serial Ports  238
   Troubleshooting Serial Ports and Devices  238
LPT (Parallel)  240
   Parallel Port Configuration  243
   Types of Parallel Cables  244
   How to Configure or Disable Parallel Ports  246
   Adding Parallel Ports  247
   Troubleshooting Parallel (LPT) Ports, Devices, and Switchboxes  247
   Testing Parallel and Serial Ports  248
Contents

PS/2 Mouse and Keyboard 249
Audio 249
  Analog Audio Mini-Jacks 249
  SPDIF Digital Audio 250
Mouse 251
  Mouse Hardware Resource Use 252
  Troubleshooting Mice and Pointing Devices 253
  Maintaining Mice and Pointing Devices 257
Keyboard 258
  Troubleshooting Keyboards 258
  Maintaining Keyboards 259
Bar Code Reader 259
Touch Screen 260
  Touch Screen Interfacing to the Computer 261
  Installing a Touch Screen 262
  Troubleshooting a Touch Screen 262
KVM Switch 263
Review All the Key Topics 264
Complete the Tables and Lists from Memory 265
Define Key Terms 265
Complete Hands-On Lab 265
  Lab 6-1: Check USB Device Power Usage 265
Answer Review Questions 266
Answers to Hands-On Lab 269
  Lab 6-1: Check USB Device Power Usage 269
Answers and Explanations to Review Questions 269

Chapter 7  Video Displays and Video Cards 273
Video Card Types 274
  Video Card Cooling 275
Display Types 276
  CRT Monitor 277
  LCD Monitor 278
  LED Monitor 279
Plasma 279
Data Projector 280
OLED 281
Installing a Video Card 282
   BIOS Configuration 282
   Video Card Physical and Driver Installation 282
Video Connector Types 285
   VGA 285
   DVI 286
   HDMI 286
   DisplayPort 288
   Component/RGB 289
   S-Video 289
   Composite 289
   Installing a Monitor 289
Video Display Settings 292
   Resolution 292
   Color Quality (Color Depth) 295
   Refresh Rates 296
Troubleshooting Displays and Video Cards 297
   Troubleshooting Picture Quality Problems with OSD 298
   Using Advanced Display Properties for Troubleshooting 299
   Troubleshooting Video Hardware 300
   Preventative Maintenance for Displays 302
Review All the Key Topics 304
Complete the Tables and Lists from Memory 304
Define Key Terms 305
Complete Hands-On Labs 305
   Lab 7-1: Select the Appropriate Video Connectors 305
Answer Review Questions 306
Answers to Hands-On Labs 309
   Lab 7-1: Select the Appropriate Video Connectors 309
Answers and Explanations to Review Questions 310
Chapter 8  Customized PCs and Multimedia Devices  313

Customized PC Configurations  314
  Graphic/CAD/CAM Design Workstation  314
  Audio/Video Editing Workstation  316
  Virtualization Workstation  318
  Gaming PC  319
  Home Theater PC  321
  Standard Thick Client  322
  Thin Client  323
  Home Server PC  323

Evaluating Onboard Components  324
  General System Information  324
  Processor Information and Hardware-Assisted Virtualization Readiness  326

Installing and Configuring Multimedia Devices  327
  Webcams  327
  Digital Cameras  328
  Sound Cards  329
  Installing a MIDI Enabled Device  332
  Microphone  333
  Video Capture and TV Tuner Cards  335

Review All the Key Topics  337
Complete the Tables and Lists from Memory  337
Define Key Terms  338
Complete Hands-On Labs  338
  Lab 8-1: Evaluate a Computer's Suitability for Various Tasks  338

Answer Review Questions  341
Answers to Hands-On Labs  343
  Lab 8-1: Evaluate a Computer's Suitability for Various Tasks  343

Answers and Explanations to Review Questions  343

Chapter 9  Laptop and Notebook Computers  345

Laptop Expansion Options  346
  PCMCIA (PC Card, CardBus)  346
  ExpressCard  350
  Memory  352
Connecting USB Drives to Your Laptop  352
Flash Memory Cards  352
Best Practices for Laptop Disassembly  353
Hardware Device Replacement  354
  Removing and Replacing the Battery  355
  Replacing a Laptop Keyboard or Pointing Device  356
  Replacing Speakers  358
  Replacing a Laptop Hard Drive  358
  Performing a Memory Upgrade  360
  Replacing an Optical Drive  362
  Removing a Wireless Card (Mini-PCI or Mini-PCIe)  362
  Replacing the Screen  365
  Replacing the Fan, Heat Sink, and CPU  366
Laptop Displays  368
  LCD Displays  369
  LED Displays  369
  OLED Displays  369
  Plasma Displays  370
  Display Resolutions and Viewing Quality Considerations  370
  Inverter and Backlight Components  372
  Wi-Fi Antenna Components  373
Laptop Features  374
  Special Laptop Function Keys  374
  Working with Dual Displays  375
  Working with Port Replicators and Docking Stations  380
  Physically Securing a Laptop Computer  381
Troubleshooting Laptop Problems  382
  Troubleshooting Display Problems  382
  Power Problems  384
  Keyboard Problems  385
  Network Problems  386
Review All the Key Topics  387
Complete the Tables and Lists from Memory  388
Define Key Terms  388
Mobile Security  429
  Protecting Against Stolen or Lost Devices  429
  Protecting Against Compromised or Damaged Devices  432
  Turning Off Applications and Resets  435
  Security Wrap-Up  438
Review All the Key Topics  439
Define Key Terms  440
Complete Hands-On Labs  440
  Lab 10-1: Troubleshoot a Mobile Wi-Fi Connection  440
  Lab 10-2: Secure a Mobile Device  440
Answer Review Questions  441
Answers to Hands-On Labs  444
  Lab 10-1: Troubleshoot a Mobile Wi-Fi Connection  444
  Lab 10-2: Secure a Mobile Device  444
Answers and Explanations to Review Questions  445

Chapter 11  Printers  449
Laser Printers  450
  Toner Cartridges  450
  Color Laser Printing Differences  454
Inkjet Printers  455
  Ink Cartridges  457
  Calibrating the Printer  458
Thermal Printers  459
  Thermal Print Processes  459
  Thermal Printer Ribbons  460
  Thermal Printer Paper  460
Impact Printers  461
  Impact Dot Matrix Print Process  462
  Impact Dot-Matrix Printheads  463
  Impact Printer Ribbons  463
  Impact Printer Paper and Media  464
Printer Installation and Configuration 464
  Installing a Printer 465
  Installing RAM 467
  Upgrading Firmware 469
  Printer Interface Types 469
  Printer Sharing in Windows 471
  Configuring Options and Device Settings 472
  Printing a Test Page 476
  Working with the Print Spooler 477
Printer Maintenance 478
  Laser Printer Maintenance 478
  Inkjet Printer Maintenance 480
  Thermal Printer Maintenance 482
  Impact Printer Maintenance 483
Printer Troubleshooting 484
  Streaks and Smudges 484
  Faded Prints 485
  Ghost Images 486
  Toner Not Fused to Paper 486
  Creased Paper 487
  Paper Not Feeding 487
  Paper Jam 487
  No Connectivity 488
  Garbled Characters on Paper 488
  Vertical Lines on a Page 489
  Backed Up Print Queue 489
  Low Memory Errors 490
  Access Denied 492
  Printer Won’t Print 492
  Color Output in Wrong Print Colors 492
  Unable to Install Printer 492
  Error Codes 492
Review All the Key Topics 494
Define Key Terms 494
Complete the Hands-On Lab  495
  Lab 11-1: Solve Inkjet Printing Problems  495
Answer Review Questions  495
Answers to Hands-On Lab  498
  Lab 11-1: Solve Inkjet Printing Problems  498
Answers and Explanations to Review Questions  498

Chapter 12 Storage Devices  501
Drive Interface Types  502
  External and Internal Drive Interfaces  502
  PATA and SATA Performance Characteristics  504
  PATA Cabling, Configuration, and Setup  506
  SATA Configuration and Cabling  508
SCSI IDs  510
  Hot-Swappable Drive Interfaces  511
Hard Disk Drives  512
  Performance Factors for SATA and PATA Hard Disks  512
Internal Hard Disk Drive Installation  513
eSATA Drives  519
SSD and Flash Drives  520
  Flash Memory Cards  520
  Flash Card Reader  523
  USB Flash Memory Drives  524
SSD  525
RAID  526
  Creating an ATA or SATA RAID Array  528
Optical Drives  531
  Comparing CD, DVD, and Blu-ray Drives and Media  531
  DVD Media Types  532
  Blu-ray Media Types  532
  Drive Speed Ratings  533
  Recording Files to Optical Discs  533
Floppy Drives  538
  Floppy Drive Capacities  538
  Floppy Disk Drive Hardware Configuration  539
  Maintaining Floppy Disks, Data, and Drives  540
Tape Drives 541
Troubleshooting Hard Drives, SSDs, and RAID Arrays 542
  Read/Write Failures 543
  Slow Performance 543
  Noises Coming from Hard Disk 546
  Boot Failure 547
  Drive Not Recognized 548
  Operating System Not Found 548
  RAID Not Found 549
  RAID Failure 549
  Disk Surface and Data Recovery Tools 550
Review All the Key Topics 553
Complete the Tables and Lists from Memory 553
Define Key Terms 554
Complete Hands-On Lab 554
  Lab 12-1: Configure SATA Ports 554
  Lab 12-2: Configure PATA Jumper Blocks 555
Answer Review Questions 557
Answers to Hands-On Lab 560
  Lab 12-1: Configure SATA Ports 560
  Lab 12-2: Configure PATA Jumper Blocks 560
Answers and Explanations to Review Questions 561

Chapter 13 Installing and Upgrading Windows 565
Installing Windows 566
  Minimum and Recommended Hardware Requirements 566
  Boot Methods 570
  Types of Installation 570
  Time/Date/Language/Region Settings 579
  Partitioning 580
  File System Types and Formatting 586
  Loading Alternative Third-Party Disk Drivers 588
  Workgroup Versus Domain Setup 589
Transferring User Data 589
  Windows Easy Transfer 590
  User State Migration Tool 591
Updating Windows 592
  Using Windows Update and Microsoft Update 592
  Installing Service Packs Manually 593
Setting Up Recovery Partitions and Discs 595
Review All the Key Topics 597
Complete the Tables and Lists from Memory 597
Define Key Terms 598
Complete Hands-On Lab 598
  Lab 13-1: Selecting Installation Options for Windows 7 598
Answer Review Questions 599
Answers to Hands-On Lab 602
  Lab 13-1: Selecting Installation Options for Windows 7 602
Answers and Explanations to Review Questions 602
Chapter 14 Using and Managing Windows 605
Windows Versions and Editions 606
  Windows XP Family 607
  Windows Vista Family 607
  Windows 7 Family 608
Windows Features 609
  Windows Desktop (Aero, Aero Glass, Sidebar, Gadgets) 610
  Shadow Copy 612
  ReadyBoost 613
  Compatibility Mode 615
  Windows XP Mode 618
  Administrative Tools 618
File Structure and Paths 620
Command-Line Tools 621
  Starting a Command-Prompt Session with CMD.EXE 621
  Internal Commands Overview 622
  Using Wildcards to Specify a Range of Files 624
  COPY 624
  XCOPY 625
  ROBOCOPY.EXE 627
  MKDIR, CHDIR, and RMDIR (MD, CD, and RD) 628
Format/Format.exe 629
Diskpart 633
DEL 635
Tasklist 636
Taskkill 638
Administrative Features 640
  Computer Management (MMC) 640
  Performance Monitor/System Monitor 641
  Services (Services.msc) 642
  Task Scheduler 645
  Print Management 648
  Task Manager 648
Disk Management 650
  Mount Points and Mounting a Drive 655
  Windows File Systems 657
Run-Line Utilities 661
  Notepad 662
  Windows Explorer 662
  MSInfo32 (System Information) 670
  DXDiag (DirectX Diagnostics) 672
Control Panel 673
  Starting Control Panel 674
  Category and Icon Views 674
  Shortcuts to Control Panel Functions 678
  Display Options 678
  Folder Options 679
  System 680
  Power Options 682
Add/Remove Programs (Windows XP) 686
  Programs and Features (Windows Vista/7) 687
Automatic Updates (Windows XP) 688
  Tablet PC Settings (Windows Vista/7) 688
Pen and Input Devices (Windows Vista) 689
  Problem Reports and Solutions (Windows Vista, and 7) 689
Devices and Printers 689
HomeGroup (Windows 7) 690
Action Center (Windows 7) 691
Client-Side Virtualization 692
Host/Guest Virtualization 692
Hypervisor 692
Features and Benefits of Virtual Machines 693
Resource Requirements 693
Emulator Requirements 693
Security Requirements 694
Review All the Key Topics 695
Complete the Tables and Lists from Memory 695
Define Key Terms 696
Complete Hands-On Lab 696
Lab 14-1: Open and Use the Command Prompt 696
Lab 14-2: Using Microsoft Management Console 696
Answer Review Questions 697
Answers to Hands-On Lab 700
Lab 14-1: Open and Use the Command Prompt 700
Lab 14-2: Using Microsoft Management Console 701
Answers and Explanations to Review Questions 701

Chapter 15 Troubleshooting and Maintaining Windows 705
STOP (Blue Screen of Death) Errors 706
Causes of BSOD Errors 707
Researching Causes and Solutions 707
BSOD and Spontaneous Shutdown and Restart 708
Boot Failures 709
Windows 7/Vista Boot Errors 710
Windows XP Boot Errors 712
Missing Operating System Error 713
Missing Graphical Interface 714
GUI Fails to Load 714
Other Windows Problems 714
Improper Shutdowns 714
Device Fails to Start 715
Missing DLL Message  715
Services Fail to Start  715
Compatibility Error  716
Slow System Performance  716
Boots to Safe Mode  717
File Fails to Open  717
Windows Diagnostic and Repair Tools  717
    Using System File Checker (SFC)  719
    Using MSConfig  720
    Using REGSVR32  721
    Using REGEDIT  722
    Using Event Viewer  724
    Using Safe Mode and Other Advanced Boot Options  726
Using Device Manager  729
Using Windows XP Recovery Console  735
Using Automated System Recovery to Restore a Windows XP
    Installation  739
Using Windows Recovery Environment  741
Maintaining Windows  744
    Using Windows Backup for XP  745
    Using Windows Vista's Backup and Restore Center  748
    Using Windows 7's Backup and Restore  750
CHKDSK.EXE  754
Defrag  755
    System Restore and Restore Points  756
Firmware Updates  760
Review All the Key Topics  761
Complete the Tables and Lists from Memory  761
Define Key Terms  762
Complete Hands-On Lab  762
    Lab 15-1: Check System Protection Settings  762
    Lab 15-2: Using Event Viewer  762
    Lab 15-3: Using Device Manager  762
Answer Review Questions  763
Answers to Hands-On Lab  765
  Lab 15-1: Check System Protection Settings  765
  Lab 15-2: Using Event Viewer  765
  Lab 15-3: Using Device Manager  766
Answers to Review Questions  766

Chapter 16  Networking  769
  Network Models  770
    Client/Server Versus Peer-to-Peer  770
  LANs and WANs  773
  Network Topologies  774
  Network Devices  775
  Internet Connectivity Technologies  778
    Modems and Dial-Up Internet Connectivity  778
    ISDN Internet Connectivity  784
    Broadband Internet Services (DSL, Cable, Satellite)  786
    Fiber-Optic  790
    Cellular  790
    WiMAX  791
  LANs and Internet Connectivity  791
  TCP/IP  792
    HTTP/HTTPS  792
    SSL  792
    TLS  792
    HTML  793
    FTP  794
    Telnet  794
    SSH  795
    DNS  795
    DHCP  796
    Email  797
    Remote Desktop  798
    SNMP  798
    SMB  799
    LDAP  799
TCP and UDP Ports 799
Cable and Connector Types 801
  UTP and STP Cabling 801
  Fiber-Optic Cabling 805
  Coaxial Cabling 805
  Plenum and PVC 806
  Connector Types 806
Networking Tools 808
Network Types 809
Wireless Network Standards 811
  Wireless Ethernet 811
  Bluetooth 812
  Infrared 813
  Cellular 813
  VoIP 813
Switches and Hubs 814
Building a Small Office/Home Office Network 815
  Installing Network Interface Cards 815
  Configuring Network Interface Cards 816
  TCP/IPv4 Configuration 819
  IPv6 Addressing 827
  Setting Up Shared Resources 829
  Administrative Shares 834
  Setting Up the Network Client 834
  Using Shared Resources 836
  Browser Installation and Configuration 841
  Multifunction Network Device Configurations 845
Using Network Command-Line Tools 846
  Using the Net Command 847
  Using Ping 847
  Using Tracert 848
  Using NSLookup 849
  Using Ipconfig 849
  Using Netstat 849
  Using NBTSTAT 850
Network and Internet Troubleshooting 851
  Can't Access Network Resources 851
  Significant Drops in Network Performance 851
  Unattended PC Drops Its Network Connection 852
  All Users Lose Network Connection 853
  Users Can Access Some Shared Resources But Not Others 853
  Can't Print to a Network Printer 853
  Ping and Tracert Work, But User Can't Display Web Pages with Browser 854
Overview of Creating a Small Office/Home Office Network 854
Review All the Key Topics 856
Complete the Tables and Lists from Memory 857
Define Key Terms 857
Complete Hands-On Labs 857
  Lab 16-1: Select the Appropriate Type of Cable 858
  Lab 16-2: Select the Appropriate IP Networks 858
  Lab 16-3: Select the Network Option and Appropriate Ports 859
  Lab 16-4: Install an Appropriate Wireless Network 859
Answer Review Questions 859
Answers to Hands-On Labs 864
  Lab 16-1: Select the Appropriate Type of Cable 864
  Lab 16-2: Select the Appropriate IP Networks 864
  Lab 16-3: Select the Network Option and Appropriate Ports 864
  Lab 16-4: Install an Appropriate Wireless Network 865
Answers and Explanations to Review Questions 865

Chapter 17 Security 869
Security Fundamentals 870
  Secure and Insecure File Systems 870
  Authentication Technologies 871
  Protection Against Viruses and Malware 872
  Software Firewalls 873
Data and Physical Security 873
  Data Access Local Security Policy 874
  Encryption Technologies 875
Backups 877
Data Migration 877
Data and Data Remnant Removal 877
Password Management 878
Locking a Workstation 878
Incident Reporting 879
Social Engineering 880
Physical Security 881
Securing Wireless Networks 883
  WEP and WPA Encryption 883
  Access Point Configuration for Maximum Security 885
Securing Wired Networks 891
Access Control Purposes and Principles 892
  Operating System Access Control 892
Data Destruction/Disposal Techniques 898
Installing, Configuring, and Troubleshooting Security Features 899
  BIOS Security Features 899
  Software Firewalls 900
  Configuring Exceptions 902
  Wireless Network Configuration 904
  Unused Wireless Connections 910
  File Systems (Converting from FAT32 to NTFS) 912
  Malicious Software Protection 913
Review All the Key Topics 919
Define Key Terms 919
Complete Hands-On Labs 920
  Lab 17-1: Hard Drive Security and Disposal 920
  Lab 17-2: Secure a Customer's Wireless Network 920
Answer Review Questions 921
Answers to Hands-On Labs 924
  Lab 17-1: Hard Drive Security and Disposal 924
  Lab 17-2: Secure a Customer's Wireless Network 924
Answers and Explanations to Review Questions 925
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Mark Edward Soper has been working with PCs since the days of the IBM PC/XT and AT as a salesperson, technology advisor, consultant, experimenter, and technology writer and content creator. Since 1992, he has taught thousands of students across the country how to repair, manage, and troubleshoot the hardware, software, operating systems, and firmware inside their PCs. He has created many versions of his experimental computer known as “FrankenPC” for this and previous books. Mark earned his CompTIA A+ Certification in 1999 and has written four other A+ Certification books covering previous and current versions of the A+ Certification exams for Pearson imprints.

Mark has contributed to many editions of Upgrading and Repairing PCs, working on the 11th through 18th and 20th editions; co-authored Upgrading and Repairing Networks, Fifth Edition; and has written two books about digital photography, Easy Digital Cameras and The Shot Doctor: The Amateur’s Guide to Taking Great Digital Photos.

In addition, Mark has contributed to Que’s Special Edition Using series on Windows Me, Windows XP, and Windows Vista and to Que’s Windows 7 In Depth. He has also contributed to Easy Windows Vista and has written two books about Windows Vista: Maximum PC Microsoft Windows Vista Exposed and Unleashing Microsoft Windows Vista Media Center. Mark has also written two books about Windows 7: Easy Microsoft Windows 7 and Sams Teach Yourself Microsoft Windows 7 in 10 Minutes. Mark has also created a number of hardware tutorial videos available from the OnGadgets&Hardware podcast channel at www.quepublishing.com.

Mark has also written many blog entries and articles for MaximumPC.com and Maximum PC magazine. He has taught A+ Certification and other technology-related subjects at Ivy Tech Community College in Evansville, Indiana. See Mark’s website at www.markesoper.com for news and information about upcoming projects.

David L. Prowse is an author, a computer network specialist, and a technical trainer. Over the past several years he has authored several titles for Pearson Education, including the well-received CompTIA A+ Exam Cram. As a consultant, he installs and secures the latest in computer and networking technology. Over the past decade he has taught CompTIA A+, Network+, and Security+ certification courses, both in the classroom and via the Internet. He runs the website www.davidlprowse.com, where he gladly answers questions from students and readers.
Dedication

For Mayer and Naomi.
Acknowledgments

After more than 12 years as a full-time technology content provider, I’m more conscious than ever of two things—how richly I have been blessed by God in my family and in the team of technology experts I get to work with.

Thanks first and foremost to Almighty God. He gives gifts and strives earnestly to help us discover them.

Thanks also to my family, PC and Mac users alike, whose good-natured discussions keep everybody looking for the perfect technology. Thanks especially to Cheryl for her love and patience. A big thanks as well to Jeremy, for performing laptop tear-downs and assisting with system builds.

As always, Pearson has put together an outstanding team for this edition, and I especially want to thank the two Daves: Dave Dusthimer for his vision of becoming the leading provider of A+ study material and Dave Prowse, my co-author, for helping make this book the best edition yet.

Thanks again to Scott Mueller, whose original edition of Upgrading and Repairing PCs was the impetus for taking my tech career to the next level, and for the opportunity to work with him on many projects over the years, including this one.

Thanks also to Betsy Brown, Andrew Cupp, Sandra Schroeder, and Tonya Simpson for keeping this process rolling along. And a big thank-you to technical editor Chris Crayton for great suggestions and tips along the way.

Finally, a thank you to Vanessa, Tim, and Gary.

All of us want to see you, our readers, succeed both in passing your exams and in your IT careers. We all wish you the very best.
About the Technical Editor

Chris Crayton is an author, technical editor, technical consultant, and trainer. Formerly, he worked as a computer and networking instructor at Keiser University; as network administrator for Protocol, a global electronic customer relationship management (eCRM) company; and at Eastman Kodak headquarters as a computer and network specialist. Chris has authored several print and online books on PC repair, CompTIA A+, CompTIA Security+, and Microsoft Windows. Mr. Crayton has also served as technical editor and contributor on numerous technical titles for many of the leading publishing companies. He holds MCSE, A+, and Network+ certifications.
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.

As an associate publisher for Pearson IT Certification, I welcome your comments. You can email or write me directly to let me 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 I cannot help you with technical problems related to the topic of this book. We do have a User Services group, however, where I will forward specific technical questions related to the book.*

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

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Indianapolis, IN 46240 USA

Reader Services

Visit our website and register this book at www.pearsonitcertification.com/register for convenient access to any updates, downloads, or errata that might be available for this book.
It Pays to Get Certified

In a digital world, digital literacy is an essential survival skill.

Certification proves you have the knowledge and skill to solve business problems in virtually any business environment. Certifications are highly-valued credentials that qualify you for jobs, increased compensation and promotion.

- The CompTIA A+ credential—provides foundation-level knowledge and skills necessary for a career in PC repair and support.
- Starting Salary—CompTIA A+ Certified individuals can earn as much as $65,000 per year.
- Career Pathway—CompTIA A+ is a building block for other CompTIA certifications such as Network+, Security+ and vendor specific technologies.
- More than 850,000—Individuals worldwide are CompTIA A+ certified.
- Mandated/Recommended by organizations worldwide—Such as Cisco and HP and Ricoh, the U.S. State Department, and U.S. government contractors such as EDS, General Dynamics, and Northrop Grumman.

Some of the primary benefits individuals report from becoming A+ certified are:
- More efficient troubleshooting
- Improved career advancement
- More insightful problem solving
CompTIA Career Pathway

CompTIA offers a number of credentials that form a foundation for your career in technology and allows you to pursue specific areas of concentration. Depending on the path you choose to take, CompTIA certifications help you build upon your skills and knowledge, supporting learning throughout your entire career.

Steps to Certification

<table>
<thead>
<tr>
<th>Steps to Getting Certified and Staying Certified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review Exam Objectives</td>
</tr>
<tr>
<td>Practice for the Exam</td>
</tr>
<tr>
<td>Purchase an Exam Voucher</td>
</tr>
<tr>
<td>Take the Test!</td>
</tr>
</tbody>
</table>
Join the Professional Community

Join IT Pro Community
http://itpro.comptia.org

The free IT Pro online community provides valuable content to students and professionals.

Career IT Job Resources
- Where to start in IT
- Career Assessments
- Salary Trends
- US Job Board

Forums on Networking, Security, Computing and Cutting Edge Technologies
Access to blogs written by Industry Experts
Current information on Cutting Edge Technologies
Access to various industry resource links and articles related to IT and IT careers

Content Seal of Quality

This courseware bears the seal of CompTIA Approved Quality Content. This seal signifies this content covers 100% of the exam objectives and implements important instructional design principles. CompTIA recommends multiple learning tools to help increase coverage of the learning objectives.

Why CompTIA?
- Global Recognition—CompTIA is recognized globally as the leading IT non-profit trade association and has enormous credibility. Plus, CompTIA’s certifications are vendor-neutral and offer proof of foundational knowledge that translates across technologies.
- Valued by Hiring Managers—Hiring managers value CompTIA certification because it is vendor- and technology-independent validation of your technical skills.
- Recommended or Required by Government and Businesses—Many government organizations and corporations either recommend or require technical staff to be CompTIA certified. (For example, Dell, Sharp, Ricoh, the U.S. Department of Defense, and many more.)
- Three CompTIA Certifications ranked in the top 10—in a study by DICE of 17,000 technology professionals, certifications helped command higher salaries at all experience levels.

How to obtain more information

Visit CompTIA online: www.comptia.org to learn more about getting CompTIA certified.
Contact CompTIA: Call 866-835-8020 ext. 5 or email questions@comptia.org
Connect with us:
Introduction

CompTIA A+ Certification is widely recognized as the first certification you should receive in an information technology (IT) career. Whether you are planning to specialize in PC hardware, Windows operating system management, or network management, the CompTIA A+ Certification exams measure the baseline skills you need to master to begin your journey toward greater responsibilities and achievements in IT.

CompTIA A+ Certification is designed to be a vendor-neutral exam that measures your knowledge of industry-standard technology.

Goals and Methods

The number one goal of this book is a simple one: to help you pass the 2012 version of the CompTIA A+ Certification exams 220-801 and 220-802.

Because CompTIA A+ Certification exams now stress problem-solving abilities and reasoning more than memorization of terms and facts, our goal is to help you master and understand the required objectives for each exam.

To aid you in mastering and understanding the A+ Certification objectives, this book uses the following methods:

- The beginning of each chapter defines the topics to be covered in the chapter; it also lists the corresponding CompTIA A+ objective numbers.
- The body of the chapter explains the topics from a hands-on and a theory-based standpoint. This includes in-depth descriptions, tables, and figures geared to build your knowledge so that you can pass the exam. The chapters are broken down into several topics each.
- The key topics indicate important figures, tables, and lists of information that you should know for the exam. They are interspersed throughout the chapter and are listed in table format at the end of the chapter.
- You can find memory tables and lists on the disc as Appendix A, “Memory Tables,” and Appendix B, “Memory Tables Answer Key.” Use them to help memorize important information.
- Key terms without definitions are listed at the end of each chapter. Write down the definition of each term, and check your work against the complete key terms in the glossary.
Hand-on labs test you on your knowledge of key concepts. Develop possible solutions and check your work against the answers at the end of the chapter.

Each chapter includes review questions meant to gauge your knowledge of the subjects. If an answer to a question doesn’t come readily to you, be sure to review that portion of the chapter. The answers with detailed explanations are at the end of each chapter.

What’s New?

You’ll find plenty that’s new and improved in this edition, including

- Updated coverage of motherboard features
- New coverage of custom system configurations
- Updated processor coverage
- Updated BIOS dialogs including UEFI BIOS examples
- USB 3.0
- SATA 6.0Gbps
- SSDs and how to fine-tune them for best performance
- Laptop teardown procedures
- Updated display technologies
- Video and display troubleshooting
- New seven-step laser printing process
- Better coverage of color laser printers
- New coverage of dealing with prohibited content/activity
- Enhanced coverage of Windows features
- Enhanced discussion of Windows upgrade paths and methods
- Windows 7 Enterprise features
- Virtualization
- Windows Virtual PC and Windows XP Mode
- Improved Control Panel discussion
- New Mobility domain covering iOS and Android devices
- Best practices for security (physical, digital, wireless network, wired network, and workstation folders)
- Drive wiping and destruction methods
- Security troubleshooting
- Wireless network troubleshooting

For a number of years, the CompTIA A+ Certification objectives were divided into a hardware exam and an operating systems exam. Starting with the 2006 exam, the exams were restructured so that knowledge of hardware and operating systems was needed for both exams. With the 2012 edition, the exams have been restructured again in a way that, we believe, will help you prepare more easily and avoid duplication of information. 220-801 covers hardware topics and operational procedures, whereas 220-802 covers operating systems, security, a brand new mobile devices domain, and troubleshooting.

For more information about how the A+ certification can help your career, or to download the latest official objectives, access CompTIA’s A+ webpage at www.comptia.org/certifications/listed/a.aspx.

One method used by many A+ certification authors is to simply follow the objectives step by step. The problem is that because different parts of the computer—such as hard disk, display, Windows, and others—are covered in many different objectives, this approach creates a lot of overlap between chapters and does not help readers understand exactly how a particular part of the computer fits together with the rest.

In this book, we have used a subsystem approach. Each chapter is devoted to a particular part of the computer so that you understand how the components of each part work together and how each part of the computer works with other parts. To make sure you can relate the book’s contents to the CompTIA A+ Certification objectives, each chapter contains cross-references to the appropriate objectives as needed, and we provide a master cross-reference list later in this introduction.

Who Should Read This Book?

The CompTIA A+ exams measure the necessary competencies for an entry-level IT professional with the equivalent knowledge of at least 500 hours of hands-on experience in the lab or field. This book is written for people who have that amount of experience working with desktop PCs and laptops. Average readers will have attempted in the past to replace a hardware component within a PC; they should also understand how to navigate through Windows and access the Internet.
Readers will range from people who are attempting to attain a position in the IT field to people who want to keep their skills sharp or perhaps retain their job due to a company policy that mandates that they take the new exams.

This book is also aimed at the reader who wants to acquire additional certifications beyond the A+ certification (Network+, Security+, and so on). The book is designed in such a way to offer easy transition to future certification studies.

**Strategies for Exam Preparation**

Strategies for exam preparation will vary depending on your existing skills, knowledge, and equipment available. Of course, the ideal exam preparation would consist of building a PC from scratch and installing and configuring the operating systems covered including Windows 7 (Ultimate edition is recommended), Windows Vista (Ultimate edition is preferred), and Windows XP Professional. To make things easier for the reader, we recommend that you use Microsoft’s Windows Virtual PC (which works with Windows 7 Professional, Ultimate, and Enterprise) or Virtual PC 2007 (which works with other Windows 7 editions, Windows Vista, and Windows XP). Either program enables you to run virtual operating systems from within your current operating system without the need for an additional computer and can be downloaded for free from Microsoft’s website. We also recommend that you have access to a laptop, a laser printer, and as many peripheral PC devices as possible. This hands-on approach will really help to reinforce the ideas and concepts expressed in the book. However, not everyone has access to this equipment, so the next best step you can take is to read through the chapters in this book, jotting down notes with key concepts or configurations on a separate notepad. Each chapter contains a quiz that you can use to test your knowledge of the chapter’s topics. It’s located near the end of the chapter.

After you have read through the book, look at the current exam objectives for the CompTIA A+ Certification Exams listed at http://certification.comptia.org/home.aspx. If there are any areas shown in the certification exam outline that you would still like to study, find those sections in the book and review them.

When you feel confident in your skills, attempt the practice exams included on the disc with this book. As you work through the practice exams, note the areas where you lack confidence and review those concepts or configurations in the book. After you review the areas, work through the practice exam a second time and rate your skills. Keep in mind that the more you work through the practice exam, the more familiar the questions will become.

After you have worked through the practice exams a second time and feel confident with your skills, schedule the real CompTIA A+ 220-801 and 220-802 exams through either Sylvan Prometric (www.2test.com) or Pearson Vue (www.vue.com).
To prevent the information from evaporating out of your mind, you should typically take the exam within a week of when you consider yourself ready to take the exam.

The CompTIA A+ Certification credential for those passing the certification exams is now valid for 3 years (effective January 1, 2011). To renew your certification without retaking the exam, you must participate in continuing education (CE) activities and pay an annual maintenance fee of $25.00 ($75.00 for 3 years). To learn more about the certification renewal policy, see http://certification.comptia.org/getCertified/stayCertified.aspx.

CompTIA A+ 220-801 and 220-802 Exam Objectives

Table I-1 lists the objectives and the chapters where they are covered. Be sure to check http://certification.comptia.org/home.aspx for any updates to the objectives.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Chapters</th>
</tr>
</thead>
<tbody>
<tr>
<td>220-801</td>
<td></td>
</tr>
<tr>
<td>1.0 PC Hardware</td>
<td></td>
</tr>
<tr>
<td>1.1 Configure and apply BIOS settings.</td>
<td>1, 3</td>
</tr>
<tr>
<td>1.2 Differentiate between motherboard components, their purposes, and properties.</td>
<td>1, 2</td>
</tr>
<tr>
<td>1.3 Compare and contrast RAM types and features.</td>
<td>1, 5</td>
</tr>
<tr>
<td>1.4 Install and configure expansion cards.</td>
<td>7, 8</td>
</tr>
<tr>
<td>1.5 Install and configure storage devices and use appropriate media.</td>
<td>1, 12</td>
</tr>
<tr>
<td>1.6 Differentiate among various CPU types and features and select the appropriate cooling method.</td>
<td>1, 2</td>
</tr>
<tr>
<td>1.7 Compare and contrast various connection interfaces and explain their purpose.</td>
<td>1, 6, 7</td>
</tr>
<tr>
<td>1.8 Install an appropriate power supply based on a given scenario.</td>
<td>1, 4</td>
</tr>
<tr>
<td>1.9 Evaluate and select appropriate components for a custom configuration, to meet customer specifications or needs.</td>
<td>8</td>
</tr>
<tr>
<td>1.10 Given a scenario, evaluate types and features of display devices.</td>
<td>1, 7</td>
</tr>
<tr>
<td>1.11 Identify connector types and associated cables.</td>
<td>1, 6, 7</td>
</tr>
<tr>
<td>1.12 Install and configure various peripheral devices.</td>
<td>6, 8</td>
</tr>
<tr>
<td>2.0 Networking</td>
<td></td>
</tr>
<tr>
<td>2.1 Identify types of network cables and connectors.</td>
<td>16</td>
</tr>
<tr>
<td>2.2 Categorize characteristics of connectors and cabling.</td>
<td>16</td>
</tr>
<tr>
<td>Objective</td>
<td>Chapters</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>2.3 Explain properties and characteristics of TCP/IP.</td>
<td>16</td>
</tr>
<tr>
<td>2.4 Explain common TCP and UDP ports, protocols, and their purpose.</td>
<td>16</td>
</tr>
<tr>
<td>2.5 Compare and contrast wireless networking standards and encryption types.</td>
<td>16</td>
</tr>
<tr>
<td>2.6 Install, configure, and deploy a SOHO wireless/wired router using appropriate settings.</td>
<td>16</td>
</tr>
<tr>
<td>2.7 Compare and contrast Internet connection types and features.</td>
<td>16</td>
</tr>
<tr>
<td>2.8 Identify various types of networks.</td>
<td>16</td>
</tr>
<tr>
<td>2.9 Compare and contrast network devices their functions and features.</td>
<td>16</td>
</tr>
<tr>
<td>2.10 Given a scenario, use appropriate networking tools.</td>
<td>16</td>
</tr>
<tr>
<td>3.0 Laptops</td>
<td></td>
</tr>
<tr>
<td>3.1 Install and configure laptop hardware and components.</td>
<td>9</td>
</tr>
<tr>
<td>3.2 Compare and contrast the components within the display of a laptop.</td>
<td>9</td>
</tr>
<tr>
<td>3.3 Compare and contrast laptop features.</td>
<td>9</td>
</tr>
<tr>
<td>4.0 Printers</td>
<td></td>
</tr>
<tr>
<td>4.1 Explain the differences between the various printer types and summarize the associated imaging process.</td>
<td>11</td>
</tr>
<tr>
<td>4.2 Given a scenario, install, and configure printers.</td>
<td>11</td>
</tr>
<tr>
<td>4.3 Given a scenario, perform printer maintenance.</td>
<td>11</td>
</tr>
<tr>
<td>5.0 Operational Procedures</td>
<td></td>
</tr>
<tr>
<td>5.1 Given a scenario, use appropriate safety procedures.</td>
<td>18</td>
</tr>
<tr>
<td>5.2 Explain environmental impacts and the purpose of environmental controls.</td>
<td>4, 18</td>
</tr>
<tr>
<td>5.3 Given a scenario, demonstrate proper communication and professionalism.</td>
<td>18</td>
</tr>
<tr>
<td>5.4 Explain the fundamentals of dealing with prohibited content/activity.</td>
<td>18</td>
</tr>
</tbody>
</table>

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**220-802**

<table>
<thead>
<tr>
<th>Objective</th>
<th>Chapters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 Compare and contrast the features and requirements of various Microsoft Operating Systems.</td>
<td>14</td>
</tr>
<tr>
<td>1.2 Given a scenario, install, and configure the operating system using the most appropriate method.</td>
<td>13</td>
</tr>
<tr>
<td>1.3 Given a scenario, use appropriate command line tools.</td>
<td>14</td>
</tr>
<tr>
<td>1.4 Given a scenario, use appropriate operating system features and tools.</td>
<td>13, 14</td>
</tr>
<tr>
<td>1.5 Given a scenario, use Control Panel utilities (the items are organized by “classic view/large icons” in Windows).</td>
<td>14</td>
</tr>
<tr>
<td>Objective</td>
<td>Chapters</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>1.6 Setup and configure Windows networking on a client/desktop.</td>
<td>16</td>
</tr>
<tr>
<td>1.7 Perform preventive maintenance procedures using appropriate tools.</td>
<td>15</td>
</tr>
<tr>
<td>1.8 Explain the differences among basic OS security settings.</td>
<td>17</td>
</tr>
<tr>
<td>1.9 Explain the basics of client-side virtualization.</td>
<td>14</td>
</tr>
<tr>
<td>2.0 Security</td>
<td></td>
</tr>
<tr>
<td>2.1 Apply and use common prevention methods.</td>
<td>17</td>
</tr>
<tr>
<td>2.2 Compare and contrast common security threats.</td>
<td>17</td>
</tr>
<tr>
<td>2.3 Implement security best practices to secure a workstation.</td>
<td>17</td>
</tr>
<tr>
<td>2.4 Given a scenario, use the appropriate data destruction/disposal method.</td>
<td>17</td>
</tr>
<tr>
<td>2.5 Given a scenario, secure a SOHO wireless network.</td>
<td>17</td>
</tr>
<tr>
<td>2.6 Given a scenario, secure a SOHO wired network.</td>
<td>17</td>
</tr>
<tr>
<td>3.0 Mobile Devices</td>
<td></td>
</tr>
<tr>
<td>3.1 Explain the basic features of mobile operating systems.</td>
<td>10</td>
</tr>
<tr>
<td>3.2 Establish basic network connectivity and configure email.</td>
<td>10</td>
</tr>
<tr>
<td>3.3 Compare and contrast methods for securing mobile devices.</td>
<td>10</td>
</tr>
<tr>
<td>3.4 Compare and contrast hardware differences in regards to tablets and laptops.</td>
<td>10</td>
</tr>
<tr>
<td>3.5 Execute and configure mobile device synchronization.</td>
<td>10</td>
</tr>
<tr>
<td>4.0 Troubleshooting</td>
<td></td>
</tr>
<tr>
<td>4.1 Given a scenario, explain the troubleshooting theory.</td>
<td>1</td>
</tr>
<tr>
<td>4.2 Given a scenario, troubleshoot common problems related to motherboards, RAM, CPU and power with appropriate tools.</td>
<td>1, 2, 3, 4, 5, 6</td>
</tr>
<tr>
<td>4.3 Given a scenario, troubleshoot hard drives and RAID arrays with appropriate tools.</td>
<td>1, 12</td>
</tr>
<tr>
<td>4.4 Given a scenario, troubleshoot common video and display issues.</td>
<td>7</td>
</tr>
<tr>
<td>4.5 Given a scenario, troubleshoot wired and wireless networks with appropriate tools.</td>
<td>1, 16</td>
</tr>
<tr>
<td>4.6 Given a scenario, troubleshoot operating system problems with appropriate tools.</td>
<td>15</td>
</tr>
<tr>
<td>4.7 Given a scenario, troubleshoot common security issues with appropriate tools and best practices.</td>
<td>17</td>
</tr>
<tr>
<td>4.8 Given a scenario, troubleshoot, and repair common laptop issues while adhering to the appropriate procedures.</td>
<td>9</td>
</tr>
<tr>
<td>4.9 Given a scenario, troubleshoot printers with appropriate tools.</td>
<td>1, 11</td>
</tr>
</tbody>
</table>
Pearson IT Certification Practice Test Engine and Questions on the Disc

The disc in the back of the book includes the Pearson IT Certification Practice Test engine—software that displays and grades a set of exam-realistic multiple-choice questions. Using the Pearson IT Certification Practice Test engine, you can either study by going through the questions in Study Mode or take a simulated exam that mimics real exam conditions.

The installation process requires two major steps: installing the software and then activating the exam. The disc in the back of this book has a recent copy of the Pearson IT Certification Practice Test engine. The practice exam—the database of exam questions—is not on the disc.

NOTE  The cardboard disc case in the back of this book includes the disc and a piece of paper. The paper lists the activation code for the practice exam associated with this book. Do not lose the activation code. On the opposite side of the paper from the activation code is a unique, one-time use coupon code for the purchase of the Premium Edition eBook and Practice Test.

Install the Software from the Disc

The Pearson IT Certification Practice Test is a Windows-only desktop application. You can run it on a Mac using a Windows Virtual Machine, but it was built specifically for the PC platform. The minimum system requirements are

- Windows XP (SP3), Windows Vista (SP2), or Windows 7
- Microsoft .NET Framework 4.0 Client
- Microsoft SQL Server Compact 4.0
- Pentium class 1GHz processor (or equivalent)
- 512MB RAM
- 650MB disc space plus 50MB for each downloaded practice exam

The software installation process is pretty routine compared with other software installation processes. If you have already installed the Pearson IT Certification Practice Test software from another Pearson product, there is no need for you to reinstall the software. Simply launch the software on your desktop and proceed to activate the practice exam from this book by using the activation code included in the disc sleeve.
The following steps outline the installation process:

**Step 1.** Insert the disc into your PC.

**Step 2.** The software that automatically runs is the Pearson software to access and use all disc-based features, including the exam engine and the disc-only appendixes. From the main menu, click the option to **Install the Exam Engine**.

**Step 3.** Respond to windows prompts as with any typical software installation process.

The installation process gives you the option to activate your exam with the activation code supplied on the paper in the disc sleeve. This process requires that you establish a Pearson website login. You need this login to activate the exam, so please do register when prompted. If you already have a Pearson website login, there is no need to register again. Just use your existing login.

**Activate and Download the Practice Exam**

After the exam engine is installed, you should then activate the exam associated with this book (if you did not do so during the installation process) as follows:

**Step 1.** Start the Pearson IT Certification Practice Test software from the Windows **Start** menu or from your desktop shortcut icon.

**Step 2.** To activate and download the exam associated with this book, from the **My Products** or **Tools** tab, select the **Activate** button.

**Step 3.** At the next screen, enter the Activation Key from the paper inside the cardboard disc holder in the back of the book. When entered, click the **Activate** button.

**Step 4.** The activation process downloads the practice exam. Click **Next** and then click **Finish**.

After the activation process finishes, the **My Products** tab should list your new exam. If you do not see the exam, make sure you have selected the **My Products** tab on the menu. At this point, the software and practice exam are ready to use. Simply select the exam, and click the **Open Exam** button.

To update a particular exam you have already activated and downloaded, simply select the **Tools** tab, and select the **Update Products** button. Updating your exams will ensure you have the latest changes and updates to the exam data.
If you want to check for updates to the Pearson Cert Practice Test exam engine software, simply select the Tools tab, and select the Update Application button. This will ensure you are running the latest version of the software engine.

Activating Other Exams

The exam software installation process, and the registration process, must happen only once. Then, for each new exam, only a few steps are required. For instance, if you buy another new Pearson IT Certification Cert Guide or Cisco Press Official Cert Guide, extract the activation code from the disc sleeve in the back of that book—you don’t even need the disc at this point. From there, all you need to do is start the exam engine (if not still up and running), and perform Steps 2–4 from the previous list.

Premium Edition

In addition to the two free practice exams provided on the disc, you can purchase two additional exams with expanded functionality directly from Pearson IT Certification. The Premium Edition eBook and Practice Test for this title contains two additional full practice exams as well as an eBook (in both PDF and ePub format). In addition, the Premium Edition title also has remediation for each question to the specific part of the eBook that relates to that question.

If you have purchased the print version of this title, you can purchase the Premium Edition at a deep discount. There is a coupon code in the disc sleeve that contains a one-time use code as well as instructions for where you can purchase the Premium Edition.

To view the premium edition product page, go to www.informit.com/title/978078978492.
This chapter covers the following subjects:

- **Power Supplies**—This section describes the device that transforms AC power from the wall outlet into DC power that your computer can use. It also describes the various form factors and voltage levels, and how to protect your power supply.

- **Troubleshooting Power Problems**—This section demonstrates how to troubleshoot complete failure and intermittent power supply problems that you might encounter.

- **Avoiding Power Supply Hazards**—This section has guidelines for avoiding shock and fire hazards when working with power supplies.

- **Power Protection Types**—In this section you learn about devices that can protect your computer from over and under voltage issues. These include surge protectors, uninterruptible power supplies, and line conditioners.

- **System Cooling**—This last section describes the various ways to cool your system, including fans and liquid cooling, and demonstrates how to monitor the system temperature.

This chapter covers CompTIA A+ 220-801 objectives 1.8 and 5.2 and CompTIA A+ 220-802 objective 4.2.
Clean, well-planned power is imperative, from the AC outlet to the electrical protection equipment to the power supply. Many of the issues that you see concerning power are due to lack of protection or improper planning, and as such you will see several questions on the A+ exams regarding this subject.

In this chapter we delve into how power is conveyed to the computer, which power supply to select depending on your configuration and needs, how to install and troubleshoot power supplies, and how to cool the system.
Power issues are largely ignored by most computer users, but a properly working power supply is the foundation to correct operation of the system. When the power supply stops working, the computer stops working, and when a power supply stops functioning properly—even slightly—all sorts of computer problems can take place. From unexpected system reboots to data corruption, from unrecognized bus-powered USB devices to system overheating, a bad power supply is bad news. The power supply is vital to the health of the computer. So, if your computer is acting “sick,” you should test the power supply to see if it’s the cause. To keep the power supply working properly, use surge suppression and battery backup (UPS) units.

The **power supply** is really misnamed: It is actually a power converter that changes high-voltage alternating current (AC) to low-voltage direct current (DC). There are lots of wire coils, capacitors, and other components inside the power supply that do the work, and during the conversion process, a great deal of heat is produced. Most power supplies include one or two fans to dissipate the heat created by the operation of the power supply; however, a few power supplies designed for silent operation use passive heat sink technology instead of fans. On power supplies that include fans, fans also help to cool the rest of the computer. Figure 4-1 shows a typical desktop computer’s power supply.

**Power Supply Ratings**

Power supply capacity is rated in watts, and the more watts a power supply provides, the more devices it can safely power.

You can use the label attached to the power supply, shown in Figure 4-2, to determine its wattage rating and see important safety reminders.
The power supply shown in Figure 4-2 is a so-called “split rail” design with two separate 12V outputs (+12V1 and +12V2). This type of design is frequently used today to provide separate 12V power sources for processors (which reduce 12V power to the power level needed) and other devices such as PCI Express video cards, fans, and drives. Add the values together to get the total 12V output in amps (34A).

Typically, power supplies in recent tower-case (upright case) machines use 400-watt or larger power supplies, reflecting the greater number of drives and cards that can be installed in these computers. Power supplies used in slimline desktop computers have typical ratings of around 220–300 watts. The power supply rating is found on the top or side of the power supply, along with safety rating information and amperage levels produced by the power supply’s different DC outputs.

How can you tell whether a power supply meets minimum safety standards? Look for the appropriate safety certification mark for your country or locale. For example, in the U.S. and Canada, the backward UR logo is used to indicate the power supply has the UL and UL Canada safety certifications as a component (the familiar circled UL logo is used for finished products only).
1. Power supply rating  
2. AC input voltage levels  
3. DC output levels by type  
4. +3.3V, +5V, and +12V maximum load  
5. Hazard warnings  
6. Product certifications

**CAUTION**  Power supplies that do not bear the UL or other certification marks should not be used, as their safety is unknown. For a visual guide to electrical and other safety certification marks in use around the world, visit the Standard Certification Marks page at www.technick.net/public/code/cp_dpage.php?aiocp_dp=guide_safetymarks.

Use the following methods to determine the wattage rating needed for a replacement power supply:

- Whip out your calculator and add up the wattage ratings for everything connected to your computer that uses the power supply, including the motherboard, processor, memory, cards, drives, and bus-powered USB devices. If the total wattage used exceeds 70% of the wattage rating of your power supply, you should upgrade to a larger power supply. Check the vendor spec sheets for wattage ratings.

- If you have amperage ratings instead of wattage ratings, multiply the amperage by the volts to determine wattage and then start adding. If a device uses two or three different voltage levels, be sure to carry out this calculation for each voltage level, and add up the figures to determine the wattage requirement for the device.

- Use an interactive power supply sizing tool such as the calculators provided by eXtreme Outervision (www.extreme.outervision.com) or PC Power and Cooling (www.pcpower.com).
Table 4-1 provides calculations for typical compact desktop and performance desktop systems.

<table>
<thead>
<tr>
<th>MicroATX System with Integrated Video</th>
<th>Full-Size ATX System with SLI (Dual Graphics Cards)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Components</td>
<td>Wattage</td>
</tr>
<tr>
<td>AMD A8 3800 (4 core with in-core graphics and L2 cache)</td>
<td>65</td>
</tr>
<tr>
<td>microATX motherboard</td>
<td>60</td>
</tr>
<tr>
<td>4GB RAM</td>
<td>60</td>
</tr>
<tr>
<td>Rewritable DVD drive</td>
<td>30</td>
</tr>
<tr>
<td>SATA hard disk</td>
<td>20</td>
</tr>
<tr>
<td>Two case fans</td>
<td>6</td>
</tr>
<tr>
<td>CPU fan</td>
<td>3</td>
</tr>
<tr>
<td>Integrated graphics (in CPU)</td>
<td>—</td>
</tr>
<tr>
<td>Estimated wattage</td>
<td>244</td>
</tr>
<tr>
<td>Minimum power supply size recommended (80% efficiency assumed)</td>
<td>350</td>
</tr>
</tbody>
</table>

**NOTE** The 80 PLUS certification standard is an industry standard for evaluating power supply efficiency. 80 PLUS certified power supplies achieve 80% efficiency at up to 100% of rated load. The use of power supplies with 80 PLUS certification is assumed in Table 4-1. Higher standards (80 PLUS Bronze, Silver, Gold, and Platinum) achieve up to 89% efficiency at 100% of rated load on 115V power and up to 91% on 230V power. For more information, see the Ecova Plug Load Solutions website at http://www.plugloadsolutions.com/. For non-80 PLUS power supplies, assume 70% efficiency.

**Multivoltage Power Supplies**

Most power supplies are designed to handle two different voltage ranges:

- 110–120V/60Hz
- 220–240V/50Hz
Standard North American power is now 115–120V/60Hz-cycle AC (the previous standard was 110V). The power used in European and Asian countries is typically 230–240V/50Hz AC (previously 220V). Power supplies typically have a slider switch with two markings: 115 (for North American 110–120V/60HzAC) and 230 (for European and Asian 220–240V/50Hz AC). Figure 4-3 shows a slider switch set for correct North American voltage. If a power supply is set to the wrong input voltage, the system will not work. Setting a power supply for 230V with 110–120V current is harmless; however, feeding 220–240V into a power supply set for 115V will destroy the power supply, and possibly other onboard hardware.

![Power supply components](image)

**Figure 4-3**  A typical power supply’s sliding voltage switch set for correct North American voltage (115V). Slide it to 230V for use in Europe and Asia.

**NOTE**  Note that some power supplies for desktop and notebook computers can automatically determine the correct voltage level and cycle rate. These are referred to as *autoswitching power supplies* and lack the voltage/cycle selection switch shown in Figure 4-3.

The on/off switch shown in Figure 4-3 controls the flow of current into the power supply. It is not the system power switch, which is located on the front of most recent systems and is connected to the motherboard. When you press the system power switch, the motherboard signals the power supply to provide power.
Power Supplies

Power Supply Form Factors and Connectors

When you shop for a power supply, you also need to make sure it can connect to your motherboard. There are two major types of power connectors on motherboards:

- 20-pin, used by older motherboards in the ATX family
- 24-pin, used by recent ATX/BTX motherboards requiring the ATX12V 2.2 power supply standard

Some high-wattage power supplies with 20-pin connectors might also include a 20-pin to 24-pin adapter. Some 24-pin power supplies include a 24-pin to 20-pin connector.

Some motherboards use power supplies that feature several additional connectors to supply added power, as follows (see Figure 4-4):

- The four-wire square ATX12V connector provides additional 12V power to the motherboard; this connector is sometimes referred to as a “P4” or “Pentium 4” connector.
- Many recent high-end power supplies use the eight-wire EPS12V connector (see Figure 4-6) instead of the ATX12V power connector. Often, the EPS12V lead is split into two four-wire square connectors to be compatible with motherboards that use either ATX12V or EPS12V power leads.
- Some older motherboards use a six-wire AUX connector to provide additional power.

Figure 4-5 lists the pinouts for the 20-pin and 24-pin ATX power supply connectors shown in Figure 4-4.
Figure 4-4  20-pin ATX and 24-pin ATX power connectors compared to four-pin ATX12V and six-wire AUX power connectors.

Figure 4-5  Pinout for standard ATX 20-pin and 24-pin power connectors.
The power supply also powers various peripherals, such as the following:

- PATA hard disks, CD and DVD optical drives, and case fans that do not plug into the motherboard use a four-pin Molex power connector.
- 3.5-inch floppy drives use a four-pin Berg power connector.
- Serial ATA (SATA) hard disks use an L-shaped 15-pin thinline power connector.
- High-performance PCI Express x16 video cards that require additional 12V power use a PCI Express six-pin or eight-pin power cable.

Figure 4-6 illustrates these power connectors.

![Power supply connectors for peripherals and modern motherboards.](image)

If your power supply doesn’t have enough connectors, you can add Y-splitters to divide one power lead into two, but these can short out and can also reduce your power supply’s efficiency. You can also convert a standard Molex connector into an SATA or floppy drive power connector with the appropriate adapter.

Some power supplies (see Figure 4-7) use modular connections so that you can customize the power supply connections needed for your hardware.

**CAUTION** Many recent and older Dell desktop computers use proprietary versions of the 20-pin or 24-pin ATX power supply connectors. Dell’s versions use a different pinout that routes voltages to different wires than in standard power supplies. Consequently, if you plug a standard power supply into a Dell PC that uses the proprietary version or use a regular motherboard as an upgrade for a model that has the proprietary power supply, stand by for smoke and fire! To determine whether a particular Dell computer model requires a proprietary power supply, check the PC Power and Cooling PSU recommendation for your Dell system at [www.pcpower.com/Dell.html](http://www.pcpower.com/Dell.html).
If your wattage calculations or your tests (covered later in this chapter) agree that it’s time to replace the power supply, make sure the replacement meets the following criteria:

- Have the same power supply connectors and the same pinout as the original.
- Have the same form factor (shape, size, and switch location)
- Have the same or higher wattage rating; a higher wattage rating is highly desirable
- Support any special features required by your CPU, video card, and motherboard, such as SLI support (support for PCI Express connectors to power dual high-performance PCI Express x16 video cards), high levels of +12V power (ATX12V v2.2 4-pin or EPS12V 8-pin power connectors), and so on

**TIP** To ensure form factor connector compatibility, consider removing the old power supply and taking it with you if you plan to buy a replacement at retail. If you are buying a replacement online, measure the dimensions of your existing power supply to ensure that a new one will fit properly in the system.
Removing and Replacing the Power Supply

Installing a new power supply is one of the easier repairs to make. You don’t need to fiddle with driver CDs or Windows Update to get the new one working. But, you do need to be fairly handy with a screwdriver or nut driver.

Typical power supplies are held in place by several screws that attach the power supply to the rear panel of the computer. The power supply also is supported by a shelf inside the case, and screws can secure the power supply to that shelf. To remove a power supply, follow these steps:

**Step 1.** Power down the computer. If the power supply has an on/off switch, turn it off as well.

**Step 2.** Disconnect the AC power cord from the computer.

**Step 3.** Open the case to expose the power supply, which might be as simple as removing the cover on a desktop unit or as involved as removing both side panels, front bezel, and case lid on a tower PC. Consult the documentation that came with your computer to determine how to expose the power supply for removal.

**Step 4.** Disconnect the existing power supply from the motherboard (see Figure 4-8). The catch securing the power supply connector must be released to permit the connector to be removed.

1. Catch securing power supply connector
2. PATA/IDE drive connectors
3. Memory module
4. Active heat sink for processor

**Figure 4-8** Disconnecting the power supply from the motherboard.

www.allitebooks.com
Step 5. Disconnect all other power supply leads to the motherboard (fan monitors, ATX12V, EPS12V, AUX).

Step 6. Disconnect the power supply from all drives and add-on cards.

Step 7. Disconnect the power supply from all fans.

Step 8. Remove the power supply screws from the rear of the computer case (see Figure 4-9).

![Figure 4-9](image)

*Figure 4-9* Removing the mounting screws from a typical power supply.

Step 9. Remove any screws holding the power supply in place inside the case. (Your PC might not use these additional screws.)

Step 10. Lift or slide the power supply out of the case.

Before installing the replacement power supply, compare it to the original, making sure the form factor, motherboard power connectors, and switch position match the original. If the new power supply has a fan on top (as well as the typical rear-mounted fan), make sure the fan faces the inside of the case.

To install the replacement power supply, follow these steps:

Step 1. Lift or slide the power supply into the case.

Step 2. Attach the power supply to the shelf with screws (if required).

Step 3. Slide the power supply to the rear of the computer case; line up the holes in the unit carefully with the holes in the outside of the case.
Step 4. Connect the power supply to all fans, drives, add-on cards, and motherboard.

Step 5. Check the voltage setting on the power supply. Change it to the correct voltage for your location if necessary.

Step 6. Connect the AC power cord to the new power supply.

Step 7. Turn on the computer.

Step 8. Start the system normally to verify correct operation, and then run the normal shutdown procedure for the operating system. If necessary, turn off the system with the front power switch only.

Step 9. Close the case and secure it.

Troubleshooting Power Supplies

Objective: 220-802: 4.2

Problems with power supplies can cause a variety of symptoms, including

- Overheating
- Spontaneous rebooting
- Intermittent device failure (particularly of bus-powered USB devices)
- Loud noises

What can cause these symptoms, and how can you solve the problems behind the symptoms?

Overloaded Power Supplies—Symptoms and Solutions

What happens if you connect devices that require more wattage than a power supply can provide? This is a big problem called an overload. An overloaded power supply has three major symptoms:

- Overheating
- Spontaneous rebooting (cold boot with memory test) due to incorrect voltage on the Power Good line running from the power supply to the motherboard
- Intermittent failures of USB bus-powered devices (mice, keyboard, USB flash drives, portable USB hard disks) because these devices draw power from the system's power supply via the USB port.

Here’s a good rule of thumb: If your system starts spontaneously rebooting and you don’t see a blue screen (STOP) error, replace the power supply as soon as possible. However, power supply overheating can have multiple causes; follow the steps listed in the section “Overheating,” later in this chapter, before replacing an overheated power supply.

To determine whether Power Good or other motherboard voltage levels are within limits, perform the measurements listed in the section “Testing Power Supplies and Other Devices with a Multimeter,” later in this chapter.

**Loud Noises from the Power Supply**

Computers usually run quietly, but if you hear loud noises coming from the power supply, it’s a sure sign of problems. A whirring, rattling, or thumping noise while the system is on usually indicates a fan failure. If a fan built in to a component such as a heat sink or power supply is failing, replace the component immediately.

**CAUTION** Should you try to replace a standard power supply fan? No. Because the power supply is a sealed unit, you would need to remove the cover from most power supplies to gain access to the fan. The capacitors inside a power supply retain potentially lethal electrical charges. Instead, scrap the power supply and replace it with a higher-rated unit. Refer to the section “Removing and Replacing the Power Supply,” earlier in the chapter.

A power supply that makes a loud bang, followed by a system crash, has had an onboard capacitor blow up. The easiest way to diagnose this is to smell the power supply after turning it off and disconnecting it from AC power. If you can smell a burnt odor with a chemical overtone to it coming from the power supply’s outside vent, your power supply has died. This odor can linger for weeks. Sadly, when a power supply blows up like this, it can also destroy the motherboard, bus-powered USB devices connected to the computer, and other components.
Finding Solutions to a “Dead” System

A dead system that gives no signs of life when turned on can be caused by the following:

- Defects in AC power to the system
- Power supply failure or misconfiguration
- Temporary short circuits in internal or external components
- Power supply or other component failure

With four suspects, it’s time to play detective. Use the procedure outlined next to find the actual cause of a dead system. If one of the test procedures in the following list corrects the problem, the item that was changed is the cause of the problem. Power supplies have a built-in safety feature that shuts down the unit immediately in case of short circuit.

The following steps are designed to determine whether the power problem is caused by a short circuit or another problem:

**Step 1.** Smell the power supply’s outside vent. If you can detect a burnt odor, the power supply has failed (see previous section).

**Step 2.** Check the AC power to the system; a loose or disconnected power cord, a disconnected surge protector, a surge protector that has been turned off, or a dead AC wall socket will prevent a system from receiving power. If the wall socket has no power, reset the circuit breaker in the electrical service box for the location.

**Step 3.** Check the AC voltage switch on the power supply; it should be set to 115V for North America. Turn off the power, reset the switch, and restart the system if the switch was set to 230V. Note that many desktop computer power supplies no longer require a switch selection because they are autoranging.

**CAUTION** If your area uses 230V and the power supply is set to 115V, you need a new power supply and possibly other components, because they’ve been damaged or destroyed by 100% overvoltage.

**Step 4.** If the system uses a PS/2 mouse or keyboard, check the connectors; a loose keyboard connector could cause a short circuit.
Step 5. Turn off the system, disconnect power, and open the system. Verify that the power leads are properly connected to the motherboard. Connect loose power leads, reconnect power, and restart the computer.

Step 6. Check for loose screws or other components such as loose slot covers, modem speakers, or other metal items that can cause a short circuit. Correct them and retest.

Step 7. Remove all expansion cards and disconnect power to all drives; restart the system and use a multimeter to test power to the motherboard per Table 4-3.

Step 8. If the power tests within accepted limits with all peripherals disconnected, reinstall one card at a time and check the power. If the power tests within accepted limits, reattach one drive at a time and check the power.

Step 9. If a defective card or drive has a dead short, reattaching the defective card or drive should stop the system immediately upon power-up. Replace the card or drive and retest.

Step 10. Check the Power Good line at the power supply motherboard connector with a multimeter.

It’s a long list, but chances are you will track down the offending component before you reach the end of it.

Overheating

Got an overheated power supply? Not sure? If you touch the power supply case and it’s too hot to touch, it’s overheated. Overheated power supplies can cause system failure and possible component damage, due to any of the following causes:

- Overloading
- Fan failure
- Inadequate airflow outside the system
- Inadequate airflow inside the system
- Dirt and dust

Use the following sections to figure out the possible effects of these problems in any given situation.
Overloading

An overloaded power supply is caused by connecting devices that draw more power (in watts) than the power supply is designed to handle. As you add more card-based devices to expansion slots, use more bus-powered USB and IEEE-1394 drives and devices, and install more internal drives in a system, the odds of having an overloaded power supply increase.

If a power supply fails or overheats, check the causes listed in the following sections before determining whether you should replace the power supply. If you determine that you should replace the power supply, purchase a unit that has a higher wattage rating.

Fan Failure

The fan(s) inside the power supply cool it and are partly responsible for cooling the rest of the computer. If they fail, the power supply and the entire computer are at risk of damage. Fans also might stop turning as a symptom of other power problems.

A fan that stops immediately after the power comes on usually indicates incorrect input voltage or a short circuit. If you turn off the system and turn it back on again under these conditions, the fan will stop each time.

To determine whether a fan has failed, listen to the unit; it should make less noise if the fan has failed. You can also see the fan blades spinning rapidly on a power supply fan that is working correctly. If the blades aren’t turning or are turning very slowly, the fan has failed or is too clogged with dust to operate correctly.

To determine whether case fans have failed, look at them through the front or rear of the system, or, if they are connected to the motherboard, use the system monitoring feature in the system BIOS to check fan speed. Figure 4-10 illustrates a typical example.

**NOTE** If a fan has failed because of a short circuit or incorrect input voltage, you will not see any picture onscreen because the system cannot operate.

If the system starts normally but the fan stops turning later, this indicates a true fan failure instead of a power problem.
Figure 4-10  The system fan (case fan) has either failed or was never connected to the motherboard power/monitor header.

Inadequate Airflow Outside the System

The power supply’s capability to cool the system depends in part on free airflow space outside the system. If the computer is kept in a confined area (such as a closet or security cabinet) without adequate ventilation, power supply failures due to overheating are likely.

Even systems in ordinary office environments can have airflow problems; make sure that several inches of free air space exist behind the fan outputs for any computer.

Inadequate Airflow Inside the System

As you have seen in previous chapters, the interior of the typical computer is a messy place. Wide ribbon cables used for some types of drives, drive power cables, and expansion cards create small air dams that block airflow between the heat sources—such as the motherboard, CPU, drives, and memory modules—and the fans in the power supply. Figure 4-11 illustrates a typical system with a lot of cable clutter that can interfere with airflow.
You can do the following to improve airflow inside the computer:

- Use cable ties to secure excess ribbon cable and power connectors out of the way of the fans and the power supply.
- Replace any missing slot covers.
- Make sure that auxiliary case fans, chipset fans, and CPU fans are working correctly.
- Use SATA drives in place of PATA drives. SATA drives use narrow data cables.

Figure 4-12 illustrates a different system that uses cable management (cable ties, bundling cables between the drive bays and outer case wall, and routing behind the motherboard) to improve airflow.

For more information about cooling issues, see the section “System Cooling,” later in this chapter for details.
Dirt and Dust

Most power supplies, except for a few of the early ATX power supplies, use a cooling technique called *negative pressure*; in other words, the power supply fan works like a weak vacuum cleaner, pulling air through vents in the case, past the components, and out through the fan. Vacuum cleaners are used to remove dust, dirt, cat hairs, and so on from living rooms and offices, and even the power supply’s weak impression of a vacuum cleaner works the same way.

When you open a system for any kind of maintenance, look for the following:

- Dirt, dust, hair, and gunk clogging the case vents
- A thin layer of dust on the motherboard and expansion slots
- Dirt and dust on the power supply vent and fans

Yuck! You never know what you’ll find inside a PC that hasn’t been cleaned out for a year or two. So how can you get rid of the dust and gunk? You can use either a vacuum cleaner specially designed for computer use or compressed air to remove dirt and dust from inside the system. If you use compressed air, be sure to spread newspapers around the system to catch the dirt and dust. If possible, remove the computer from the computer room so the dust is not spread to other equipment.
Fans Turn But System Doesn't Start

Fans connected directly to the power supply will run as soon as the system is turned on, but if the system doesn't start up, this could indicate a variety of problems. Check the following:

- Make sure the main ATX and 12V ATX or EPS power leads are securely connected to the appropriate sockets.
- Make sure the CPU and memory modules are securely installed in the appropriate sockets.

Testing Power Supplies and Other Devices with a Multimeter

How can you find out that a defective power supply is really defective? How can you make sure that a cable has the right pinouts? Use a multimeter. A multimeter is one of the most flexible diagnostic tools around. It is covered in this chapter because of its usefulness in testing power supplies, but it also can be used to test coaxial, serial, and parallel cables, as well as fuses, resistors, and batteries.

Multimeters are designed to perform many different types of electrical tests, including the following:

- DC voltage and polarity
- AC voltage and polarity
- Resistance (Ohms)
- Diodes
- Continuity
- Amperage

All multimeters are equipped with red and black test leads. When used for voltage tests, the red is attached to the power source to be measured and the black is attached to ground.

Multimeters use two different readout styles: digital and analog. Digital multimeters are usually autoranging, which means they automatically adjust to the correct range for the test selected and the voltage present. Analog multimeters, or non-autoranging digital meters, must be set manually to the correct range and can be damaged more easily by overvoltage. Figure 4-13 compares typical analog and digital multimeters.
Multimeters are designed to perform tests in two ways: in series and in parallel. Most tests are performed in parallel mode, in which the multimeter is not part of the circuit but runs parallel to it. On the other hand, amperage tests require that the multimeter be part of the circuit, so these tests are performed in series mode. Many low-cost multimeters do not include the ammeter feature for testing amperage (current), but you might be able to add it as an option.

Figure 4-14 shows a typical parallel mode test (DC voltage for a motherboard CMOS battery) and the current (amperage) test, which is a serial-mode test.

Table 4-2 summarizes the tests you can perform with a multimeter.
Figure 4-14  A parallel-mode (DC current) test setup (left) and an amperage (current) serial-mode test setup (right).

Table 4-2  Using a Multimeter

<table>
<thead>
<tr>
<th>Test to Perform</th>
<th>Multimeter Setting</th>
<th>Probe Positions</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC voltage (wall outlet)</td>
<td>AC</td>
<td>Red to hot, black to ground.</td>
<td>Read voltage from meter; should be near 115V in North America.</td>
</tr>
<tr>
<td>DC voltage (power supply outputs to motherboard, drives, batteries)</td>
<td>DC</td>
<td>Red to hot, black to ground.</td>
<td>Read voltage from meter; compare to default values.</td>
</tr>
</tbody>
</table>
You can use a multimeter to find out whether a power supply is properly converting AC power to DC power. Here’s how: Measure the DC power going from the power supply to the motherboard. A power supply that does not meet the measurement standards listed in Table 4-3 should be replaced.

If the system monitor functions in the system BIOS do not display voltage levels (refer to Figure 4-10 for an example of a system that does display voltage levels in the BIOS), you can take the voltage measurements directly from the power supply connection to the motherboard. Both 20-pin and 24-pin P1 (ATX) power connectors are designed to be back-probed as shown in Figure 4-15; you can run the red probe through the top of the power connector to take a reading (the black probe uses the power supply enclosure or metal case frame for ground). Some motherboards bring these same voltage levels to a more convenient location on the motherboard for testing.

### Table 4-2

<table>
<thead>
<tr>
<th>Test to Perform</th>
<th>Multimeter Setting</th>
<th>Probe Positions</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuity (cables, fuses)</td>
<td>CONT</td>
<td>Red to lead at one end of cable; black to corresponding lead at other end.</td>
<td>No CONT signal indicates bad cable or bad fuse.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For a straight-through cable, check the same pin at each end. For other types of cables, consult a cable pinout to select the correct leads.</td>
<td>Double-check leads and retest to be sure.</td>
</tr>
<tr>
<td>Resistance (Ohms)</td>
<td>Ohms</td>
<td>Connect one lead to each end of resistor.</td>
<td>Check reading; compare to rating for resistor.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A fuse should have no resistance.</td>
</tr>
<tr>
<td>Amperage (Ammeter)</td>
<td>Ammeter</td>
<td>Red probe to positive lead of circuit (power disconnected!); black lead to negative lead running through component to be tested.</td>
<td>Check reading; compare to rating for component tested.</td>
</tr>
</tbody>
</table>
Table 4-3  Acceptable Voltage Levels

<table>
<thead>
<tr>
<th>Rated DC Volts</th>
<th>Acceptable Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>+5.0</td>
<td>+4.8–5.2</td>
</tr>
<tr>
<td>-5.0</td>
<td>-4.8–5.2</td>
</tr>
<tr>
<td>-12.0</td>
<td>-11.4–12.6</td>
</tr>
<tr>
<td>+12.0</td>
<td>+11.4–12.6</td>
</tr>
<tr>
<td>+3.3</td>
<td>+3.14–3.5</td>
</tr>
<tr>
<td>Power Good</td>
<td>+3.0–6.0</td>
</tr>
</tbody>
</table>

Red probe from multimeter back-probing +12V line
DC voltage readout

Multimeter's mode selector switch set to DV voltage

Figure 4-15  Testing the +12V line on an ATX power supply. The voltage level indicated (+11.92V) is well within limits.

If a power supply fails any of these measurements, replace it and retest the new unit.
Avoiding Power Supply Hazards

To avoid shock and fire hazards when working with power supplies, follow these important guidelines:

- **Never disassemble a power supply or push metal tools through the openings in the case**—Long after you shut off the system, the capacitors inside the power supply retain potentially fatal voltage levels. If you want to see the interior of a power supply safely, check the websites of leading power supply vendors such as PC Power and Cooling.

- **If you are replacing the power supply in a Dell desktop computer, determine whether the computer uses a standard ATX or Dell proprietary ATX power supply**—Many Dell computers built from September 1998 to the present use a nonstandard version of the ATX power supply with a different pinout for the power connector. Install a standard power supply on a system built to use a Dell proprietary model, or upgrade from a Dell motherboard that uses the Dell proprietary ATX design to a standard motherboard, and you can literally cause a power supply and system fire!

  **NOTE**  The proprietary Dell version of the 20-pin ATX (P1) connector has no 3.3V (orange) lines, and its Power Good (gray wire) line is pin 5, not pin 8 as with a standard ATX power supply. The 3.3V (orange) wires are routed to the 6-pin Dell proprietary auxiliary connector. The proprietary Dell version of the 24-pin ATX (P1) connector also uses pin 5 for Power Good and provides 3.3V power (blue/white) through pins 11, 12, and 23, rather than through 1, 2, 12, and 13 as with a standard 24-pin ATX power supply. Make sure you buy a power supply made specifically for your Dell model.

- **Always use a properly wired and grounded outlet for your computer and its peripherals**—You can use a plug-in wiring tester to quickly determine whether a three-prong outlet is properly wired; signal lights on the tester indicate the outlet's status (see Figure 4-16).
Figure 4-16 An outlet tester like this one can find wiring problems quickly. This outlet is wired correctly.

Power Protection Types

220-801

Objective:
220-801: 5.2

Question. How well can a power supply work if it has poor-quality AC power to work with?

Answer. Not very well. Because computers and many popular computer peripherals run on DC power that has been converted from AC power, it's essential to make sure
that proper levels of AC power flow to the computer and its peripherals. There are four problems you might run into:

- Overvoltages (spikes and surges)
- Undervoltages (brownouts)
- Power failure (blackouts)
- Noisy power (interference)

Extremely high levels of transient or sustained overvoltages can damage the power supply of the computer and peripherals, and voltage that is significantly lower than required will cause the computer and peripherals to shut down. Shutdowns happen immediately when all power fails. A fourth problem with power is interference; “noisy” electrical power can cause subtle damage, and all four types of problems put the most valuable property of any computer, the data stored on the computer, at risk. Protect your computer's power supply and other components with appropriate devices:

- Surge suppressors, which are also referred to as surge protectors
- Battery backup systems, which are also referred to as uninterruptible power supply (UPS) or standby power supply (SPS) systems
- Power conditioning devices

**Surge Suppressors**

Stop that surge! While properly designed surge suppressors can prevent power surges (chronic overvoltage) and spikes (brief extremely high voltage) from damaging your computer, low-cost ones are often useless because they lack sufficient components to absorb dangerous surges. Surge suppressors range in price from under $10 to close to $100 per unit.

Both spikes and surges are overvoltages: voltage levels higher than the normal voltage levels that come out of the wall socket. *Spikes* are momentary overvoltages, whereas surges last longer. Both can damage or destroy equipment and can come through data lines (such as RJ-11 phone or RJ-45 network cables) as well as through power lines. In other words, if you think of your PC as a house, spikes and surges can come in through the back door or the garage as well as through the front door. Better “lock” (protect) all the doors. Many vendors sell data-line surge suppressors.

How can you tell the real surge suppressors from the phonies? Check for a TVSS (transient voltage surge suppressor) rating on the unit. Multi-outlet power strips do not have a TVSS rating.
Beyond the TVSS rating, look for the following features to be useful in preventing power problems:

- A low TVSS let-through voltage level (400V AC or less). This might seem high compared to the 115V standard, but power supplies have been tested to handle up to 800V AC themselves without damage.
- A covered-equipment warranty that includes lightning strikes (one of the biggest causes of surges and spikes).
- A high Joule rating. Joules measure electrical energy, and surge suppressors with higher Joule ratings can dissipate greater levels of surges or spikes.
- Fusing that prevents fatal surges from getting through.
- Protection for data cables such as telephone/fax (RJ-11), network (RJ-45), or coaxial (RG6).
- EMI/RFI noise filtration (a form of line conditioning).
- Site fault wiring indicator (no ground, reversed polarity warnings).
- Fast response time to surges. If the surge suppressor doesn’t clamp fast enough, the surge can get through.
- Protection against surges on hot, neutral, and ground lines.

If you use surge protectors with these features, you will minimize power problems. The site-fault wiring indicator will alert you to wiring problems that can negate grounding and can cause serious damage in ordinary use.

A surge suppressor that meets the UL 1449 or ANSI/IEEE C62.41 Category A (formerly IEEE 587 Category A) standards provides protection for your equipment. You might need to check with the vendor to determine whether a particular unit meets one of these standards.

**NOTE** To learn more about UL 1449 and the other UL standards it incorporates, see http://ulstandardsinfonet.ul.com/scopes/scopes.asp?fn=1449.html.

**CAUTION** High-quality surge protectors require grounding. If you plug them into an ungrounded electrical outlet, they don’t work properly. The two- to three-prong adapter you use to enable grounded equipment to plug into an ungrounded outlet is designed to be attached to a ground such as a metal water pipe (that’s what the metal loop on the adapter is for). If you can’t ground the adapter, don’t use a computer or other electronic device with it. If you do, sooner or later you’ll be sorry.
Battery Backup Units (UPS and SPS)

A UPS is another name for a **battery backup** unit. A UPS provides emergency power when a power failure strikes (a blackout) or when power falls below minimum levels (a brownout).

There are two different types of UPS systems: true UPS and SPS systems. A true UPS runs your computer from its battery at all times, isolating the computer and monitor from AC power. There is no switchover time with a true UPS when AC power fails because the battery is already running the computer. A true UPS inherently provides power conditioning (preventing spikes, surges, and brownouts from reaching the computer) because the computer receives only battery power, not the AC power coming from the wall outlet. True UPS units are sometimes referred to as line-interactive battery backup units because the battery backup unit interacts with the AC line, rather than the AC line going directly to the computer and other components.

An SPS is also referred to as a UPS, but its design is quite different. Its battery is used only when AC power fails. A momentary gap in power (about 1ms or less) occurs between the loss of AC power and the start of standby battery power; however, this switchover time is far faster than is required to avoid system shutdown because computers can coast for several milliseconds before shutting down.

SPS-type battery backup units are far less expensive than true UPSs but work just as well as true UPSs when properly equipped with power-conditioning features.

**NOTE** In the rest of this section, the term **UPS** refers to both true UPS or SPS units except as noted, because most backup units on the market technically are SPS but are called UPS units by their vendors. Make sure you understand the differences between these units for the exam.

Battery backup units can be distinguished from each other by differences in the following:

- **Runtimes**—The amount of time a computer will keep running on power from the UPS. A longer runtime unit uses a bigger battery and usually costs more than a unit with a shorter runtime. Fifteen minutes is a minimum recommendation for a UPS for an individual workstation; much larger systems are recommended for servers that might need to complete a lengthy shutdown procedure.

- **Network support**—Battery backup units made for use on networks are shipped with software that broadcasts a message to users about a server shutdown so that users can save open files and close open applications and then shuts down the server automatically before the battery runs down.
Power Protection Types

- **Automatic shutdown**—Some low-cost UPS units lack this feature, but it is essential for servers or other unattended units. The automatic shutdown feature requires an available USB (or RS-232 serial) port and appropriate software from the UPS maker. If you change operating systems, you need to update the software for your UPS to be supported by the new operating system.

- **Surge suppression features**—Virtually all UPS units today have integrated surge suppression, but the efficiency of integrated surge suppression can vary as much as separate units. Check for UL-1449 and ANSI/IEEE C62.41 Category A ratings to find reliable surge suppression in UPS units.

Figure 4-17 illustrates the rear of a typical UPS unit.

![Figure 4-17](image)

**Figure 4-17** A typical UPS with integrated surge suppression for printers and other AC powered devices, 10/100/1000 Ethernet (including VoIP), and conventional telephony devices.

**NOTE** Always plug a UPS directly into a wall outlet, not into a power strip or surge suppressor.

**Buying the Correct-Sized Battery Backup System**

Battery backups can’t run forever. But then, they’re not supposed to. This section describes how you can make sure you get enough time to save your files and shut down your computer. UPS units are rated in VA (volt-amps), and their manufacturers have interactive buying guides you can use online or download to help you select a model with adequate capacity. If you use a UPS with an inadequate VA rating for your equipment, your runtime will be substantially shorter than it should be.
Here's how to do the math: You can calculate the correct VA rating for your equipment by adding up the wattage ratings of your computer and monitor and multiplying the result by 1.4. If your equipment is rated in amperage (amps), multiply the amp rating by 120 (volts) to get the VA rating.

For example, my computer has a 450W power supply, which would require a 630VA-rated UPS (450×1.4) and a 17-inch monitor that is rated in amps, not watts. The monitor draws 0.9A, which would require a 108VA-rated UPS (0.9×120). Add the VA ratings together, and my computer needs a 750VA-rated battery backup unit or larger. Specifying a UPS with a VA rating at least twice what is required by the equipment attached to the UPS (for example, a 1500VA or higher rating, based on a minimum requirement of 750VA) will greatly improve the runtime of the battery.

In this example, a typical 750VA battery backup unit would provide about 5 minutes of runtime when used with my equipment. However, if I used a 1500VA battery backup, I could increase my runtime to more than 15 minutes because my equipment would use only about half the rated capacity of the UPS unit.

If you need a more precise calculation, for example, if you will also power an additional monitor or other external device, use the interactive sizing guides provided by battery backup vendors, such as American Power Conversion (www.apc.com).

**CAUTION** You should not attach laser printers to the battery-backup outlets on a UPS because their high current draw will cause the runtime of the battery to be very short. If the UPS has some outlets that provide surge protection only, you can use those outlets for a laser printer. In most cases, only the computer and monitor need to be attached to the UPS. However, inkjet printers, external modems, and external USB or FireWire hard disks have low current draw and can be attached to the UPS with little reduction in runtime.

**Power-Conditioning Devices**

Although power supplies are designed to work with voltages that do not exactly meet the 115V or 230V standards, power that is substantially higher or lower than what the computer is designed for can damage the system. Electrical noise on the power line, even with power at the correct voltage, also causes problems because it disrupts the correct sinewave alternating-current pattern the computer, monitor, and other devices are designed to use.

Better-quality surge protectors often provide power filtration to handle electromagnetic interference (EMI)/radio frequency interference (RFI) noise problems from laser printers and other devices that generate a lot of electrical interference.
However, to deal with voltage that is too high or too low, you need a true power conditioner.

Power-conditioning units take substandard or overstandard power levels and adjust them to the correct range needed by your equipment. Some units also include high-quality surge protection features.

To determine whether you need a power-conditioning unit, you can contact your local electric utility company to see whether it loans or rents power-monitoring devices. Alternatively, you can rent them from power consultants. These units track power level and quality over a set period of time (such as overnight or longer) and provide reports to help you see the overall quality of power on a given line.

Moving surge- and interference-causing devices such as microwaves, vacuum cleaners, refrigerators, freezers, and furnaces to circuits away from the computer circuits helps minimize power problems. However, in older buildings, or during times of peak demand, power conditioning might still be necessary. A true (line-interactive) UPS provides built-in power conditioning by its very nature (see the previous discussion).

System Cooling

Objective: 220-802: 4.2

Today’s computers often run much hotter than systems of a few years ago, so it’s important to understand how to keep the hottest-running components running cooler. The following sections discuss the components that are most in need of cooling and how to cool them (processor cooling is discussed in Chapter 2, “Motherboards and Processors”).

Northbridge and Southbridge Chips and Voltage Regulators

Motherboards use a one-chip or two-chip chipset (also referred to as northbridge and southbridge chips) to route data to and from the processor. The northbridge or Memory Controller Hub (MCH) chip, because it carries high-speed data such as memory and video to and from the processor, becomes hot during operation, and, if the component overheats and is damaged, the entire motherboard must be replaced. For this reason, most motherboards feature some type of cooler for the northbridge chip.
Although the southbridge or I/O Controller Hub (ICH) chip carries lower-speed traffic, such as hard disk, audio, and network traffic, it can also become overheated. As a result, most recent motherboards also feature cooling for the southbridge chip. Some chipsets combine both functions into a single chip, which also requires cooling.

Three methods have been used for cooling the motherboard chipset. Passive heat sinks attached directly to the chipset chips are inexpensive but do not provide sufficient cooling for high-performance systems. Active heat sinks provide better cooling than passive heat sinks, but low-quality sleeve-bearing fans often used in these coolers can cause premature fan failure and lead to overheating. The latest trend in chipset and motherboard cooling uses heat pipes, which draw heat away from the chipset or other high-temperature components, such as the voltage regulator for CPU power, and dissipates it through high-performance, very large passive heat sinks located away from the chipset itself. While you can add other types of coolers to chipset chips, heat pipes are factory-installed.

Figure 4-18 illustrates passive and active heat sinks for northbridge and southbridge chips.

Figure 4-19 illustrates a motherboard that uses heat pipes for component cooling.
Video Card Cooling

Another major heat source in modern systems is the video card’s graphics processing unit (GPU) chip, which renders the desktop, graphics, and everything else you see on your computer screen. With the exception of a few low-end video cards, almost all video cards use active heat sinks to blow hot air away from the GPU.

However, the memory chips on a video card can also become very hot. To cool both the GPU and video memory, most recent midrange and high-end video card designs use a fan shroud to cool both components. Fan shrouds often require enough space to prevent the expansion slot next to the video card from being used.

Figure 4-20 illustrates a typical video card with a two-slot fan shroud.

Case Fans

Most ATX chassis have provisions for at least two case fans: one at the front of the system and one at the rear of the system. Case fans can be powered by the motherboard or by using a Y-splitter connected to a four-pin Molex power connector. Case fans at the front of the system should draw air into the system, while case fans at the rear of the system should draw air out of the system.
The EVGA GeForce GTX 580 is a high-performance PCI Express x16 video card that requires a two-slot fan shroud. Image courtesy of EVGA Corporation.

Figure 4-21 shows a typical rear case fan. You can plug fans like this into the three-prong chassis fan connection found on many recent motherboards or into the 4-pin Molex drive power connector used by hard drives. If the motherboard power connector is used, the PC Health or hardware monitor function found in many recent system BIOS setup programs can monitor fan speed (refer to Figure 4-10).

**NOTE** Some case fans that can be powered by a Molex power connector include a special power cable that permits the fan speed to be monitored by the motherboard, even though the motherboard is not used to power the fan.

Case fans are available in various sizes up to 200mm (80, 92, and 120mm are the most common sizes). Measure the opening at the rear of the case to determine which fan size to purchase. Some systems, such as the one shown earlier in Figure 4-11, might feature two rear fans or a rear fan and a top fan.

**Thermal Compound**

When passive or active heat sinks are installed on a processor, northbridge or southbridge chip, GPU or other component, *thermal compound* (also known as thermal transfer material, thermal grease, or phase change material) must be used to provide the best possible thermal transfer between the component and the heat sink.
Heat sinks supplied with boxed processors might use a preapplied phase-change material on the heat sink, whereas OEM processors with third-party heat sinks usually require the installer to use a paste or thick liquid thermal grease or silver-based compound. Coolers for northbridge or southbridge chips might use thermal grease or a phase-change pad.

If the thermal material is preapplied to the heat sink, make sure you remove the protective tape before you install the heat sink. If a third-party heat sink is used, or if the original heat sink is removed and reinstalled, carefully remove any existing thermal transfer material from the heat sink and processor die surface. Then, apply new thermal transfer material to the processor die before you reinstall the heat sink on the processor. Figure 4-22 illustrates the application of thermal compound to a northbridge chip before attaching a heat sink.
Figure 4-22  Applying thermal grease to the northbridge chip.
Exam Preparation Tasks

Review All the Key Topics

Review the most important topics in the chapter, noted with the key topics icon in the outer margin of the page. Table 4-4 lists a reference of these key topics and the page numbers on which each is found.

<table>
<thead>
<tr>
<th>Table 4-4  Key Topics for Chapter 4</th>
</tr>
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<tbody>
<tr>
<td><strong>Key Topic</strong></td>
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<tr>
<td>Text</td>
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<td>Text</td>
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<td>Figure 4-1</td>
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<td>Figure 4-4</td>
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<td>Text</td>
</tr>
</tbody>
</table>
Complete the Tables and Lists from Memory

Print a copy of Appendix A, “Memory Tables,” (found on the CD), or at least the section for this chapter, and complete the tables and lists from memory. Appendix B, “Memory Tables Answer Key,” also on the CD, includes completed tables and lists to check your work.

Define Key Terms

Define the following key terms from this chapter, and check your answers in the glossary.

- power supply
- AC, DC
- multimeter
- surge suppressor
- battery backup
- thermal compound

Complete Hands-On Lab

Complete the hands-on labs, and then see the answers and explanations at the end of the chapter.

Lab 4-1: Check Power Supply Voltages

Scenario: You are a technician working at a PC repair bench. You need to determine whether the power supply is supplying correct voltage to the motherboard without opening the system.

Procedure: Start the system, open the BIOS setup program, and open the dialog that displays power levels (System Health, PC Health, System Monitor are typical names). Check the voltage levels listed against those listed in Table 4-3.

NOTE

If the system does not display voltage levels in the system BIOS, use a multimeter and the information in Figure 4-5, Table 4-2, and Table 4-3 to check voltage levels.

Lab 4-2: Check for Airflow Problems Inside the System

Scenario: You are a technician working at a PC repair bench. You need to determine whether the cable layout inside the system may be causing overheating.

Procedure: Use the procedure for Lab 4-1 to check system temperature after running the system for about a half-hour. Record the current temperature. Shut down the system, unplug it from AC power, and open the system. Compare the
interior of the system to Figures 4-11 and 4-12. If the system resembles Figure 4-11, the system needs better cable organization.

Answer Review Questions

Answer these review questions and then see the answers and explanations at the end of the chapter.

1. Which of the following would you use to keep the power supply working properly? (Choose two.)
   a. Surge protector
   b. Extra power supply
   c. UPS units
   d. Multimeter

2. Power supplies are rated using which of the following units?
   a. Amps
   b. Volts
   c. Watts
   d. Output

3. Newer tower-case computers’ power supplies typically have which of the following power output ratings?
   a. 300 watts
   b. 400 watts
   c. 250 watts
   d. 500 watts or higher

4. Most power supplies in use today are designed to handle which two voltage ranges? (Choose two.)
   a. 115
   b. 300
   c. 230
   d. 450
5. Which of the following are causes of power supply overheating?
   a. Overloading the power supply.
   b. Fan failure.
   c. Dirt or dust.
   d. All of these options are correct.

6. How many pins are used for the main power connection by recent ATX/BTX motherboards with ATX12V 2.2 power supplies?
   a. 24
   b. 48
   c. 32
   d. 16

7. What is the four-pin square power connector on the motherboard used for?
   a. Extra power to PCIe slots
   b. 5-volt power for fans
   c. 12-volt power for processors
   d. 12-volt power for fans

8. What is the six-pin power lead on the power supply used for?
   a. Extra power to PCIe x16 cards
   b. Extra power for PCI cards
   c. Power for case fans
   d. Power supply diagnostics

9. Which of the following steps would you use to remove a power supply?
   a. Shut down the computer. If the power supply has an on/off switch, turn it off as well.
   b. Disconnect the AC power cord from the computer.
   c. Disconnect power connections from the motherboard, hard drives, and optical drives.
   d. All of these options are correct.
10. To avoid power supply hazards you must never do which of the following?  
(Choose two.)
   a. Disassemble the power supply.
   b. Put metal tools through the openings.
   c. Switch the voltage to 220.
   d. Put a smaller power supply in the computer.

11. Which device provides emergency power to a computer in case of a complete power failure?
   a. UTP
   b. UPS
   c. Power strip
   d. Surge protector

12. What is the minimum time recommendation for a UPS to supply power for an individual workstation?
   a. 30 minutes
   b. 45 minutes
   c. 1 hour
   d. 15 minutes

13. Which of the following correctly describe an SPS? (Choose all that apply.)
   a. The battery on an SPS is only used when the AC power fails.
   b. An SPS is on all the time.
   c. A momentary gap in power occurs between loss of AC power and when the SPS comes online.
   d. An SPS is far less expensive than a UPS.

14. When a system is dead and gives no signs of life when you turn on the computer, which of the following might be the cause? (Choose all that apply.)
   a. Defects in AC power to the system
   b. Power supply failure or misconfiguration
   c. Temporary short circuits in internal or external components
   d. Power button or other component failure
15. Processors and other components use a finned metal device to help with cooling. What is this device called? (Choose two.)
   a. Passive heat sink
   b. Thermal compound
   c. Active heat sink
   d. Chassis heat sink

16. What is the purpose of thermal compound?
   a. Provides the best possible thermal transfer between a component and its heat sink
   b. Provides the best possible thermal transfer between a component’s heat sink and its fan
   c. To negate the effects of thermal contraction and expansion in adapter cards
   d. Provides the best possible thermal transfer between the northbridge and its fan

Answers to Hands-On Lab

Lab 4-1: Check Power Supply Voltages

Answer: If the voltage levels are within limits, the power supply is healthy. If any of the voltage levels are out of range, the power supply should be replaced with a power supply of the same or higher wattage rating.

Lab 4-2: Check for Airflow Problems Inside the System

Answer: Use cable ties and reroute long cables between the drive bays at the back wall of the system or along the edge of the motherboard to reduce snarls and improve airflow. After reassembling the system, reconnecting it to AC power, and booting the system to the BIOS setup program, recheck system temperature after running the system for a half-hour. If the temperature is lower, you have improved airflow inside the system. Even if the system temperature remains the same, you have made it easier to work inside the system in the future.
Answers and Explanations to Review Questions

1. **A, C.** To keep your power supply up and running and to help prevent damage from power surges, you should use a surge protector. The UPS will supply power for a short period of time to the computer system in case of total power outage.

2. **C.** Power supplies are rated in watts, and the more watts a power supply provides, the more devices it can safely power.

3. **D.** Most newer tower computers have 500 watt or larger power supplies in them because of the greater number of drives and expansion cards that are available now.

4. **A, C.** Standard North American power is 115 volts, and power in most parts of Europe and Asia is 230 volts. Some power supplies have a slider on the back to switch between the two voltages.

5. **D.** All of the listed reasons can cause damage to the power supply as well as overheating your computer.

6. **A.** Most of the newer power supplies in use today have 24 pins. Older motherboards have a 20-pin connection.

7. **C.** This connector is the ATX12V connector, which provides 12V power dedicated to the processor (a voltage regulator on the motherboard reduces 12V to the actual power required by the processor).

8. **A.** The six-pin (or 6+2 pin) power supply lead provides additional power needed by high-performance PCIe x16 cards, such as those used for SLI or for CrossFire X multi-GPU installations.

9. **D.** All of the listed answers are correct. You must disconnect from the wall first; then once inside the computer unhook the connection to the motherboard, drives, and other devices.

10. **A, B.** The capacitors inside the power supply retain potentially fatal voltage levels. To prevent shock you should not disassemble power supplies or stick in a metal object such as a screwdriver.

11. **B.** A UPS (uninterruptible power supply) will keep a standard desktop up and running in case of a complete power outage.

12. **D.** UPSs are designed to supply power to a computer long enough for you to complete a formal shutdown.

13. **A, C, D.** When an SPS is used there is a momentary gap, usually about 1ms or less, between when the power goes off and when the SPS starts supplying power. SPSs are also less expensive and are not used at all times.
14. A, B, C, D. When turning on a system that shows no signs of life you must consider all of these as potential problems.

15. A, C. All processors require a heat sink. A heat sink is a finned metal device that radiates heat away from the processor. An active heat sink (a heat sink with a fan) is required for adequate processor cooling on current systems. Some older systems used a specially designed duct to direct airflow over a processor with a passive heat sink (a heat sink without a fan). Most motherboards’ northbridges use passive heat sinks or heat pipes.

16. A. Thermal compound (also known as thermal transfer material, thermal grease, or phase change material) provides for the best possible thermal transfer between a component (for example a CPU) and its heat sink. This prevents CPU damage. The fan and adapter cards should not have thermal compound applied to them.
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## Symbols and Numerals

<table>
<thead>
<tr>
<th>Symbol/Number</th>
<th>Page(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1-TuffTEST</td>
<td>569</td>
</tr>
<tr>
<td>3-claw parts retrieval tools</td>
<td>15</td>
</tr>
<tr>
<td>3D games, troubleshooting</td>
<td>300</td>
</tr>
<tr>
<td>7 editions (Windows)</td>
<td>608-609</td>
</tr>
<tr>
<td>10BASE2 cabling</td>
<td>806</td>
</tr>
<tr>
<td>10BASE5 cabling</td>
<td>805</td>
</tr>
<tr>
<td>10BASE-T networks</td>
<td>810</td>
</tr>
<tr>
<td>32-bit architectures</td>
<td>73, 620</td>
</tr>
<tr>
<td>64-bit architectures</td>
<td>73, 607, 620</td>
</tr>
<tr>
<td>80 PLUS certification standard</td>
<td>133</td>
</tr>
<tr>
<td>100BASE-TX networks</td>
<td>810</td>
</tr>
<tr>
<td>104-key keyboards</td>
<td>258</td>
</tr>
<tr>
<td>115-120V/60Hz-cycle AC</td>
<td>134</td>
</tr>
<tr>
<td>230-240V/50Hz AC</td>
<td>134</td>
</tr>
<tr>
<td>802.11a Ethernet standard</td>
<td>811</td>
</tr>
<tr>
<td>802.11b Ethernet standard</td>
<td>811</td>
</tr>
<tr>
<td>1000BASE-T networks</td>
<td>810</td>
</tr>
<tr>
<td><code>&lt; &gt;</code> (HTML tags)</td>
<td>793</td>
</tr>
</tbody>
</table>

## Accessing

- **AC (alternating current), 130**
  - outlet safety, 932
  - power flow problems, 156
  - power loss restart, 94
  - voltage testing, 151

- **Accelerated Graphics Port (AGP) slots**, 38-39, 274
- **accelerometers, 409**
- **access denied messages, 492**
- **access point security**
  - default administrator passwords, changing, 890
  - default SSIDs, changing, 886
  - DHCP versus static IP addresses, 885
  - firewalls, 891
  - firmware, updating, 890
  - MAC addresses, filtering, 887-890
  - radio levels, 891
  - SSID broadcasting, disabling, 886
  - WAP location, 891
- **accessing**
  - operating systems, controlling, 892
    - administrator accounts, 893
    - auditing, 897-898
    - components, 896
    - event logging, 897-898
    - groups, 894
    - guest accounts, 893
    - moving/copying files/folders, 896
    - permissions, 895-896
    - principle of least privilege, 895
    - restricted spaces, 896
    - UAC, 893-894
    - user accounts, 893
shared resources, 836
WinRE, 741-742
Acer beep codes website, 111
Acronis True Image, 747
Action Center (Windows), 691
active heat sinks, 75
active matrix OLEDs (AMOLEDs), 369
add-on cards
modems, 779
point of failure, 12
USB ports, 214
Add Printer Wizard, 465-466
Add/Remove Programs (Windows control panel), 686
addresses
I/O ports, 235
IP, 824-826
classes, 824-826
Duplicate IP Address error message, 851
octets, 825
static versus DHCP, 885
static versus server-assigned, 819-820
subnet masks, 824
IPv6, 827-829
IRQ port, 235
MAC, filtering, 846, 887-890
unicast, 828
administration
default passwords, changing, 890
operating system access, controlling, 893
administrator accounts, 893
auditing, 897-898
components, 896
event logging, 897-898
groups, 894
guest accounts, 893
moving/copying files/folders, 896
permissions, 895-896
principle of least privilege, 895
restricted spaces, 896
UAC, 893-894
user accounts, 893
Windows
computer management (MMC), 640-641
Performance Monitor, 641-642
print management, 648
services, 642-644
System Monitor, 641-642
Task Manager, 648-649
Task Scheduler, 645-646
administrative shares, 834
administrative tools (Windows), 618-619
ADSL (Asynchronous DSL), 786
Advanced Boot Options, 726-729
Advanced RISC Machines (ARM) processors, 398
Advanced Technology Extended (ATX) motherboards, 31
adware, 915
Aero/Aero Glass (Windows), 610
AGP (Accelerated Graphics Port) slots, 38-39, 274
air (environment), 936
airflow problems, troubleshooting, 146-147
Airplane Mode, 412
All Control Panel Items view (Windows control panel), 676
alternating current. See AC
AMD processors, 64
Intel, comparison, 58
Sockets
940, 66
AM2, 66-67
AM2+, 67
AM3, 67-68
AM3+, 68
FM1, 69
PGA, 64
website, 70
AMD Virtualization Technology and Microsoft Hyper-V System Compatibility Check Utility website, 326
American Megatrend BIOS Support website, 115
American Power Conversion website, 160
AMI BIOS beep codes website, 111
amperage (ammeter), testing, 152
AMOLEDs (active matrix OLEDs), 369
amperage (ammeter), testing, 152
AMR (audio modem riser) slots, 41-42
analog audio mini-jacks, 249-250
analog connections. See dial-up Internet connections
Android, 404-405
advanced wireless settings, 417
Airplane Mode, 412
antivirus software, 434
applications
sources, 408
turning off, 435
Bluetooth, 418-419
cloud backups, 433
GPS, enabling/disabling, 411
hard resets, 437
Market, 408
Open-Source Project (AOSP), 404
passcodes, setting, 430
POP3 email, configuring, 421-422
remote wipe programs, 432
rooting, 408
screen calibration, 409
screen orientation, locking, 408
synchronizing to PCs, 424-427
updating, 433
versions, 405
Wi-Fi, configuring, 414
Answers That Work Task List Programs website, 644
antistatic bags, 931
antistatic wrist straps, 930
anti-virus programs, 872-873
mobile devices, 434
testing, 913
Windows Defender, 916
anycast addressing, 828
AOSP (Android Open-Source Project), 404
APIPA (Automatic Private IP address), 828
App Store, 408
Apple iOS, 406
accelerometers, 409
advanced wireless settings, 418
Airplane Mode, 413
antivirus software, 435
applications
sources, 408
turning off, 436
Bluetooth, 420
charging devices, 427
GPS, enabling/disabling, 411
gyroscopes, 409
hard resets, 437
jailbreaking, 408
passcodes, setting, 431
POP3 email, configuring, 422-423
remote wipe programs, 432
screen calibration, 411
screen orientation, locking, 408
soft resets, 436
synchronizing to PCs, 427
updating, 434
versions, 406
Wi-Fi, configuring, 415

applications (mobile devices)
screen orientation, 409
sources, 408
turning off, 435-436

ARM (Advanced RISC Machine)
processors, 398

Asian power standard voltage, 134

ASR (Automated System Recovery), 718, 739-741

assembly tools, 15

Asynchronous DSL (ADSL), 786

ATA RAID arrays, creating, 528-530
backing up data, 530
configuring, 529
connecting, 528
enabling, 529
requirements, 528

ATA specifications, 504-505

Attrib command, 737-738

ATX (Advanced Technology Extended)
motherboards, 31

audio
BIOS settings, 92
connectors, 45
editing systems, configuring, 316-317
microphones, 333-335
MIDI enabled devices, installing, 332
modem riser (AMR) slots, 41-42
ports, 102, 249-250
sound cards
audio jacks/cable color standards, 330
configuring, 332
defined, 329
installing, 331-332

auditing
enabling, 874
security, 897-898

authentication, 871
biometrics, 872
multifactor, 872
smart cards, 871
username/password/PIN, 871

Auto Restart Errors, 708-709
Automated System Recovery (ASR), 718, 739-741
Automatic Private IP address (APIPA), 828
automatic shutdown (battery backup units), 159
Automatic Updates (Windows control panel), 688
autoranging digital meters, 149
autorun, disabling, 918

B
backed up print queues, troubleshooting, 489-490
backlight components (laptop displays), 372
Backup and Restore Center (Windows 7), 750-753
Backup and Restore Center (Vista), 748-750

backups
ASR, 739
mobile devices, 432-433
security, 877

Windows
Backup and Restore Center (7), 750-753
Backup and Restore Center (Vista), 748-750
file copy utilities, compared, 753
image (7), 752
image (Vista), 749
image (XP), 747
NTBackup, 745-747
Registry, 724
restoring, 746, 750-752

baiting, 880
banks (memory), 185
bar code readers, 259-260
basic disks, 583
basic input/output system. See BIOS
Basic Rate Interface (BRI), 785
Batch command, 737
batteries
backup units, 158-160
automatic shutdown, 159
laser printers, 160
network support, 158
runtimes, 158
size, determining, 159-160
surge suppression features, 159
types, 158
CMOS, 12, 88-89
iPads, charging, 427

laptops
replacing, 355-356
troubleshooting, 384
mobile devices, 399
smartphones, replacing, 401
BD-R (writeable/nonerasable), 532
BD-RE (rewritable/erasable), 532
BD-ROM (read-only, Blu-ray), 532
beep codes, 111
Belarc Advisor, 115, 325, 568
binary to decimal conversions, 825
biometrics, 872, 882-883
BIOS (basic input/output system), 85
chip failures, 12
counting
AC power loss restart, 94
automatically, 95
boot sequence, 92
boot settings/sequence, 98-100
boot-time diagnostic screen, 93
boot virus detection, 94
clock, 92
exiting, 109
floppy drive, 94
hardware monitor, 92, 105
integrated ports/peripherals, 100-103
keyboard, 93
main menu, 96
memory, 92, 106
onboard audio, modem, network, 92
parallel ports, 93
PATA drives, 94
plug-and-play OS, 93
PnP/PCI, 105
power management, 93, 104
primary VGA, 93
processors, 106
PS/2 mouse, 92
quiet boot, 93
S1/S3 standby, 94
SATA drives, 94
saving changes, 109
security features, 108-109
serial ports, 93
setup passwords, 94
setup program, 89-90
shadowing, 93
Standard Features/Settings menu, 96
system information, 98
UEFI, 91
USB function, 93
USB legacy, 93
user/power-on password, 94
virtualization, 93, 106-107
Wake on LAN, 94
write-protect boot sector, 94
defined, 85
devices/features supported, 87
loose chips, 56
PATA
    configuring, 508
    hard drives, configuring, 519
POST
    beep codes, 111
    error messages, 112
    hex codes, 112-113
    overview, 110
SATA hard disk drives, configuring, 516
security features, 899-900
settings, 88-89
setup, 324
tasks, 87
time and setting resets, 53
updates, 114-115
    failure recovery, 117
    Flash, 115-117
    replacing, 118-119
USB ports, enabling, 215
video card settings, 282
BitLocker encryption, 876
BlackBerry devices
    Desktop Software, 428
e-mail, configuring, 423
synchronizing to PCs, 428
blackouts, 933
blank screen on bootup, troubleshooting, 54
Blu-ray
    CDs/DVDs, compared, 531-532
drive speeds, 533
types, 532
Blue Screen of Death (BSOD) errors, 706-709
Bluetooth
    classes, 812
laptop connectivity, troubleshooting, 386
mobile devices, 418
    Android, 418-419
    iOS, 420
    troubleshooting, 420-421
networks, 812
printers, 469-470
boot failures, troubleshooting, 547
boot.ini files, re-creating, 713
boot sequence settings, configuring, 92
boot virus detection settings, 94
Bootcfg command, 737
bootup
3TB hard drives, 659
Advanced Options, 726-729
BIOS settings, configuring, 98-100
blank screens, troubleshooting, 54
clean, 714
diagnostic screen, configuring, 93
failures, 709
    GUI not loading, 714
    missing GUI, 714
    Missing Operating System, 713
    Vista/7, 710-711
    XP, 712-713
multiboot configurations, 711
operating system not found, troubleshooting, 548
POST code beeps, troubleshooting, 54
quiet, configuring, 93
sequence, 98-100
Windows installation, 570
WinRE Startup Repair option, 743
BRI (Basic Rate Interface), 785
bridges, 776
broadband Internet services, 786
cable, 788-789
DSL, 786-787
satellite, 789-790
brownouts, 933
BSOD (Blue Screen of Death) errors, 706-709
BTX motherboards, 32
buffer size (hard drives), 513
burning smells (hard drives), 55
bus
    powered hubs, 214
    speeds, 71
topologies, 774
Business edition (Windows Vista), 608
cable Internet service, 788-789
Cables. See also connectors
    component video, 289
    composite, 289
    DisplayPort, 288
    DVI, 286
    Ethernet color coding diagram website, 803
    front panel failures, 12
    HDMI, 286-288
    header, 213
    IEEE 1394, 218
    lengths, 211
    managing, 935
    networks
        coaxial, 805-806
        connectors, 806-807
        fiber-optic, 805
        municipality rules/regulations, 808
        parallel (LPT) crossover, 801
        plenum, 806
        PVC, 806
        serial (RS-232) null modem, 801
        STP, 801-803
        types, 801
        UTP, 801-803
    parallel ports
        connectors, 240-241
        pinout, 241-242
        types, 244-245
    PATA, 506, 517
    patch, 809
    PC Cards, 349
    power supplies, testing, 152
    RGB, 289
RJ-11, troubleshooting, 782
S-video, 289
SATA, 508-510, 515
SCSI, 225-227
serial, 235
troubleshooting, 239
types, 235
testing tools, 808
USB
1.1/2.0, 210
3.0, 211
length, 212
cache memory, 70-71, 195
CAD/CAM design configurations, 314-315
calculating power supply requirements, 132-133
calibrating
inkjet printers, 458, 480
laser printers, 479
mobile device screens, 409-411
CardBus cards, 348-350
ExpressCards, compared, 350
inserting, 349
installing, 816
removing, 349
cardkey systems, 882
cards
add-on
point of failure, 12
USB ports, 214
CardBus, 348
ExpressCards, compared, 350
inserting, 349
installing, 816
removing, 349
combo, 817
Express failures, 13
ExpressCards, 350-352
CardBus cards, compared, 350
inserting, 350
media remote controls, 350
performance, 350
removable adapters, 350
removing, 351
types, 350
flash memory
CompactFlash, 521
laptops, 552
memory sticks, 521-522
microSD, 522
microSDHC, 522
miniSD, 522
miniSDHC, 522
MultiMedia, 521
readers, 523-524
Secure Digital, 522
Secure Digital Extended Capacity, 522
Secure Digital High Capacity, 522
SmartMedia, 521
types, 520-523
xD-Picture Cards, 523
IEEE 1394, 220
memory, 400-403
mini-PCI, 363
Mini-PCIe, 364
network interface
configuring, 816-819
installing, 815-816
PC, 346, 349-350
cables, 349
CardBus support, 348
combo, 349
dongs, 348
failures, 13
inserting, 349
removing, 349
types, 346-347
ZV support, 349
POST, 113
SCSI, 228
smart, 871, 882
sound
   audio jacks/cable color standards, 330
   configuring, 332
   defined, 329
   installing, 331-332
SVGA, 286
TV tuner, 336
VGA, 285
video
   3D game problems, 300
   AGP slots, 274
   BIOS configuration, 282
capture, 335-336
   cooking, 163, 275-276
defined, 274
driver installation, 282-284
driver problems, 300
GPUs, 275
no picture after replacing, 301
PCI Express x16, 274
physical installation, 282-284
troubleshooting, 300-302
types, 274
   video connectors. See video, connectors
wireless, removing from laptops, 362-365
ZV (Zoomed Video), 349
Carrier Sense Multiple Access/
   Collision Detect (CSMA/CD), 810
case fans, 163-164
Category view (Windows control
   panel), 674
Cathode Ray Tube (CRT) monitors, 277
CD command, 623, 629
CDs
   autorun, disabling, 918
drive speeds, 533
DVDs/Blu-ray, compared, 531-532
erasing data, 534
recordable (R)/rewriteable (RW), 531
recording data
   third-party programs, 536-537
   Windows Vista/7, 535-536
   Windows XP, 533-534
cellular networks, 790, 813
CF (CompactFlash) cards, 521
chain of custody, 939
charging iPads, 427
ChDir command, 737
Cheapernet, 806
chemical safety, 936-938
chips
   BIOS, 12, 56
creep, 56
   memory, 179
   northbridge/southbridge, 161-162
chipsets, 42-44
Chkdsk utility, 737, 754-755
classes
   Bluetooth, 812
   IP addresses, 826
      listing of, 824
      subnet masks, 825
clean boots, 714
clean Windows install, 571-573

cleaning
desktops, 148
floppy drives, 540
heating elements (thermal printers), 482
keyboards, 259
laser printers, 454, 479-480
mobile device screens, 411
clearing print queues, 490
client/server networks, 770-772
client-side virtualization, 692
clients
client/server networks, 772
network configuration, 834-836
thick, 322
thin, 323
wireless, configuring, 904
troubleshooting, 909-910
Windows 7, 908-909
Windows Vista, 908
Windows XP SP2/SP3, 905-908
clock settings, configuring, 92
cloning laptop displays to secondary displays, 377-378
closed-source software. See Apple iOS
Cls command, 737
CLS command, 623
CMD utility, 661
CMOS
batteries, 12, 88-89
BIOS settings, storing, 88-89
Checksum errors, 119
configuring
automatically, 95
boot settings/sequence, 98-100
hardware monitor, 105
integrated ports/peripherals, 100-103

main menu, 96
memory, 106
PnP/PCI, 105
power management, 104
processors, 106
security features, 108-109
Standard Features/Settings menu, 96
system information, 98
virtualization, 106-107

memory, 88-89

POST
error messages, 112
hex codes, 112-113

settings
AC power loss restart, 94
boot sequence, 92
boot-time diagnostic screen, 93
boot virus detection, 94
clock, 92
floppy drive, 94
hardware monitor, 92
keyboard, 93
memory, 92
onboard audio, modem, or network, 92
parallel ports, 93
PATA, drives, 94
plug-and-play OS, 93
power management, 93
primary VGA, 93
PS/2 mouse, 92
quiet boot, 93
S1/S3 standby, 94
SATA drives, 94
serial ports, 93
setup passwords, 94
shadowing, 93
USB 3.0 function, 93
USB function, 93
USB legacy, 93
user/power-on password, 94
virtualization, 93
Wake on LAN, 94
write-protect boot sector, 94
CNR (communications network riser) slots, 41-42
coaxial cabling, 805-806
color
3D games, troubleshooting, 300
display quality, configuring, 295-296
flickers, troubleshooting, 301
fringes around text/graphics, troubleshooting, 301
laser printers, 454
printed pages, troubleshooting, 492
projectors, 302
PS/2 ports, 249
quality, 301
screen/printer not matching, 300
COM 4 I/O port conflicts, troubleshooting, 238
COM ports. See serial ports
combo cards, 349, 817
command-line tools
networks
IPconfig, 849
NBTSTAT, 850
Net, 847
netstat, 849
NSLookup, 849
Ping, 847-848
Tracert, 848
Windows
CD command, 629
command prompts, starting, 621-622
COPY command, 624-625
DEL command, 635-636
Diskpart, 633-635
Format command, 629-630
FORMAT.EXE, 631-632
internal commands, 622-623
MD command, 629
RD command, 629
ROBOCOPY.EXE, 627-628
Taskkill utility, 638-640
Tasklist.exe, 636-638
wildcards, 624
XCOPY command, 625-627
Command Prompt (Windows), 744
command prompts, starting, 621-622
commands. See also utilities
CD, 623, 629
CLS, 623
COPY, 622-625
DATE, 622
DEL, 622, 635-636
DIR, 623
ECHO, 623
ERASE, 623
Format, 629-630
IPconfig, 849
MD, 623, 629
NBTSTAT, 850
Net, 847
netstat, 849
NSLookup, 849
PATH, 623
Ping, 847-848
PROMPT, 623
RD, 623, 629
Recovery Console, 737-739
RENAME, 623
SET, 623
TIME, 622
Tracert, 848
TYPE, 623
VER, 623
VOL, 623
XCOPY, 625-627
Common Tasks View (Windows Explorer), 664-665
communication (customers), 939-941
communications network riser (AMR) slots, 41-42
CompactFlash (CF) cards, 521
compatibility
addresses, 828
errors, 716
RAM, 192
compatibility mode (Windows), 615-617
component video connectors, 289
composite video connectors, 289
compressed air, 18
compromised mobile device protection, 432-435
antivirus software, 434
backups, 432-433
operating system updates, 433
CompTIA A+ certification website, 18
computer management (MMC), 640-641
Computer Protection Program website, 874
computer safety
electricity, 932-934
AC outlets, 932
blackouts, 933
brownouts, 933
dirty power, 933
fires, 934
power surges, 933
sags, 933
surge suppressors, 933
ESD, preventing, 930-932
personal physical, 934-935
computers
assembly/disassembly tools, 15
components
general system information, 324
processor information, 326
cooling
case fans, 163-164
motherboards, 161-162
thermal compound, 164
video cards, 163
desktops
components, 4-9
front/rear views, 5
points of failure, 12-13
destruction/disposal methods, 898-899
firmware, 11
hardware, 10
laptops. See laptops
locking, 878-879
safety. See computer safety
software, 10-11
synchronizing
Android devices, 424-427
BlackBerry devices, 428
iOS devices, 427
Windows CE/Mobile devices, 428
conditioning (laser printers EP process), 453
configuring
ATA/SATA RAID arrays, 529
BIOS
AC power loss restart, 94
automatically, 95
boot sequence, 92
boot settings/sequence, 98-100
boot-time diagnostic screen, 93
boot virus detection, 94
clock, 92
floppy drive, 94
hardware monitor, 92, 105
integrated ports/peripherals, 100, 103
keyboard, 93
main menu, 96
memory, 92, 106
onboard audio, modem, network, 92
parallel ports, 93
PATA, drives, 94
plug-and-play OS, 93
PnP/PCI, 105
power management, 93, 104
primary VGA, 93
processors, 106
PS/2 mouse, 92
quiet boot, 93
S1/S3 standby, 94
SATA drives, 94
security features, 108-109, 899-900
serial ports, 93
settings, 88
setup passwords, 94
setup program, 89-90
shadowing, 93
Standard Features/Settings menu, 96
system information, 98
UEFI, 91
USB 3.0 function, 93
USB function, 93
USB legacy, 93
user/power-on password, 94
video cards, 282
virtualization, 93, 106-107
Wake on LAN, 94
write-protect boot sector, 94
Bluetooth, 419
Android devices, 418-419
iOS devices, 420
troubleshooting, 420-421
displays
color quality, 295-296
control panel, 678
refresh rates, 296-297
resolution, 292-295
DMA/UDMA transfers, 545
DNS, 827
email for mobile devices
BlackBerry, 423
IMAP, 423
POP3, 421-423
troubleshooting, 423
web-based, 421
exceptions, 902-903
file/printer sharing, 829
floppy drive hardware, 539-540
hard drives. See disk management
hardware monitor, 105
ISDN connections, 785
mobile device displays, 408-411
calibration, 409-411
screen orientation, 408-409
multifunction network devices, 845
DMZ, 846
MAC address filtering, 846
NAT, 845
port forwarding, 845
network interface cards, 816-819
full-duplex/half-duplex modes, 817
hardware resources, 816
media types, 817
WLANs, 818-819
parallel ports, 243-246
PATA
  BIOS, 508
  hard drives, 519
  jumper blocks, 507
printers, 472-474
  preferences, 473
  properties sheets, accessing, 472-473
  properties versus preferences, 474
  saving changes, 475
processors, 106
SATA hard disk drives, 516
SCSI device IDs, 223-224
serial ports, 236-237
shared resources, 829
  access, 836
  administrative shares, 834
  clients, 834-836
  drive mapping, 840-841
  file/printer sharing, 829
  folders/drives, 830-834
  FQDNs, 840
  identifying, 836
  offline, 839
  printers, 834
  UNC, 838-839
software firewalls, 900-901
SOHO. See SOHO
sound cards, 332
System Restore, 759
systems
  audio/video editing, 316-317
  gaming, 319-320
  graphic/CAD/CAM design, 314-315
  home servers, 323-324
home theaters, 321-322
thick clients, 322
thin clients, 323
virtualization, 318-319
TCP/IP, 819
  advanced settings, 822
  alternate configuration, 821
  DHCP servers, 821
  DNS, 827
  gateways, 826
  IP addressing, 824-826
  manually, 822
  static versus server-assigned IP addressing, 819-820
  subnet masks, 824
  Windows, 820
  WINS, 826
TV tuner cards, 336
web browsers, 841-842
  Internet connections, 842-843
  script settings, enabling/disabling, 843
  security, 844-845
webcams, 327
Wi-Fi for mobile devices
  Android, 414
  iOS, 415
  tethering, 416
WINS, 826
wireless clients, 904
  Windows 7, 908-909
  Windows Vista, 908
  Windows XP SP2/SP3, 905-908
WLANs, 818-819
connections
  ATA/SATA RAID arrays, 528
  Bluetooth, 386
Internet

- **broadband**, 786-787
- **cable**, 788-789
- **cellular**, 790
- **dial-up**, 778-784
- **downstream/upstream**, 786
- **fiber-optic**, 790
- **ISDN**, 784-785
- **LANs**, 791
- **satellite**, 789-790
- **WiMAX**, 791

**mobile device network**, 424

- **Bluetooth**, 418-421
- **GSM**, 412-413
- **Wi-Fi**, 414-418

**networks**, 853

**PATA hard drives to motherboards**, 518

**PCs to mobile devices**

- **Android**, 424-427
- **BlackBerry devices**, 428
- **iOS**, 427
- **Windows CE/Mobile**, 428

**printers**, 488

**projectors to laptops**, 379

**SATA hard disk drives to motherboards**, 516

**wireless**, 386, 910-912

**connectors. See also cables**

- **Narrow SCSI**, 226
- **network cables**, 803, 806-807
- **parallel ports**, 240-241
- **PATA hard drives power**, 517
- **power supplies**, 135-138
- **serial ports**, 239

**content view (Windows Explorer)**, 667

**continuous reboots**, 53

**control panel (Windows)**

- **Action Center**, 691
- **Add/Remove Programs**, 686
- **All Control Panel Items view**, 676
- **Automatic Updates**, 688
- **Category view**, 674
- **Devices and Printers**, 689
- **display settings, configuring**, 678
- **features**, 673-674
- **folder options**, 679
- **function access via property sheets**, 678
- **HomeGroup**, 690
- **Pen and Input Devices**, 689
- **power options**, 682
  - **Windows Vista/7**, 685-686
  - **Windows XP**, 683-684
- **Problem Reports and Solutions**, 689
- **Programs and Features**, 687
- **starting**, 674
- **switching views**, 676
- **System properties sheet**, 680-682
- **Tablet PC Settings**, 688

**CONVERT.EXE**, 660

**converting numbers**, 825

**cooling**

- **case fans**, 163-164
- **motherboards**, 161-162
- **negative pressure**, 148
- **processors**, 74
  - **heat sinks**, 75
  - **liquid**, 76
- **thermal compound**, 164
- **video cards**, 163, 275-276

**Copy command**, 622-625, 737

**copying files/folders**, 896

**CPUs. See processors**

**CPU-Z website**, 326
cimmers, 18
CRT (Cathode Ray Tube) monitors, 277
CSMA/CD (Carrier Sense Multiple Access/Collision Detect), 810
customers
interaction, 939-941
property, respecting, 941
customizing
computers
audio/video editing, 316-317
gaming, 319-320
graphics/CAD/CAM design, 314-315
home servers, 323-324
home theaters, 321-322
thin clients, 323
virtualization, 318-319
power connectors, 137
cutting tools, 808

daisy-chaining (SCSI)
creating, 227
maximum length, 229
overview, 222
termination methods, 229
damaged mobile device protection, 432-435
antivirus software, 434
backups, 432-433
operating system updates, 433
data
migrating, 877
mobile devices, protecting, 429
antivirus software, 434
backups, 432-433
compromised/damaged devices, 432-435
lost/stolen, 432
operating system updates, 433
passcode locking, 429, 432
projectors, 280-281
recovery
EFS files, 875
external drive docks, 550
external drive enclosures, 550
hard disk diagnostic programs, 551
software, 552
Windows-based disk tools, 551
security
backups, 877
destruction/disposal methods, 898-899
encryption, 875-876
incident reporting, 879
local security policies, 874
locking computers, 878-879
migration, 877
passwords, 878
physical protection, 883
remnant removal, 877
social engineering, 880-881
transferring, 589
USMT, 590-591
Windows Easy Transfer, 590
DATE command, 622
dates and times
BIOS resets, 53
clock, setting, 92
DC (direct current), 130, 151
DDR SDRAM (double-data-rate SDRAM), 181
DDR2 SDRAM (double double-data-rate SDRAM), 182
DDR3 SDRAM (double-data-rate 3 SDRAM), 182
dead shorts, troubleshooting, 57
dead systems, troubleshooting, 143-144
decimal to binary conversions, 825
defective power supplies, 149-152
AC to DC conversions, 152
AC voltage, 151
acceptable voltage levels, 152
amperage, 152
cables, 152
DC voltage, 151
resistance, 152
Defrag utility, 718, 755
defragmenting hard drives, 755
DEL command, 622, 635-636
Delete command, 737
deleting data from optical discs, 534
Dell
beep codes website, 111
power supplies, 137, 154
demilitarized zone (DMZ), 846
Depot International website, 479
desktops. See also computers
cleaning, 148
components, 4-5, 8-9
firmware, 11
hardware, 10
laptops, compared, 345
memory modules comparison, 185
points of failure, 12-13
software, 10-11
destruction (computers), 898-899
details view (Windows Explorer), 667
developing (laser printers EP process), 453
Device Manager, 718, 729-735
categories, viewing, 729
device property sheets, opening, 730
disabling devices, 731, 734-735
error codes, 733-734
malfunctioning devices, 731-733
problems, troubleshooting, 732
removing devices, 735
starting, 729
devices
BIOS support, 87
Control Panel settings, 689
disabling, 734-735
drivers, installing, 216
failures, 715
IEEE 1394
overview, 219
troubleshooting, 221
networks, 775
bridges, 776
firewalls, 777
bubs, 775
Internet appliances, 777
modems, 776
multifunction, configuring, 845-846
NAS, 776
repeaters, 776
routers, 777
switches, 775
VoIP phones, 777
WAPs, 776
property sheets, opening, 730
removing, 735
SCSI
cables, 225-227
daisy chaining, 222, 227-229
IDs, configuring, 223-224
signaling types, 227
standards, 225
terminating, 229
troubleshooting, 230-231
serial port supported, 231
storage. See storage devices

Devices and Printers (Windows Control Panel), 689

DHCP (Dynamic Host Configuration Protocol), 796
TCP/IP, configuring, 821
versus static IP addresses, 885
diagnostic and repair tools, 717-719
Advanced Boot Options, 726-729
Automated System Recovery, 718, 739-741
Defrag, 718
Device Manager, 718, 729-735
Event Viewer, 718, 724
Fixboot, 718
Fixmbr, 718
MSConfig, 718-721
Recovery Console, 718, 735-739
REGEDIT, 718, 722-724
REGSVR32, 718, 721
Repair Discs, 719
Safe Mode, 718
System File Checker, 718-719
WinRE, 718, 741-744
dialog boxes
Display Settings, 293, 690
Hardware Monitor, 106
Map Network Drive, 841
Mouse properties, 690
Network, 836
Offline Files, 839
PnP/PCI Configuration, 105
Power Options, 686
Services, 643
Speech Recognition, 335
Virtual Memory, 682
dial-up Internet connections, 778
creating, 783
modems
installing, 781-783
serial port similarities, 778
standards, 781
types, 779
requirements, 784
service providers, 783
digital audio mini-jacks, 250
digital cameras, 328-329
digital micromirror devices (DMDs), 281
digital TV vendor websites, 322
dim displays, troubleshooting, 383
DIMM (Dual Inline Memory Module), 184
Dir command, 623, 737
direct current (DC), 130, 151
direct thermal printing, 460
DirectX diagnostics, 661, 672
dirt/dust (power supplies), 148
dirty power, 933
Disable command, 737
disabling
autorun, 918
Bluetooth
Android devices, 419
iOS devices, 420
devices, 734-735
GPS (mobile devices), 411
Internet scripts, 843
SSID broadcasting, 886
disassembling laptops, 353
disassembly tools, 15
disk cloning Windows, 577-579
Disk Management, 650
configuration options
  active partitions, 652
  converting basic disks to dynamic, 652
  creating logical drives, 655
  creating partitions, 652, 655
  creating volumes, 655
  drive arrays, creating, 653
  extending partitions, 651-653
  formatting partitions, 651-652
  initializing disks, 651
  logical drives, creating, 651
  primary partitions, creating, 651
disk arrays supported, 651
disk status, viewing, 655
file systems
  converting, 660
  defined, 657
  FAT32, 657
  FAT64, 658
  NTFS, 658-660
mounting drives, 655-656
“Disk Status Descriptions” website, 655
Diskpart utility, 633-635, 737
disks
  basic, 583
dynamic, 583
  encrypting, 876
Display Settings dialog box, 293, 690
displaying objects in Windows Explorer
  Windows Vista/7, 667
  Windows XP, 666
DisplayPort connectors, 288
displays
  control panel settings, 678
  CRT monitors, 277
data projectors, 280-281
installing, 289-291
laptops
  backlight components, 372
dual, 375-379
  failures, 13
  inverters, 372-373
  LCDs, 369
  LEDs, 369
  nonnative resolutions, 371
  OLEDs, 369
  plasma, 370
  quality factors, 370-371
  replacing, 365-366
  resolutions, 370
  troubleshooting, 382-384
  Wi-Fi antennas, 373
  windowboxing, 372
LCD, 278-280, 369
LED, 279, 369
mobile devices, 399
  adjusting, 408-411
  calibration, 409-411
  screen orientation, locking, 408-409
  troubleshooting screen calibration problems, 411
multitouch touch screens, 398
OLED, 281
plasma, 279
settings
  color quality, 295-296
  refresh rates, 296-297
  resolution, 292-295
touch screen, 260-261
  installing, 262
  interfacing, 261
surface treatments, 261
troubleshooting, 262-263

troubleshooting
3D games, 300
color fringes around text/graphics, 301
color quality, 301
flickers, 300-301
icon size, 300
monitors/projectors, 300-302
mouse pointers, 300
no picture with replacement video cards, 301
picture quality, 298-301
picture size changes, 301
projectors, 301-302
refresh rates, 301
resolution, 301
screen/printer colors not matching, 300
text size, 300
video cards, 300-302
wavy lines, 301
types, 276

video cards
AGP slots, 274
BIOS configuration, 282
cooling, 275-276
defined, 274
driver installation, 282-284
GPUs, 275
PCI Express x16 slots, 274
physical installation, 282-284
types, 274

video connectors
component, 289
composite, 289
DisplayPort, 288
DVI, 286
HDMI, 286-288
RGB, 289
SVGA, 286
S-video, 289
VGA, 285
disposable (computers), 898-899
DLL (dynamic link library), 715
DLL messages, missing, 715
DLP projectors, 280
DMA/UDMA transfers, configuring, 545
DMDs (digital micromirror devices), 281
DMZ (demilitarized zone), 846
DNS (Domain Name System), 795-796, 827
docking stations (laptops), 380-381
dongles (PC Cards), 348
doors security, 881-882
dot matrix printers
paper, replacing, 483
printheads, 463, 483
printing process, 462
ribbons, replacing, 483
double-data-rate (DDR) SDRAM, 181
double-data-rate 3 (DDR3) SDRAM, 182
double double-data-rate (DDR2)
SDRAM, 182
double-sided memory, 188
downloading applications, 408
downstream, 786
DRAM (dynamic RAM), 180-181
drivers
devices, 216
printers, 464-467
third-party, 588
video cards
installing, 282-284
troubleshooting, 300

drives
arrays, creating, 653
Blu-ray
CD/DVD drives, compared, 531-532
media types supported, 532
speeds, 533
CD
DVD/Blu-ray drives, compared, 531-532
erasing data in Windows XP, 534
recording data, 533-537
speeds, 533
data recovery tools
data recovery software, 552
external drive docks, 550
external drive enclosures, 550
hard disk diagnostic programs, 551
Windows-based disk tools, 551
DMA/UDMA transfers, configuring, 545
DVD
CD/DVD drives, compared, 531-532
erasing data in Windows XP, 534
media types supported, 532
recording data, 533-537
speeds, 533
SuperMulti DVD, 532
eSATA, 519
failures, 13
floppy, 538
  capacities, 538
cleaning, 540
defined, 538
external, 540
  hardware configuration, 539-540
  maintenance, 540-541
hard. See hard drives
hybrid, 513
interfaces, 502
  external, 502
  hot-swappable, 511
  internal, 502
  overview, 503
PATA BIOS configuration, 508
PATA cabling, 506
PATA jumper block configuration, 507
PATA/SATA standards, 504-505
SATA cabling, 508-510
SCSI, 510
logical, 651, 655
loud noises, troubleshooting, 546
mapping, 840-841
mounting, 655-656
optical
  Blu-ray media types, 532
  comparing, 531-532
  DVD media types, 532
  erasing data in Windows XP, 534
  recording data, 533-537
  speeds, 533
  types, 531
PATA, 517-519
  BIOS settings, configuring, 97
  cabling, 506
  configuring, 100, 507-508
  installing, 517-519
  settings, 94
  standards, 504-505
point of failure, 12
RAID, 526
  ATA/SATA arrays, creating, 528-530
  levels, 526-527
recognition problems, troubleshooting, 548
SATA
  BIOS settings, configuring, 97
  cabling, 508-510
  host adapters, 517
  installing, 515-517
  ports, configuring, 100
  RAID arrays, creating, 528-530
  settings, 94
  standards, 504-505
sharing, 830-834
  access, 836
  drive mapping, 840-841
  FQDNs, 840
  identification, 836
  offline, 839
  simple file sharing, 831
  UNC, 838-839
  user/group permissions, 832-834
tape, 541-542
USB flash memory, 524
viewing with Windows Explorer, 664
DSL, 786-787
dual-channel memory, 180
dual displays (laptops), 375
  cloning to secondary display, 377-378
Extended Desktop, enabling
  Windows 7, 376-377
  Windows XP/Vista, 375-376
projectors, connecting, 379
troubleshooting, 383
Dual Inline Memory Module (DIMM), 184
DualView, 375-377
duplexing assemblies (laser printers), 450
Duplicate Computer Name error messages, 851
Duplicate IP Address error message, 851
DVDs
  autorun, disabling, 918
  CDs/Blu-ray, comparing, 531-532
  drive speeds, 533
  erasing data, 534
  recording data
    third-party programs, 536-537
    Windows Vista/7, 535-536
    Windows XP, 533-534
  rewriteable/erasable (RW), 532
  SuperMulti drives, 532
types, 532
  writeable/nonerasable (R), 532
DVI connectors, 286
DXDiag utility, 661, 672
dye-sublimation printing, 460
dynamic disks, 583
Dynamic Host Configuration Protocol. See DHCP
dynamic link library (DLL), 715
dynamic RAM (DRAM), 180-181

E

ECC memory (error-correcting code), 179, 187
ECHO command, 623
Ecova Plug Load Solutions website, 133
efficiency (power supplies), 133
EFI (Extensible Firmware Interface), 659
EFS (Encrypted File System), 870, 875
EIA-568B standard, 803
The Elder Geek's Windows Services Guide website, 644
electricity. See also power safety, 932-934
AC outlets, 932
blackouts, 933
brownouts, 933
dirty power, 933
fires, 934
power surges, 933
sags, 933
surge suppressors, 933
testing tools, 16
electrophotographic (EP) process, 453
electrostatic discharge (ESD), preventing, 930-932
Elston Systems website, 113
e-mail
mobile devices, configuring
BlackBerry, 423
IMAP, 423
POP3, 421-423
troubleshooting, 423
web-based, 421
protocols, 797-798
spam, 915
emulator requirements virtualization, 693
Enable Boot Logging option, 728
Enable command, 737
Enable low-resolution video option, 728
Enable VGA Mode, 728
enabling
Airplane Mode (smartphones), 412
ATA/SATA RAID arrays, 529
auditing, 874
Bluetooth
Android devices, 418
iOS devices, 420
Extended Desktop
Windows 7, 376-377
Windows XP/Vista, 375-376
GPS (mobile devices), 411
Internet scripts, 843
USB ports in BIOS, 215
Encrypted File System (EFS), 870, 875
encryption, 875-876
Enterprise edition
Windows 7, 609
Windows Vista, 608
environmental controls, 936-938
EP (electrophotographic) process, 451
cleaning, 454
conditioning, 453
developing, 453
exposing, 453
fusing, 454
prerequisites, 452
processing, 453
transferring, 453
ERASE command, 623
error codes (Device Manager), 733-734
error-correcting code (ECC) memory, 179, 187
error messages (POST), 112
eSATA hard drives, 519
ESD (electrostatic discharge), preventing, 16, 930-932
eSupport website, 115
Ethernet
cable color coding diagram, 803
networks
bubs, 814
switches, 814
wired, 810
wireless, 811-812
ports, configuring, 102
printers, 469-470
European power standard voltage, 134
evaluating onboard components
general system information, 324
processor information, 326
event logging, 897-898
Event Viewer, 718, 724
exceptions, configuring, 902-903
exFAT file systems, 658
Exit command, 737
Expand command, 738
expansion options
laptops, 346
CardBus cards, 348
ExpressCards, 350-352
flash memory cards, 352
memory, 352
PC Cards, 346-350
USB, 350-352
ZV cards, 349
motherboards, 31, 36-42
AGP, 38-39
AMR, 41-42
CNR, 41-42
comparison, 40
PCI, 36
PCI-E, 39
PCI-X, 37
Explorer (Windows), 661-662
Common Tasks view, 664-665
display options, 666-667
drives, viewing, 664
Favorite Links view, 665
libraries, 668
My Computer window, 669
starting, 662
Windows 7 view, 665
exposing (laser printers EP process), 453
ExpressCards, 350-351
CardBus cards, compared, 350
failures, 13
inserting, 350
media remote controls, 352
performance, 350
removable adapters, 350
removing, 351
types, 350
Extended Desktop, enabling
Windows 7, 376-377
Windows XP/Vista, 375-376
Extended Graphics Array (XGA), 370
extended partitions, 582, 651-653
Extensible Firmware Interface (EFI), 659
external drives
docks, 550
enclosures, 550
eSATA, 519
floppy, 540
interfaces, 502
external modems, 779
extra large icons (Windows Explorer), 667
eyebrow tweezers, 15

F

faded prints, troubleshooting, 485-486
fans
case, 163-164
connectors, 44
laptops, removing, 366
power supplies, troubleshooting, 145, 149

FAST (Files and Settings Transfer) Wizard, 590
Fast SCSI, 225
Fast-Wide SCSI, 225
FAT16 file systems, 587
FAT32 file systems, 587, 657
  converting to NTFS, 912
  NTFS, compared, 658
FAT64 file systems, 658
fatal errors, 110
Favorite Links View (Windows Explorer), 665
fiber-optic cabling, 805
fiber-optic Internet services, 790
file systems, 586-588
  32-bit versus 64-bit, 620
  converting, 660
  defined, 657
  determining, 659
  FAT32, 657
    converting to NTFS, 912
    NTFS, compared, 658
  FAT64, 658
  NTFS, 658-660
security, 870
Windows Vista, 620
Windows 7, 620
Window XP, 620

File Transfer Protocol (FTP), 794
files
  boot.ini, re-creating, 713
  copy utilities, 753
  decrypting, 875
displaying in Windows Explorer, 666-667
encrypting, 875
erasing from CDs/DVDs, 534
moving/copying permissions, 896
not opening, 717
NTDETECT.COM, 712
NTLDR, 712
Ntoskrnl.exe, reinstalling, 713
recording to CDs/DVDs
  third-party programs, 536-537
  Windows Vista/7, 535-536
  Windows XP, 533-534
sharing, 830-834
  access, 836
  configuring, 829
  drive mapping, 840-841
  FQDNs, 840
  identification, 836
  offline, 839
  simple file sharing, 831
  UNC, 838-839
  user/group permissions, 832-834
Files and Settings Transfer (FAST) Wizard, 590
FileZilla, 794
filmstrip view (Windows Explorer), 667
filtering MAC addresses, 846, 887-890
fire protection, 934
firewalls, 777
  network access point security, 891
  software, 873
    configuring, 900-901
    troubleshooting, 903-904
FireWire, 218-220
  400, 218
  800, 218
cables, 218
cards, installing, 220
compatible devices, 219
configuring, 102
printers, 470
troubleshooting, 220-221
versions, 218
firmware, 11
first responses, 938
printers, upgrading, 469
updates (Windows), 760
five-wire resistive technology, 261
Fixboot command, 718, 738-739
Fixmbr command, 718, 738-739
Flash BIOS updates, 115-117
flash memory, 520
cards
  CompactFlash, 521
  laptops, 522
  microSD, 522
  microSDHC, 522
  miniSD, 522
  miniSDHC, 522
  MultiMedia, 521
  readers, 523-524
  Secure Digital, 522
  SmartMedia, 521
types, 520-523
  xD-Picture Cards, 523
SSDs, 525-526
USB drives, 524
Flash recovery jumpers, 117
FlexATX motherboards, 32
flicker-free refresh rates, 296
flickers (displays), troubleshooting, 300-301, 383
floppy drives, 538
  BIOS settings, configuring, 94, 97
capacities, 538
cleaning, 540
defined, 538
external, 540
hardware configuration, 539-540
maintenance, 540-541
Fn key (laptops), 374-375
folders
  control panel options, 679
displaying in Windows Explorer, 666-667
  moving/copying permissions, 896
  sharing, 830-834
    access, 836
    drive mapping, 840-841
    FQDNs, 840
    identification, 836
    offline, 839
    simple file sharing, 831
    UNC, 838-839
    user/group permissions, 832-834
Format command, 629-632, 738
form factors (motherboards), 31-32
forwarding ports, 845
four-wire resistive technology, 261
FQDNs (Fully Qualified Domain Names), 840
front panel cable failures, 12
front panel connectors, 46
front view (desktops), 5
FTP (File Transfer Protocol), 794
full-duplex mode (networks), 817
Fully Qualified Domain Names (FQDNs), 840
function keys (laptops), 374-375
fuser assemblies (laser printers), 450
fusing (laser printers EP process), 454
FXO ports, 814
G

G-Sensor calibration, 409
gadgets (Windows), 611
gaming systems, configuring, 319-320
garbled characters (printers), troubleshooting, 488
gateways
   - router alternatives, 791
   - TCP/IP, configuring, 826
general packet radio service (GPRS), 412
generic hubs (USB), 214
geotracking, 412
ghost cursors, troubleshooting, 384
ghost images, troubleshooting, 486
Gibson Research Corporation
   - Perfect Passwords, 884
   - SecurAble, 326
Global Positioning System (GPS), 411
Global System for Mobile
   Communications (GSM), 412-413
global unicast addresses, 828
GoldMemory, 196
Google
   - Open Handset Alliance, 404
   - Play, 408
GPRS (general packet radio service), 412
GPS (Global Positioning System), 411
GPUs (graphics processing units), 275
graphical user interfaces (GUIs), 714
graphics
   - AGP slots, 38-39
   - cards. See video, cards
   - color fringes, troubleshooting, 301
   - design configurations, 314-315
   - primary VGA BIOS, configuring, 93
   - processing units (GPUs), 275
   - quality, troubleshooting, 301
   - sizes, 301
   - Windows requirements, 567
grayware, 915
GSM (Global System for Mobile
   Communications), 412-413
guest accounts, 893
GUIs (graphical user interfaces), 714
gyroscopes, 409

H

half-duplex mode (networks), 817
hard drives, 512
   - 3TB, booting, 659
   - arrays, creating, 653
   - configuring. See Disk Management
data recovery software, 552
defragmenting, 755
diagnostic programs, 551
dynamic conversions, 652
error checking, 754-755
eSATA, 519
external, 519
initializing, 651
internal, installation, 513-519
laptops, replacing, 358-359
mounting, 655-656
overview, 512
partitions, 580
   - active, 652
   - creating, 652, 655
   - creating during Windows Vista/7
      installation, 584-586
   - creating during Windows XP installation, 583-584
dynamic/basic disks, 583
hard drives

extended, 582, 651-653
formatting, 651-652
primary, 581-582, 651
PATA, 517-519
  BIOS configuration, 519
cables, 517
motherboard connection, 518
power connectors, 517
performance, 512-513
restoring
  external drive docks, 550
  external drive enclosures, 550
  Windows-based tools, 551
SATA, 515-517
  BIOS configuration, 516
cables, 515
host adapters, 517
motherboard connection, 516
status, viewing, 655
troubleshooting
  boot failures, 547
  drive-recognition problems, 548
  loud noises, 546
  operating system not found, 548
  RAID, 549
  read/write failures, 543
  slow performance, 543-545
as virtual memory, 178
hard resets (mobile devices), 437
hardware, 10
  assisted virtualization, 326
  floppy drives, configuring, 539-540
  ISDN connections, 785
  laptops, replacing, 354
    batteries, 355-356
    hard drives, 358-359
    inverters, 373
  keyboards, 356-357
  memory, 360-361
  optical drives, 362
  processors, 368
  screens, 365-366
  speakers, 358
touchpads, 357-358
  wireless cards, 362-365
mobile devices, 398-404
  ARM processors, 398
  batteries, 399
  Micro-USB ports, 399
  multitouch touch screens, 398-399
  tablets versus laptops, 399-400
monitor, configuring, 92, 105
network interface card resources, 816
profiles, 681
  Windows requirements, 566-569
    compatibility, verifying, 568-569
    minimum, 567, 606-607
    Windows 7, 567
Hardware Monitor BIOS dialog box, 106
hazards (power supplies), 154
HDMI (High-Definition Multimedia Interface), 286-288
header cables, 213
heat sinks, 164
  laptops, removing, 367
  processors, 75
heating elements (thermal printers), cleaning, 482
Help command, 738
hemostat clamps, 15
hex codes (POST), 112-113
hex drivers, 15
Hi-Speed USB, 209
High-Definition Multimedia Interface (HDMI), 286-288
Hitachi Feature Tool, 547
Home Basic edition (Windows Vista), 607
Home edition (Windows XP), 607
HomeGroup feature (Windows Control Panel), 690
Home Premium edition (Windows 7/Vista), 608
home server systems, configuring, 323-324
home theater systems, configuring, 321-322
host/guest virtualization, 692
host signal processing (HSP), 779
hotfixes, 595
hot-swappable drive interfaces, 511
HP
  LaserJet error codes, 492-493
  MSDS documents website, 937
HSP (host signal processing), 779
HT technology (hyperthreading), 70
HTC Sync, 425
HTML (Hypertext Markup Language), 793-794
HTTP (Hypertext Transfer Protocol), 792
HTTPS (Hypertext Transfer Protocol Secure), 792
hubs, 775, 814
humidity (environment), 936
hybrid drives, 513
Hypertext Markup Language (HTML), 793-794
Hypertext Transfer Protocol (HTTP), 792
Hypertext Transfer Protocol Secure (HTTPS), 792
hyperthreading (HT technology), 70
hypervisor-based virtualization, 692
IBM beep codes website, 111
icons
  size, 300
  Wi-Fi, 415
  Windows Explorer, 666
identifying shared resources, 836
IEEE 802.11, 811-812
IEEE 1394, 218-220
cables, 218
cards, installing, 220
compatible devices, 219
configuring, 102
printers, 470
troubleshooting, 220-221
versions, 218
IEEE 1394a, 218
IEEE 1394b, 218
IEEE-1394 iLINK, 218
image backups, creating
  Vista, 749
  XP, 747
image deployment Windows installation, 577-579
imaging drums (laser printers), 450
IMAP (Internet Message Access Protocol), 423, 798
impact printers
  defined, 461
dot-matrix printers, 462-463
maintenance, 483
paper, 464
printer ribbons, 463
troubleshooting
  faded prints, 486
  streaks/smudges, 485
improper shutdowns, 714
incident reporting, 879
incident responses
  chain of custody, 939
  documentation, 938
  first responses, 938
infrared (networks), 813
Infrared Data Association (IrDA), 813
infrared printers, 469-471
inheritance (permissions), 895
initializing disks, 651
ink
  jet cartridges, 457-458
    clogged/damaged, 457
    ink dot creation methods, 458
    printheads, 457
    replacing, 480
toner cartridges, 450-451, 456
  installing, 451
  recycled, 451
  replacing, 478
toner not fused to paper, troubleshooting, 486
inkjet printers
  calibrating, 458, 480
  components, 456
  ink cartridges, 457-458
    clogged/damaged, 457
    ink dot creation methods, 458
    printheads, 457
  maintenance, 480
    calibration, 480
    ink cartridges, replacing, 480
    nozzle check routines, 481
overview, 455
troubleshooting
  faded prints, 486
  streaks/smudges, 484
turning on/off, 457
installing
digital cameras, 328-329
displays, 289-291
ExpressCards, 350
file/printer sharing, 829
hard drives, 513-519
IEEE 1394 cards, 220
laser printer maintenance kits, 478
memory
  modules, 189-191
  printers, 467-468
microphones, 333
MIDI enabled devices, 332
modems, 781-783
motherboards, 50-52
networks
  client software, 835
  interface cards, 815-816
  printers, 835-836
parallel ports, 247
PATA hard disk drives, 517-519
  BIOS configuration, 519
  cables, 517
  motherboard connection, 518
  power connectors, 517
PC Cards, 349
power supplies, 140
printers, 465
  Add Printer Wizard, 465-466
troubleshooting, 492
  vendor-supplied drivers, 467
SATA drives, 515-517
  BIOS configuration, 516
cables, 515
  motherboard connection, 516
SCSI cards, 228
service packs, 593-595
sound cards, 331-332
toner cartridges, 451
touch tablets, 253, 262
USB ports, 213-214
utilities (Add/Remove Programs), 686
video cards, 335-336
  BIOS configuration, 282
drivers, 282-284
  physical, 282-284
webcams, 327
Windows
  boot methods, 570
deed, 571-573
  file systems, 586-588
  hard drive partitions, creating. See hard drives, partitions
  hardware requirements, 566-569
  image deployment, 577-579
  multiboot, 573
  remote network, 577
  repair, 574-575
  third-party drivers, 588
time/date/language/region settings, 579
types, 570
  unattended, 576
  upgrade installations, 571
  without DVD drive, 570
  workgroups versus domain setup, 589
WinRE, 742
integrated I/O ports (motherboards), 33-35
integrated ports, BIOS, configuring, 100-103
  audio, 102
  Ethernet, 102
  IEEE-1394, 102
  I/O devices, 103
  PATA/IDE, 100
  SATA, 100
  USB host adapters, 102
Integrated Services Digital Network (ISDN), 784-785
Intel processors, 58
  AMD, comparison, 58
  Identification Utility website, 326
  LGA, 59
  LGA 775, 61
  LGA 1155, 63-64
  LGA 1156, 62-63
  LGA 1366, 62
  website, 70
interacting with customers, 939-941
interfaces
drive, 502
  external, 502
  hot-swappable, 511
  internal, 502
  overview, 503
  PATA/SATA, 504-510
  SCSI, 510
printers, 469-471
touch screen monitors, 261
internal commands (Windows), 622-623
internal drive interfaces, 502
Internet
Appliances, 777
broadband, 786
cable, 788-789
DSL, 786-787
satellite, 789-790
cellular connections, 790
dial-up connections, 778
creating, 783
modem installation, 781-783
modem standards, 781
modem types, 779
modems, 778
requirements, 784
service providers, 783
downstream/upstream, 786
fiber-optic connections, 790
ISDN connections
configuring, 785
hardware, 785
overview, 784
LAN connections, 791
Message Access Protocol (IMAP), 423, 798
pass-through, 416
service providers (ISPs), 783
web browsers
configuring, 841-842
Internet connections, configuring, 842-843
script settings, enabling/disabling, 843
security, 844-845
web pages not displaying, 854
WiMAX, 791
inverters (laptop displays), 372-373
I/O
bar code readers, 259-260
BIOS settings, configuring, 103
keyboards, 258-259
KVM switches, 263
mice, 251
hardware resources, 252
maintenance, 257
troubleshooting, 253-254
motherboard ports, 31-35
touch screen monitors, 260-261
installing, 262
interfacing, 261
surface treatments, 261
troubleshooting, 262-263
I/O ports
addresses, 235
audio
analog, 249-250
digital, 250
IEEE 1394, 218
cards, installing, 220
compatible devices, 219
ports and cables, 218
troubleshooting, 220-221
versions, 218
legacy, 208
mice, troubleshooting, 256
overview, 208
parallel
adding, 247
cable types, 244-245
configuring, 243-246
connectors, 240-241
defined, 240
ECP or EPP/ECP configurations, 245
loopback plugs, 248
LPT1/LPT2/LTP3 configurations, 245
PCI/PCI Express configurations, 245
pinout, 241-242
serial ports, compared, 232
testing, 248
troubleshooting, 247
PS/2, 249
SCSI
cables, 225-227
cards, installing, 228
defined, 221
device IDs, configuring, 223-224
multiple device support, 222, 227-229
Narrow host adapters, 222
signaling types, 227
standards, 225
termination methods, 229
troubleshooting, 230-231
serial, 231
adding, 238
cables, 235
configuring, 236
devices, 231
loopback plugs, 248
parallel ports, compared, 232
pinouts, 233-234
software, configuring, 236-237
troubleshooting, 238-239
types, 232
USB
1.1/2.0, 210
2.0 devices not operating at maximum speed, 217
3.0, 211
adding, 213-214
black exclamation point on yellow field error, 217
cable length, 212
defined, 209
device drivers not installed, 216
enabling in BIOS, 215
generic hubs, 214
improper designs, 215
logos, 212
power problems, 216-217
root hubs, 212
speeds, 211
standards, 209
too many connected devices, 217
iOS, 406
accelerometers, 409
advanced wireless settings, 418
Airplane Mode, 413
antivirus software, 435
application sources, 408
applications, turning off, 436
Bluetooth headsets, configuring, 420
charging devices, 427
GPS, enabling/disabling, 411
gyrosopes, 409
hard resets, 437
jailbreaking, 408
passcodes, setting, 431
POP3 email, configuring, 422-423
remote wipe programs, 432
screen calibration, 411
screen orientation, locking, 408
soft resets, 436
synchronizing to PCs, 427
updating, 434
versions, 406
Wi-Fi, configuring, 415
IP addressing, 824-826
classes, 826
listing of, 824
subnet masks, 825
Duplicate IP Address error message, 
851
octets, 825
static versus server-assigned, 819-820
static versus DHCP, 885
subnet masks, 824
iPad2
ARM processor, 398
battery, 399
Bluetooth, enabling, 420
charging, 427
multitouch touch screen, 398
POP3 email, configuring, 422-423
synchronizing to PCs, 427
iPads
Airplane Mode, 413
passcodes, setting, 431
screen orientation, locking, 408
Wi-Fi, configuring, 415
IPconfig command, 849
IPv6 addressing, 827-829
IrDA (Infrared Data Association), 813
IRQ port addresses, 235
ISDN (Integrated Services Digital Network), 784
configuring, 785
hardware, 785
overview, 784
ISPs (Internet Service Providers), 783
ITX motherboards, 32

jailbreaking mobile devices, 408
jeweler's screwdrivers, 15
jumper blocks, 44
jumpers, 44

K
Kernel memory dumps, 709
keyboards, 258
104-key layout, 258
BIOS settings, configuring, 93
keytops, removing, 259
laptops
function keys, 374-375
replacing, 356-357
troubleshooting, 385
maintenance, 259
troubleshooting, 258
KVM (keyboard-video-mouse), 263

L
land grid array. See LGA processors
languages (Windows installation), 579
LANs (local area networks), 769, 773
defined, 769
Internet connections, 791
Laplink PC Mover, 571
laptops
batteries
replacing, 355-356
troubleshooting, 384
Bluetooth connectivity, 386
components, 7
desktops, compared, 345
disassembling, 353
displays
backlight components, 372
failures, 13
inverters, 372-373
LCDs, 369
LEDs, 369
nonnative resolutions, 371
OLEDs, 369
plasma, 370
quality factors, 370-371
resolutions, 370
screens, replacing, 365-366
troubleshooting, 382-384
Wi-Fi antennas, 373
windowboxing, 372
docking stations, 380-381
dual displays, 375
cloning to secondary display, 377-378
Extended Desktop, enabling in Windows 7, 376-377
Extended Desktop, enabling in Windows XP/Vista, 375-376
projectors, connecting, 379
expansion options, 346
ExpressCards, 350-352
flash memory cards, 352
memory, 352
PC Cards, 346-350
USB Implementers Forum, 350
USB ports, 352
firmware, 11
function keys, 374-375
hard drives, 358-359
hardware, 10
hardware, replacing, 354
batteries, 355-356
hard drives, 358-359
inverters, 373
keyboards, 356-357
memory, 360-361
optical drives, 362
processors, 368
screens, 365-366
speakers, 358
touchpads, 357-358
wireless cards, 362-365
keyboards
function keys, 374-375
replacing, 356-357
troubleshooting, 385
Laptop Repair Help website, 353
memory
expansion slots, 352
upgrading, 360-361
optical drives, replacing, 362
points of failure, 13
power, troubleshooting, 384-385
processors, replacing, 366-368
security, 381
software, 10-11
speakers, 358
tables, 399-400
touchpads, 357-358
troubleshooting
Bluetooth connectivity, 386
displays, 382-384
keyboards, 385
power problems, 384-385
Wi-Fi connectivity, 386
wireless cards, removing, 362-365
large icons view (Windows Explorer), 667
laser printers
battery backup units, 160
calibrating, 479
cleaning, 479-480
color versus monochrome, 454
components, 450
defined, 450
EP process, 451
cleaning, 454
conditioning, 453
lithium-ion polymer batteries, 399
Live File System (UDF), 535
local area networks. See LANs
local security policies, 874
locking
  computers, 878-879
  mobile devices (passcodes), 429, 432
logging events, 897-898
logical drives, 651, 655
Logon command, 738
logos (USB), 212
LoJack for Laptops website, 109
loopback plugs, 16-17
lost mobile device protection, 432
loud noises, troubleshooting
  drives, 546
  power supplies, 142
low printer memory errors, troubleshooting, 490-491
LPT. See parallel ports

M

MAC addresses, filtering, 846, 887-890
magnetic storage devices, 178
magnifiers, 15
maintenance
  activities, monitoring, 914
  cleaning
    desktops, 148
    floppy drives, 540
    heating elements (thermal printers), 482
    keyboards, 259
    laser printers, 454, 479-480
    mobile device screens, 411
  displays, 302-303
  floppy drives, 540-541
keyboards, 259
memory, 196
mice/pointing devices, 257
mobile device screens, 411
printers, 18
  impact, 483
  inkjet, 480-481
  laser, 478-480
  thermal, 482-483
Windows, 744
  backed up files, restoring, 746
  Backup and Restore Center (7), 750-753
  Backup and Restore Center (Vista), 748-750
  backups, creating, 745-747
  disk defragmentation, 755
  disk drive errors, checking, 754-755
  firmware updates, 760
  image backups, creating, 747-749
  images, creating, 752
  System Restore, 756-760

malware
  protection, 872-873, 913
  recovery, 916
  removing, 916-917
  rootkits, 915
  spyware, 915
  Trojan horses, 915
  types, 914-915
  user education, 917-918
  viruses, 914
  Windows Defender, 916
  worms, 914

managing
  cables, 935
  Disk Management. See Disk Management
  power, 104
  printers, 648
  tasks (Windows), 648-649
MANs (metropolitan area networks), 773
mantraps, 882
Map command, 738
Map Network Drive dialog, 841
mapping drives, 840-841
Material Safety Data Sheet (MSDS), 936-938
MaximumPC website, 193
MD command, 623, 629
MDM (Mobile Device Management) suites, 435
Media Center Edition (XP MCE) (Windows XP), 607
medium icons view (Windows Explorer), 667
memory
  adding, 178
  banks, 185
  BIOS settings, 92, 106
  cache, 70-71
  chips, 179
  CMOS, 88-89
  DDR comparisons website, 185
dual-channel, 180
  ECC, 179, 187
  flash, 520
    cards, 352, 520-524
    SSDs, 525-526, 546
    USB drives, 524
  hard disk substitute, 178
  installing, 189-191
  Kernel memory dumps, 709
laptops, 352
   expansion slots, 352
   upgrading, 360-361
magnetic storage, compared, 178
modules
   comparison, 183-184
   DDR SDRAM, 181
   DDR2 SDRAM, 182
   DDR3 SDRAM, 182
   desktop comparisons, 185
   DRAM, 180
   loose/missing, troubleshooting, 56
   number of, 180
   per bank requirements, 179
   point of failure, 12
   Rambus Direct RAM (RDRAM), 183
   SDRAM, 181
   SRAM, 181
   types, 178
   widths, 185
motherboard slots, 31, 35
parity checking, 186-187
preventative maintenance, 196
printers
   errors, troubleshooting, 490-491
   installing, 467-468
   size, verifying, 473
RAM versus ROM, 177
registered, 188
reliability, 185, 188
single-sided/double-sided, 188
sizes, 179
smartphone cards, replacing, 400-403
speed, 179
testing programs, 196
triple-channel, 180
troubleshooting
   cache RAM, 195
   compatibility, 192
   overclocking, 192-193
   parity errors, 194
   sizing errors, 194
   speed mismatches, 193-194
types, 177
unbuffered, 188
virtual, 178, 681-682
Windows
   Memory Diagnostic Tool, 744
   requirements, 567
Memory Stick PRO Duo cards, 522
memory sticks, 521
MemTest86, 196
mesh topologies, 775
metropolitan area network (MANs), 773
mice, 251
   hardware resources, 252
   maintenance, 257
   troubleshooting, 253-256
      double-clicking icons, 256
      jerky pointer movement, 256
      pointer doesn't move, 254-256
microATX motherboards, 32
microphones, 333
   installing, 333
   testing, 334-335
   volume, 333
microSD cards, 522
microSDHC cards, 522
Microsoft
   Help and Support website, 18
   ImageX utility, 578
   Management Console (MMC), 640-641, 661
support website, 53
System Configuration Utility
(MSConfig), 661, 718-721
TechNet website, 18
Micro-USB ports, 399
MIDI enabled devices, installing, 332
migrating data, 589
security, 877
USMT, 590-591
Windows Easy Transfer, 590
mini-ATX motherboards, 32
Mini-DIN ports, 249
Mini-ITX motherboards, 32
mini-PCI card
modems, 779
types, 363
mini-PCIe cards, 364, 779
miniSD cards, 522
miniSDHC cards, 522
mirrored arrays, 653
Missing Operating System errors, 713
Mkdir command, 738
MLC (multilevel cell) SSDs, 526
MMC (Microsoft Management Console), 640-641, 661
MMC (MultiMedia) cards, 521
Mobile Device Management (MDM) suites, 435
mobile devices
applications
sources, 408
turning off, 435-436
displays, adjusting, 408-411
email configurations
BlackBerry, 423
IMAP, 423
POP3, 421-423
troubleshooting, 423
web-based, 421
geotracking, 412
GPS, 411
hardware, 398-399, 403-404
ARM processors, 398
batteries, 399
Micro-USB ports, 399
multitouch touch screens, 398-399
tables versus laptops, 399-400
network connectivity, 424
Bluetooth, 418-421
GSM, 412-413
Wi-Fi, 414-418
operating systems, 404
Android, 404-405
application sources, 408
displays, adjusting, 408-411
g eotracking, 412
GPS, 411
iOS, 406
jailbreaking, 408
rooting, 408
updating, 433
resetting
hard resets, 437
soft resets, 436
screens
calibration, 409-411
cleaning/protecting, 411
orientation, locking, 408-409
security
antivirus software, 434
backups, 432-433
compromised/damaged devices, 432-435
data protection, 429
hard resets, 437
lost/stolen, 432
operating system updates, 433
passcode locking, 429, 432
soft resets, 436
turning off applications, 435-436
smartphones
batteries, replacing, 401
memory cards, replacing, 400-403
synchronization, 429
Android devices to PCs, 424-427
BlackBerry devices to PCs, 428
iOS devices to PCs, 427
Windows CE/Mobile devices to PCs, 428
troubleshooting
hard resets, 437
screen calibration problems, 411
soft resets, 436
Wi-Fi, 416, 418

Mobility Center, 379
models (networks), 770-772
modems
BIOS settings, 92
cables, 235
defined, 776
DSL, 787
installing, 781-783
serial port similarities, 778
standards, 781
types, 779
modular power connectors, 137
modules (memory)
chips, 179
comparison, 183-184
DDR SDRAM, 181
DDR2 SDRAM, 182
DDR3 SDRAM, 182
desktop comparisons, 185
DRAM, 180
installing, 189-191
loose/missing, troubleshooting, 56
number available, 180
per bank requirements, 179
point of failure, 12
Rambus Direct RAM (RDRAM), 183
SDRAM, 181
sizes, 179
speed, 179
SRAM, 181
types, 178
widths, 185
monitoring maintenance activities, 914
monitors. See displays
monochrome laser printers, 454
More command, 738
motherboards
audio connectors, 45
chipsets, 42-44
CMOS batteries, 88-89
components, 30
cooling, 161-162
defined, 30
extension slots, 31, 36-42
AGP, 38-39
AMR, 41-42
CNR, 41-42
comparison, 40
PCI, 36
PCI-E, 39
PCI-X, 37
fan connectors, 44
form factors, 31-32
ATX, 31
BTX, 32
ITX, 32
front panel connectors, 46
header cables, 213
installing
  preparations, 50
  step-by-step instructions, 51-52
integrated I/O ports, 31-35
integrated modems, 779
jumpers, 44
make and model, determining, 115
memory slots, 31, 35
mounting holes, 48
PATA hard drives, connecting, 518
point of failure, 12
power connectors, 135
removing, 48-50
SATA hard disk drives, connecting, 516
troubleshooting
  BIOS time and settings resets, 53
  blank screen on bootup, 54
  continuous reboots, 53
  POST code beeps at startup, 54
  smoke/burning smells, 55
  system lockups, 54
  system not starting, 55-58
  unexpected shutdowns, 52
mounting drives, 655-656
mounting holes (motherboards), 48
mouse pointers, troubleshooting, 300
Mouse properties dialog box, 690
moving files/folders, 896
MSConfig (Microsoft System Configuration Utility), 661, 718-721
MSDS (Material Safety Data Sheet), 936-938
MSInfo32 utility, 661, 670
multiboot
  configurations, 711
  Windows install, 573
multicasting, 828
multicore processors, 70
multifactor authentication, 872
multifunction network devices, 845
  DMZ, 846
  NAT, 845
  port forwarding, 845-846
multilevel cell (MLC) SSDs, 526
multimedia devices
  digital cameras, 328-329
  microphones, 333-335
  MIDI enabled devices, 332
  sound cards
    audio jacks/cable color standards, 330
    configuring, 332
    defined, 329
    installing, 331-332
  TV tuner cards, configuring, 336
  video capture cards, 335-336
  webcams, 327
MultiMedia (MMC) cards, 521
multimeters, 16
  AC to DC conversions, testing, 152
  AC voltage, 151
  amperage, 152
  cables, 152
  DC voltage, 151
  defined, 149
  readout styles, 149
  resistance, 152
  tests
    leads, 149
    modes, 150
    performing, 150
  voltage levels, 152
multi-mode fiber-optic cabling, 805
multitouch touch screens, 398-399
multivoltage power supplies, 134
My Computer window (Windows Explorer), 669

N

names
domain, 796
FQDNs, 840
UNC, 838-839
Nano-ITX motherboards, 32
Narrow SCSI
device ID settings, 224
external connectors, 226
host adapters, 222
NAS (network attached storage), 776
NAT (network address translation), 845
NBTSTAT command, 850
needle-nose pliers, 15
negative pressure, 148
Net command, 847
Net Use command, 738
netstat command, 849
network address translation (NAT), 845
network attached storage (NAS), 776
Network dialog, 836
networks, 770
battery backup units support, 158
BIOS settings, 92
cabling
coaxial, 805-806
connectors, 806-807
fiber-optic, 805
municipality rules/regulations, 808
parallel (LPT) crossover, 801
plenum, 806
PVC, 806
serial (RS-232) null modem, 801
STP, 801-803
types, 801
UTP, 801-803
clients, configuring, 834
printers, 835-836
software, installing, 835
client/server, 770-772
command-line tools
IPconfig, 849
NBTSTAT, 850
Net, 847
netstat, 849
NSLookup, 849
Ping, 847-848
Tracert, 848
devices, 775
bridges, 776
firewalls, 777
hubs, 775
Internet appliances, 777
modems, 776
NAS, 776
repeaters, 776
routers, 777
switches, 775
VoIP phones, 777
WAPs, 776
HomeGroup feature, 690
hubs, 814
interface cards
configuring, 816-819
installing, 815-816
IPv6 addresses, 827-829
LANs, 773
MANs, 773
mobile device connectivity, 424
  Bluetooth, 418-421
  GSM, 412-413
  Wi-Fi, 414-418

multifunction network devices, 845
  DMZ, 846
  MAC address filtering, 846
  NAT, 845
  port forwarding, 845

network interface cards
  configuring, 816-819
  installing, 815-816

PANs, 774
peer-to-peer, 772

printers
  installing, 835-836
  sharing, 471-472

security
  wired, 891-892
  wireless, 883-891

shared resources, 829
  accessing, 836
  administrative shares, 834
  client configuration, 834-836
  drive mapping, 840-841
  file/printer sharing, installing, 829
  folders/drives, 830-834
  FQDNs, 840
  identifying, 836
  offline, 839
  printers, 834
  troubleshooting, 853
  UNC, 838-839

SOHO. See SOHO

switches, 814

TCP/IP, configuring, 819-820
  advanced settings, 822
  alternate configurations, 821
  DHCP servers, 821
  DNS, 827
  gateways, 826
  IP addressing, 824-826
  manually, 822
  static versus server-assigned IP addressing, 819-820
  WINS, 826

tools, 17, 808-809
topologies, 774-775

troubleshooting
  Duplicate Computer Names/Duplicate IP Address errors, 851
  entire network failure, 853
  interference, 852
  low radio frequency signals, 852
  performance, 851-852
  power management, 852
  printing, 853-854
  shared resources, 853
  web pages, displaying, 854

WANs, 773

web browsers
  configuring, 841-842
  Internet connections, configuring, 842-843
  script settings, enabling/disabling, 843
  security, 844-845

wired, 810
wireless
  Bluetooth, 812
  cellular, 813
  Ethernet, 811-812
  infrared, 813
  VoIP, 813-814

New Technology File System. See NTFS

no display, troubleshooting, 383
non-autoranging digital meters, 149
nonnative screen resolutions, 371
nonvolatile memory, 88-89
North American power standard voltage, 134
northbridge chips, 43, 161-162
notebooks. See laptops
Notepad, 661-662
nozzle check routines (inkjet printers), 481
NSLookup command, 849
NTBackup utility, 745-747
NTDETECT.COM files, restoring, 712
NTFS (New Technology File System), 587, 658-660, 870
  FAT32, compared, 658
  FAT32 conversions, 912
NTLDR files, restoring, 712
Ntoskrnl.exe file, reinstalling, 713
null-modem cables, 235
number conversions, 825

Occupational Safety & Health Administration (OSHA), 934
octets (IP addresses), 825
odd parity, 186
Offline Files dialog, 839
offline files/folders, 839
Ohms (resistance), testing, 152
OLED (organic light emitting diodes) displays, 281, 369
onboard components, evaluating
  general system information, 324
  processor information, 326
Open Handset Alliance, 404
open-source software. See Android

operating systems
access control, 892
  administrator accounts, 893
  auditing, 897-898
  components, 896
  event logging, 897-898
  groups, 894
  guest accounts, 893
  moving/copying files/folders, 896
  permissions, 895-896
  principle of least privilege, 895
  restricted spaces, 896
  UAC, 893-894
  user accounts, 893
mobile devices, 404
  Android, 404-405
  application sources, 408
  displays, adjusting, 408-411
  geotracking, 412
  GPS, 411
  iOS, 406
  jailbreaking, 408
  rooting, 408
  updating, 433
not found error, troubleshooting, 548

optical drives
Blu-ray media types, 532
  comparing, 531-532
DVD media types, 532
  erasing data, 534
  laptops, replacing, 362
  recording data
    third-party programs, 536-537
    Windows Vista/7, 535-536
    Windows XP, 533-534
speeds, 533
types, 531
organic light emitting diodes displays (OLEDs), 281, 369
OSHA (Occupational Safety & Health Administration), 934
overclocking, 72-73, 192-193
overheating, 12, 144
   airflow, 146-147
dirt/dust, 148
   fan failure, 145
   overloading, 145
overloaded power supplies, troubleshooting, 141, 145
overvoltages, 156

P
pairing Bluetooth
   Android devices, 418-419
   Bluetooth-enabled devices, 419
   iOS devices, 420
   troubleshooting, 420-421
PANs (personal area networks), 774
paper (printers)
   counts, resetting, 479
creased, troubleshooting, 487
   impact, 464, 483
   jams, 487-488
   not feeding, 487
   separation pads (laser printers), 450
   thermal, 460, 482
parallel (LPT) crossover cables, 801
parallel ports
   adding, 247
   BIOS settings, configuring, 93
cables, 244-245, 801
   configuring, 243-246
   connectors, 240-241
defined, 240
ECP or EPP/ECP configurations, 245
loopback plugs, 248
LPT1/LPT2/LTP3 configurations, 245
PCI/PCI Express configurations, 245
   pinout, 241-242
   printers, 469
   serial ports, compared, 232
testing, 248
troubleshooting, 247
parity checking memory, 186-187
parity errors, 194
partitions (hard drives)
   active, creating, 652
   creating, 652-655
      Windows Vista/7, 584-586
      Windows XP, 583-584
dynamic/basic disks, 583
   extended, creating, 582, 651-653
   formatting, 651-652
   primary, 581-582, 651
passcode locking mobile devices, 429, 432
passive heat sinks, 75
passive matrix OLEDs (PMOLEDs), 369
passphrases (WPA), 884
passwords, 878
   authentication, 871
default administrator, changing, 890
   setup, 94
   user/power-on, 94
PATA drives
   BIOS settings, configuring, 97
cabling, 506
   configuring, 100
      BIOS, 508
         jumper block, 507
installing, 517-519
  
  BIOS configuration, 519
cables, 517
  
  motherboard connection, 518
  
  power connectors, 517
settings, 94
standards, 504-505
patch cables, 809
PATH command, 623
paths (Windows)
  
  7, 620
32-bit versus 64-bit, 620
Vista, 620
XP, 620
PC99 system design guide, 330
PC Cards, 346-350
cables, 349
  CardBus support, 348
combo, 349
dongles, 348
failures, 13
inserting, 349
installing, 816
modems, 779, 782
removing, 349
types, 346-347
  
  ZV support, 349
PC Check, 569
PC-Diagnosys, 196
PCI BIOS configurations, 105
PCI Express x16 slots, 274
PCI modems, installing, 781
PCI/PCI Express cards, installing, 815
PCI slots, 36
PCI-X slots, 37
PCIE (PCI Express) slots, 39
PCMCIA (Personal Computer Memory Card International Association) cards, 346
PCs. See computers
peer-to-peer networks, 772
Pen and Input Devices (Windows Control Panel), 689
penlights, 15
performance
  
  ExpressCards, 350
hard drives, 512-513, 543-545
networks, 851-852
SSDs, 546
Windows, 641-642, 716
peripheral power connectors, 137
permissions
  
  inheritance, 895
moving/copying files, 896
propagation, 896
types, 895
user/group, 832-834
personal area networks (PANs), 774
Personal Computer Memory Card International Association (PCMCIA) cards, 346
personal identification number (PIN) authentication, 871
personal physical safety, 934-935
PGA (pin grid array) sockets, 64
phishing, 880
Phoenix BIOS beep codes website, 111
physical security, 881
  
  biometrics, 882-883
data protection, 883
doors, 881-882
pickup rollers (laser printers), 450
Pico-ITX motherboards, 32
picture quality, troubleshooting, 298-299
PIN (personal identification number) authentication, 871
pin grid array (PGA) sockets, 64
Ping command, 847-848
pinouts (serial ports), 233-234
plasma displays, 279, 370
plenum cabling, 806
plug-and-play OS, configuring, 93
PMOLEDs (passive matrix OLEDs), 369
PnP BIOS configurations, 105
PnP/PCI Configuration dialog, 105
point-to-point protocol over Ethernet (PPPoE), 787
pointing devices
  maintenance, 257
  troubleshooting, 253-256
double-clicking icons, 256
jerky pointer movement, 256
pointer does not move, 254-256
points of failure, 12-13
polyvinyl chloride (PVC) cabling, 806
POP (Post Office Protocol), 797
POP3 email
  Android, 421-422
  iOS, 422-423
ports
  audio, 249-250
  BIOS, configuring, 100-103
double-clicking icons, 256
  Ethernet, 102
  IEEE-1394, 102
  I/O devices, 103
  PATA/IDE, 100
  SATA, 100
  USB host adapters, 102
  component video, 289
  composite, 289
  DisplayPort, 288
  DVI, 286
  forwarding, 845
  FXO, 814
  HDMI, 286-288
  IEEE 1394, 218
cables, 218
cards, installing, 220
compatible devices, 219
troubleshooting, 220-221
versions, 218
I/O
  addresses, 235
  overview, 208
IRQ, 235
legacy, 208
mice, 251
  hardware resources, 252
  maintenance, 257
troubleshooting, 253-256
Micro-USB, 399
motherboards, 31-35
parallel. See parallel ports
PS/2, 249
replicators, 381
RGB, 289
SCSI. See SCSI
serial, 231
  adding, 238
  BIOS settings, 93
cables, 235
configuring, 236
device, 231
loopback plugs, 248
modem similarities, 778
parallel ports, compared, 232
pinouts, 233-234
printers, 469
software, configuring, 236-237
troubleshooting, 238-239
types, 232
SVGA, 286
S-video, 289
UDP, 799-800
USB
1.1/2.0, 210
2.0 devices not operating at maximum speed, 217
3.0, 211
adding, 213-214
black exclamation point on yellow field, 217
cable length, 212
defined, 209
device drivers not installed, 216
enabling in BIOS, 215
generic hubs, 214
improper designs, 215
laptops, 352
logos, 212
power problems, 216-217
printers, 469
root hubs, 212
speeds, 211
standards, 209
too many connected devices, 217
VGA, 285
POST (power-on self test), 85
beep codes, 54, 111
cards, 113
error messages, 112
hex codes, 112-113
overview, 110

Post Office Protocol (POP), 797
power
AC
flow problems, 156
loss restart settings, 94
BIOS settings, configuring, 93, 104
conditioners, 160-161
connectors, 135-138
control panel settings, 682
Windows Vista/7, 685-686
Windows XP, 683-684
disconnecting from motherboards, 139
efficiency, 133
every example, 130
installing, 140
laptops, 384-385
mounting screws, removing, 140
multivoltage, 134
networks, troubleshooting, 852
overview, 130
plans, creating, 686
protection, 933
battery backup units, 158-160
power conditioners, 160-161
surge suppressors, 156-157
removing, 139-140
safety, 135
shock/fire hazards, avoiding, 154
split rail, 131
surges, 933
testing, 16, 149-152
AC to DC conversions, 152
AC voltage, 151
acceptable voltage levels, 152
amperage, 152
cables, 152
DC voltage, 151
resistance, 152
troubleshooting
AC power flow problems, 156
dead systems, 143-144
defective, 149-152
fans, 149
loud noises, 142
overheating, 144-148
overload, 141
USB port problems, 216-217
Wake on LAN, 94
wattage ratings, 130-133
labels, 131
replacement, calculating, 132-133
safety certification, 131

power-on self test. See POST

Power Options dialog box, 686
POWERCFG.EXE, 684
PPPoE (point-to-point protocol over Ethernet), 787
pretexting, 880
PRI (Primary Rate Interface), 785
primary partitions, 581-582, 651
Primary Rate Interface (PRI), 785
primary VGA BIOS settings, configuring, 93
principle of least privilege, 895
Print Management utility, 648
print queues
backed up, 489-490
clearing, 490
releasing, 489
printers
battery backup units, 160
configuring, 472-474
preferences, 473
properties sheets, accessing, 472-473
properties versus preferences, 474
saving changes, 475
Control Panel settings, 689
drivers, 464
firmware, upgrading, 469
graphics resolution, 491
impact
defined, 461
dot-matrix print process, 462
dot-matrix printheads, 463
faded prints, 486
maintenance, 483
paper, 464
printer ribbons, 463
streaks/smudges, troubleshooting, 485

inkjet
calibrating, 458, 480
components, 456
faded prints, 486
ink cartridges, 457-458
maintenance, 480-481
overview, 455
streaks/smudges, troubleshooting, 484
turning on/off, 457

installing, 465
Add Printer Wizard, 465-466
vendor-supplied drivers, 467

interfaces, 469-471
Bluetooth, 470
Ethernet, 470
infrared, 471
Wi-Fi, 471

laser
calibrating, 479
deaning, 479-480
color versus monochrome, 454
components, 450
defined, 450
EP process, 451-454
faded prints, 486
maintenance, 478-480
streaks/smudges, troubleshooting, 484
toner cartridges, 450-451
maintenance, 18
managing in Windows, 648
memory
errors, troubleshooting, 490-491
installing, 467-468
size, verifying, 473
network
installing, 835-836
sharing, 471-472, 829, 834
troubleshooting, 853-854
spoolers, 477
test pages, printing, 476
thermal
defined, 459
dye-sublimation ribbons, 460
faded prints, 486
maintenance, 482-483
paper, 460
processes, 459
streaks/smudges, troubleshooting, 485
technologies, 459
thermal versus thermal transfer, 460
troubleshooting
access denied messages, 492
backed up queues, 489-490
colors, 300, 492
connectivity, 488
creased paper, 487
faded prints, 485-486
garbled characters, 488
ghost images, 486
HP LaserJet error codes, 492-493
installation, 492
low memory errors, 490-491
not printing, 492
paper jams, 487-488
paper not feeding, 487
streaks/smudges, 484-485
toner not fused to paper, 486
vertical lines on pages, 489
PrintTechs.com, 479
Problem Reports and Solutions (Windows Control Panel), 689
Process Explorer utility, 638
processing (laser printers EP process), 453
processors
32-bit versus 64-bit architecture, 73
AMD, 64
Intel comparison, 58
PGA sockets, 64
Socket 940, 66
Socket AM2, 66-67
Socket AM2+, 67
Socket AM3, 67-68
Socket AM3+, 68
Socket FM1, 69
website, 70
ARM, 398
bus speeds, 71
cache memory, 70-71
configuring, 106
cooling, 74
beat sinks, 75
liquid, 76
defined, 29
fan connectors, 44
hyperthreading, 70
information, retrieving, 326
quiet boot, configuring 1027

integrated GPUs, 74
Intel, 58
AMD comparison, 58
LGA, 59
LGA 775, 61
LGA 1155, 63-64
LGA 1156, 62-63
LGA 1366, 62
website, 70
laptops, replacing, 368
multicore, 70
overclocking, 72-73
point of failure, 12
virtualization support, 73
Windows requirements, 567
x84, 606
x86, 606
Professional edition
Windows 7, 609
Windows XP, 607
professionalism (customers)
interaction, 939-941
property, respecting, 941
profiles (hardware), 681
Program Compatibility Wizard
Windows 7, 615
Windows XP/Vista, 616-617
Programs and Features (Windows control panel), 687
projectors
connecting to laptops, 379
troubleshooting, 301-302
PROMPT command, 623
propagation, 896
properties sheets (printers), accessing, 472-473
property (customers), respecting, 941

protection. See also security
ESD, 16, 930-932
fire, 934
mobile device screens, 411
power supplies
battery backup units, 158-160
power conditioners, 160-161
surge suppressors, 156-157
protocols
DHCP, 796
e-mail, 797-798
FTP, 794
HTTP/HTTPS, 792
IMAP, 798
LDAP, 799
POP, 797
RDP, 798
SIP, 814
SSL, 792
TCP/IP. See TCP/IP
TLS, 792
PS/2 mouse settings, configuring, 92
PS/2 ports, 249
punch down tools, 17, 808
PVC (polyvinyl chloride) cabling, 806

Q
quality
color

displays, configuring, 295-296
troubleshooting, 301
graphics, troubleshooting, 301
laptop displays, 370-371
pictures, troubleshooting, 298-299
quiet boot, configuring, 93
radio-frequency identification (RFID) chips, 871
RAID (redundant array of inexpensive drives), 526
ATA/SATA arrays, creating, 528-530
levels, 526-527
troubleshooting, 549
RAID-5 arrays, 653
RAM (Random Access Memory). See memory
Rambus Direct RAM (RDRAM), 183
Rambus RDRAM Module (RIMM), 185
ratings (power supplies), 130-133
efficiency, 133
labels, 131
replacement, calculating, 132-133
safety certification, 131
RAW photo codecs, 329
RD command, 623, 629
RDP (Remote Desktop Protocol), 798
RDRAM (Rambus Direct RAM), 183
reading flash memory cards, 523-524
read-only, Blu-ray media (BD-ROM), 532
Read-Only Memory (ROM), 177
read/write failures, troubleshooting, 543
ReadyBoost (Windows), 613-614
Real-time Transport Control Protocol (RTCP), 814
Real-time Transport Protocol (RTP), 814
rear view (desktops), 5

recording
BSOD errors, 707
data to optical discs
third-party programs, 536-537
Windows Vista/7, 535-536
Windows XP, 533-534
recovery
Automated System Recovery (ASR), 739-741
BIOS update failures, 117
data
external drive docks, 550
external drive enclosures, 550
hard disk diagnostic programs, 551
software, 552
Windows-based disk tools, 551
malware, 916
Windows, 595-596
Windows Shadow Copy, 612
WinRE, 741-744, 916
accessing, 741-742
options, 743-744
Recovery Console, 718, 735-739, 916
access locations, 737
commands, 737-739
Attrib, 737-738
Batch, 737
Bootcfg, 737
ChDir, 737
Chkdsk, 737
Cls, 737
Copy, 737
Delete, 737
Dir, 737
Disable, 737
Diskpart, 737
Enable, 737
Exit, 737
removing
data remnants, 877
devices, 735
ExpressCards, 351
fans from laptops, 366
heat sinks from laptops, 367
keyboard keytops, 259
malware, 916-917
motherboards, 48-50
PC Cards, 349
power supplies, 139-140
processors from laptops, 367
thermal printer debris, 483
utilities (Add/Remove Programs), 686
wireless cards, 362-365

Rename command, 623, 738
repair Windows install, 574-575
repeaters, 776
replacing
BIOS chips, 118-119
impact printer paper, 483
impact printer printheads, 483
impact printer ribbons, 483
inkjet cartridges, 480
laptop hardware, 354

batteries, 355-356

hard drives, 358-359
inverters, 373
keyboards, 356-357
memory, 360-361
optical drives, 362
processors, 368
screens, 365-366
speakers, 358
touchpads, 357-358
wireless cards, 362-365
power supplies
  removing existing, 139-140
  requirements, 138
smartphone
  batteries, 401
  memory cards, 400, 403
toner cartridges, 478
requirements
  dial-up Internet connections, 784
  power supplies, calculating, 132-133
virtualization
  emulator, 693
  resource, 693
  security, 694
Windows, 566-569
  compatibility, verifying, 568-569
  hardware, 606-607
  minimum, 567
  Windows 7, 567
resetting mobile devices
  hard resets, 437
  soft resets, 436
resistance (Ohms), testing, 152
resolution (displays)
  configuring, 292-295
  laptops, 370
  troubleshooting, 301
resource requirements virtualization, 693
resource websites, 18
responding to incidents
  chain of custody, 939
  documentation, 938
  first responses, 938
restoring
  backups, 750-752
  NTDETECT files, 712
  NTLDTR files, 712
  systems, 756-760
    earlier conditions, 758
    restore points, creating, 757
  Windows, 595-596, 746
restricting spaces, 896
retrieving
  processor information, 326
  system information, 324
revolutions per minute (RPM), 513
rewritable/erasable DVDs, 532
rewriteable/erasable Blu-ray (BD-RE), 532
RFID (radio-frequency identification)
  chips, 871
RG-6 cabling, 806
RG-59 cabling, 806
RGB video connectors, 289
ribbons (printers)
  dot matrix, replacing, 483
  impact, 463
  thermal, 460, 482
RichCopy utility, 628
RIMM (Rambus RDRAM Module), 185
ring topologies, 774
RJ-11 cords, troubleshooting, 782
Rmdir command, 738
ROBOCOPY.EXE utility, 627-628
ROM (Read-Only Memory), 177
root hubs, 212
rooting mobile devices, 408
rootkits, 915
routers, 777, 791
RPM (revolutions per minute), 513
RS-232. See serial ports
RSM (Removable Storage Manager), 541
RTCP (Real-time Control Protocol), 814
RTP (Real-time Transport Protocol), 814
run-line utilities, 661
CMD, 661
DXDiag, 661, 672
Explorer, 661-662   
   Common Tasks view, 664-665   
   drives, viewing, 664   
   Favorite Links view, 665   
   libraries, 668   
   My Computer window, 669   
   starting, 662   
   Windows 7 view, 665   
   Windows Vista/7 display options, 667   
   Windows XP display options, 666
MMC, 661
MSConfig, 661
MSInfo32, 661, 670
Notepad, 661-662
Regedit, 661
SERVICES.MSC, 661
runtimes (battery backup units), 158

sags, 933
surge suppressors, 933
ESD, preventing, 16, 930-932
personal physical, 934-935
power supplies, 135
   certification, 131
   shock/fire hazards, avoiding, 154
sags (electricity), 933
SATA drives
   BIOS settings, configuring, 97
   cabling, 508-510
   host adapters, 517
   installing, 515-517
   ports, configuring, 100
   RAID arrays, creating, 528-530
   settings, 94
   standards, 504-505
satellite Internet service, 789-790
saving
   BIOS configuration changes, 109
   data to CDs/DVDs
      third-party programs, 536-537
      Windows Vista/7, 535-536
      Windows XP, 533-534
   printer settings, 475
scanning infrared monitors, 261
Scheduled Tasks (Windows), 645-646
screen calibration (mobile devices), 409-411
screen orientation (mobile devices), locking, 408-409
screwdrivers, 15
scripts (Internet), enabling/disabling, 843
SCSI (Small Computer Systems Interface), 221
cables, 225-227
cards, installing, 228

S1/S3 standby, 94
Safe Mode, 718, 728
safety
   chemicals, 936-938
   electricity, 932-934
      AC outlets, 932
      blackouts, 933
      brownouts, 933
      dirty power, 933
      fires, 934
      power surges, 933
SCSI (Small Computer Systems Interface)

daisy chaining
  creating, 227
  maximum length, 229
  overview, 222
  termination methods, 229
defined, 221
device IDs, configuring, 223-224
interface, 510
Narrow host adapters, 222
printers, 469
signaling types, 227
standards, 225
troubleshooting, 230-231
SD (Secure Digital) cards, 522
SDHC (Secure Digital High Capacity) cards, 522
SDRAM (synchronous DRAM), 181-182
SDSL (Synchronous DSL), 786
SDXC (Secure Digital Extended Capacity) cards, 522
Seagate website, 747
Secure Digital (SD) cards, 522
Secure Digital Extended Capacity (SDXC) cards, 522
Secure Digital High Capacity (SDHC) cards, 522
Secure Shell (SSH), 795
Secure Socket Layers (SSL), 792
security
  authentication, 871-872
BIOS
  features, 899-900
  settings, 108-109
boot virus detection, 94
data, 883
  backups, 877
  destruction/disposal methods, 898-899
encryption, 875-876
  local security policies, 874
  locking computers, 878-879
  migration, 877
  passwords, 878
  physical protection, 883
  remnant removal, 877
exceptions, 902-903
FAT32 conversions to NTFS, 912
file sharing, 832-834
file systems, 870
incident reporting, 879
laptops, 381
malware
  protection, testing, 913
  recovery, 916
  removing, 916-917
  rootkits, 915
  spyware, 915
  Trojan horses, 915
  types, 914-915
  user education, 917-918
  viruses, 914
  Windows Defender, 916
  worms, 914
mobile devices
  antivirus software, 434
  backups, 432-433
  compromised/damaged devices, 432-435
  data protection, 429
  hard resets, 437
  lost/stolen, 432
  operating system updates, 433
  passcode locking, 429, 432
  soft resets, 436
  turning off applications, 435-436
operating systems access, 892-898
  administrator accounts, 893
  auditing, 897-898
  components, 896
  event logging, 897-898
  groups, 894
  guest accounts, 893
  moving/copying files/folders, 896
  permissions, 895-896
  principle of least privilege, 895
  restricted spaces, 896
  UAC, 893-894
  user accounts, 893
passwords, 878
  physical, 881
    biometrics, 882-883
    data protection, 883
    doors, 881-882
social engineering, 880-881
software firewalls, 873
  configuring, 900-901
  troubleshooting, 903-904
unused wireless connections, 910-912
virtualization requirements, 694
virus protection, 872-873
web browsers, configuring, 844-845
wired networks, 891-892
wireless clients, configuring, 904
  troubleshooting, 909-910
  Windows 7, 908-909
  Windows Vista, 908
  Windows XP SP2/SP3, 905-908
wireless networks
  access point firmware, updating, 890
  default administrator passwords, changing, 890
  default SSIDs, changing, 886
  DHCP versus static IP addresses, 885
  firewalls, 891
  MAC addresses, filtering, 887-890
  radio levels, 891
  SSID broadcasting, disabling, 886
  WAP location, 891
  WEP/WPA, 883-884
self-booting diagnostic programs, 569
self-powered hubs, 214
serial ports, 231
  adding, 238
  BIOS settings, configuring, 93
  cables, 235
  configuring, 236
  devices, 231
  loopback plugs, 248
  modem similarities, 778
  parallel ports, compared, 232
  pinouts, 233-234
  printers, 469
  software, configuring, 236-237
  troubleshooting
    cabling, 239
    COM 4 I/O port conflicts, 238
    configuration problems, 239
    mismatched connectors, 239
    testing, 239
  types, 232
serial (RS-232) null modem cables, 801
server-assigned versus static IP addressing, 819-820
server/client networks, 770-772
Server Message Block (SMB), 799
servers
  client/server networks, 770-772
  DHCP
    TCP/IP, configuring, 821
    versus static IP addresses, 885
  home, 323-324
service failures, 715-717
service packs, installing, 593-595
Service Set Identifier (SSID), 818, 886
Services dialog box, 643
SERVICES.MSC utility, 661
Session Initiation Protocol (SIP), 814
Set command, 623, 738
Setup Manager Utility, 576
setup passwords, 94
Sfc (System File Checker), 718-719
Shadow Copy (Windows), 612
shadowing, 93
shared resources, 829
  accessing, 836
  administrative shares, 834
  client configuration, 834-836
  drive mapping, 840-841
  fileprinter sharing, installing, 829
  folders/drives, 830-834
    simple file sharing, 831
  user/group permissions, 832-834
FQDNs, 840
identifying, 836
offline, 839
printers, 471-472, 834
  troubleshooting, 853
UNC, 838-839
Shielded Twisted Pair. See STP
shoultering, 880
Sidebar (Windows), 611
signaling types (SCSI), 227
SIMM (Single Inline Memory Module), 184
simple file sharing, 831
Simple Mail Transfer Protocol (SMTP), 797
Simple Network Management Protocol (SNMP), 798
Single Inline Memory Module (SIMM), 184
Single Inline Pin Package (SIPP), 184
single-level cell (SLC) SSDs, 526
single-mode fiber-optic cabling, 805
single-sided memory, 188
SIP (Session Initiation Protocol), 814
SIPP (Single Inline Pin Package), 184
SiSoftware Sandra 2012, 569
site-local addresses, 828
six-step troubleshooting methodology, 14
sizes
  battery backup units, determining, 159-160
  CRT monitors, 277
  graphics, troubleshooting, 301
  icons, 300
  LCD monitors, 279
  memory, 179, 194
  printer memory, verifying, 473
  text, troubleshooting, 300
SLC (single-level cell), 526
slow hard drive performance, troubleshooting, 543-545
slow SSD performance, troubleshooting, 546
Small Computer Systems Interface. See SCSI
small icons view (Windows Explorer), 667
small office/home office. See SOHO
Small Outline DIMM (SODIMM), 185
Small Outline Rambus Module, 185
smart cards, 871, 882
SmartMedia cards, 521-522
smartphones
  Airplane Mode, 412
  battery cards, replacing, 401
  memory cards, replacing, 400, 403
SMB (Server Message Block), 799
smoke, troubleshooting, 55
SMTP (Simple Mail Transfer Protocol), 797
smudges during printing, troubleshooting, 484-485
SNMP (Simple Network Management Protocol), 798
social engineering, 880-881
sockets (AMD)
  940, 66
  AM2, 66-67
  AM2+, 67
  AM3, 67-68
  AM3+, 68
  FM1, 69
  PGA, 64
SODIMM (Small Outline DIMM), 185
soft resets (mobile devices), 436
software, 10-11
  data recovery, 552
  firewalls, 873, 900-904
  network client, installing, 835
  operating systems. See operating systems
  serial port, configuring, 236-237
SOHO (small office/home office), 815
  creation overview, 854-855
IPv6 addresses, 827-829
  network interface cards
    configuring, 816-819
    full-duplex/half-duplex modes, 817
    hardware resources, 816
    installing, 815-816
    media types, 817
    PC Card/CardBus cards, 816
    PCI/PCI Express, 815
    USB adapters, 816
    WLANs, 818-819
  shared resources, 829
    accessing, 836
    administrative shares, 834
    client configuration, 834-836
    drive mapping, 840-841
    file/printer sharing, installing, 829
    folders/drives, 830-834
    FQDNs, 840
    identifying, 836
    offline, 839
    printers, 834
    UNC, 838-839
  TCP/IP, configuring, 819
    advanced settings, 822
    alternate configuration, 821
    DHCP servers, 821
    DNS, 827
    gateways, 826
    IP addressing, 824-826
    manually, 822
    static versus server-assigned IP addressing, 819-820
    subnet masks, 824
    Windows, 820
    WINS, 826
web browsers
  configuring, 841-842
Internet connections, configuring, 842-843
multifunction network devices, 845-846
script settings, enabling/disabling, 843
security, 844-845
solid state drives (SSDs), 525
sound cards
  audio jacks/cable color standards, 330
  configuring, 332
  defined, 329
  installing, 331-332
southbridge chips, 43, 161-162
spam, 915
SPDIF (Sony/Philips Digital Interconnect Format), 250
speakers (laptops), 358
Speech Recognition dialog box, 335
speed
  bus, 71
  memory, 179, 193-194
  optical drives, 533
  USB, 211
spikes, 156
spin rate (hard drives), 513
split rail power supplies, 131
spoolers (print), 477
SPS (battery backup units), 158-160
spyware, 915
SRAM (static RAM), 181
SSDs (solid state drives), 525-526, 546
SSH (Secure Shell), 795
SSID (Service Set Identifiers), 818, 886
SSL (Secure Socket Layers), 792
Stacks view (Windows Explorer), 668

Standard Certification Marks website, 132
standards
  laptop display resolution, 370
  PATA/SATA, 504-505
  SCSI, 225
  USB ports, 209
star topologies, 774
Start menu (Windows), customizing, 612
Starter edition (Windows 7), 608
startup
  3TB hard drives, 659
  Advanced Options, 726-729
  BIOS settings, configuring, 98-100
  blank screens, troubleshooting, 54
  clean, 714
  diagnostic screen, configuring, 93
  failures, 709
    GUI not loading, 714
    missing GUI, 714
    Missing Operating System, 713
    Vista/7, 710-711
    XP, 712-713
  multiboot configurations, 711
  operating system not found, troubleshooting, 548
  POST code beeps, troubleshooting, 54
  quiet, configuring, 93
  sequence, 98-100
  Windows installation, 570
  WinRE Startup Repair option, 743
static IP addresses, 885
static RAM (SRAM), 181
static versus server-assigned IP addressing, 819-820
stolen mobile device protection, 432
STOP errors, 706-709
storage devices

data recovery tools
  data recovery software, 552
  external drive docks, 550
  external drive enclosures, 550
  hard disk diagnostic programs, 551
  Windows-based disk tools, 551

drive interfaces, 502
  external, 502
  hot-swappable, 511
  internal, 502
  overview, 503
  PATA, 504-508
  SATA, 504-510
  SCSI, 510

flash memory, 520
  cards, 520-524
  SSDs, 525-526
  USB drives, 524

floppy drives, 538
  capacities, 538
  cleaning, 540
  defined, 538
  external, 540
  hardware configuration, 539-540
  maintenance, 540-541

hard drives. See hard drives

optical drives
  Blu-ray media types, 532
  comparing, 531-532
  DVD media types, 532
  erasing data in Windows XP, 534
  recording data, 533-537
  speeds, 533
  types, 531

RAID, 526
  ATA/SATA arrays, creating, 528-530
  levels, 526-527

tape drives, 541-542

troubleshooting
  boot failures, 547
  drive-recognition problems, 548
  hard drive slow performance, 543-545
  loud noises, 546
  operating system not found, 548
  RAID, 549
  read/write failures, 543
  SSD slow performance, 546

STP (Shielded Twisted Pair) cabling
  categories, 802-803
  connectors, 803
  overview, 801-803
  standard, 803

streaks during printing, troubleshooting, 484-485

striped arrays, 653

subnet masks, 824-825

Super Extended Graphics Array Plus (SXGA+), 370

SuperMulti DVD drives, 532

SuperSpeed USB, 209

surface wave monitors, 261

surge suppressors, 157, 933

surges, 156

SVGA cards, 286

S-video connectors, 289

switchboxes, troubleshooting, 247

switches, 263, 775, 814

SXGA+ (Super Extended Graphics Array Plus), 370

Symantec Ghost Solution Suite, 578

synchronization (mobile devices), 424, 429
  Android, 424-427
  BlackBerry, 428
iOS, 427
Windows CE/Mobile, 428
synchronous DRAM (SDRAM), 181-182
Synchronous DSL (SDSL), 786
Sysprep utility, 578
system
configuring
audio/video editing, 316-317
gaming, 319-320
graphic/CAD/CAM design, 314-315
home servers, 323-324
home theaters, 321-322
thick clients, 322
thin clients, 323
virtualization, 318-319
dead, troubleshooting, 143-144
fan connectors, 44
File Checker (Sfc), 718-719
genral information, retrieving, 324
Image Manager, 576
Image Recovery option (WinRE), 743
lockups, troubleshooting, 54
Monitor (Windows), 641-642
not starting, troubleshooting, 55-58
dead shorts, 57
incorrect front panel wiring connections, 55
loose BIOS chips, 56
loose/missing memory modules, 56
loose/missing power leads, 55
properties sheet, 680
hardware profiles, 681
virtual memory settings, 681-682
restoration discs, 596
Restore (Windows), 756-760
configuring, 759
restore points, creating, 757
restoring to earlier conditions, 758
tasks to try first, 759
WinRE, 743
testing tools, 16
Systemroot command, 738

T

Tablet PC Settings (Windows Control Panel), 688
tablets, 399-400
tags (HTML), 793
tailgating, 880
tape drives, 541-542
Task Manager, 648-649
Task Scheduler (Windows), 645-646
Taskkill utility, 638-640
Tasklist.exe utility, 636-638
tasks (Windows)
creating, 645-646
managing, 648-649
TCP/IP (Transport Control Protocol/Internet Protocol), 792
configuring, 819
advanced settings, 822
alternate configuration, 821
DHCP servers, 821
DNS, 827
gateways, 826
IP addressing, 824-826
manually, 822
static versus server-assigned IP addressing, 819-820
subnet masks, 824
Windows, 820
WINS, 826
DHCP, 796
DNS, 795-796
email, 797-798
FTP, 794
HTML, 793-794
HTTP/HTTPS, 792
LDAP, 799
RDP, 798
SMB, 799
SNMP, 798
SSH, 795
SSL, 792
Telnet, 794
TLS, 792
UDP ports, 799-800
Telnet, 794
temperature (environment), 936
terminating SCSI daisy-chaining, 229
test pages, printing, 476
testing
cables, 808
electricity, 16
memory, 196
microphones, 334-335
parallel ports, 248
POST
beep codes, 111
cards, 113
error messages, 112
hex codes, 112-113
overview, 110
power supplies, 149-152
AC to DC conversions, 152
AC voltage, 151
acceptable voltage levels, 152
amperage, 152
cables, 152
DC voltage, 151
resistance, 152
security programs, 913
serial ports, 239
system, 16
tethering Wi-Fi, 416
text, troubleshooting
color fringes, 301
size, 300
thermal compound, 164
thermal printers
defined, 459
direct thermal versus thermal transfer, 460
dye-sublimation ribbons, 460
maintenance, 482-483
debri, removing, 483
beating elements, cleaning, 482
paper, 482
ribbons, 482
paper, 460
processes, 459
thermo transfer, 460
troubleshooting
faded prints, 486
streaks/smudges, 485
thermal transfer printing, 460
thin client systems, 322
thin client systems, 323
Thin Ethernet, 806
third-party
drag-and-drop file copying programs, 537
drivers, 588
optical disc mastering programs, 536
thumbnail view (Windows Explorer), 667
tiles view (Windows Explorer), 666
TIME command, 622
times and dates, 579
TLS (Transport Layer Security), 792

toner cartridges, 450-451
  installing, 451
  probes, 17, 809
  recycled, 451
  replacing, 478
  vacuums, 18

tools
  assembly/disassembly, 15
  command-line
    Ipconfig, 849
    NBTSTAT, 850
    Net, 847
    netstat, 849
    NSLookup, 849
    Ping, 847-848
    Tracert, 848
  data recovery
    external drive docks, 550
    external drive enclosures, 550
    hard disk diagnostic programs, 551
    software, 552
    Windows-based disk tools, 551
  electrical testing, 16
  ESD protection, 16
  hardware-assisted virtualization detection, 326
  multimeters
    AC to DC conversions, testing, 152
    AC voltage, 151
    amperage, 152
    cables, 152
    DC voltage, 151
    defined, 149
    readout styles, 149
    resistance, 152
    test leads, 149
    test modes, 150
  tests, performing, 150
  voltage levels, 152
  network installation/configuration, 17
  networks, 808-809
  printers, 18
  processor information, retrieving, 326
  Recovery Console, 916
  system testing, 16
  toner probe, 809
  Windows administrative, 618-619
  Windows command-line
    CD, 629
    command prompts, starting, 621-622
    COPY, 624-625
    DEL, 635-636
    Diskpart, 633-635
    Format, 629-632
    internal commands, 622-623
    MD, 629
    RD, 629
    ROBOCOPY.EXE, 627-628
    Taskkill utility, 638-640
    Tasklist.exe, 636-638
    wildcards, 624
    XCOPY command, 625-627
  Windows diagnostic and repair, 717-719
    Advanced Boot Options, 726-729
    Automated System Recovery, 718-741
    Defrag, 718
    Device Manager, 718, 729-735
    Event Viewer, 718, 724
    Fixboot, 718
    Fixemfr, 718
    MSConfig, 718-721
    Recovery Console, 718, 735-739
    REGEDIT, 718, 722-724
    REGSVR32, 718, 721
Repair Discs, 719
Safe Mode, 718
System File Checker, 718-719
WinRE, 718, 741-744
topologies (networks), 774-775
torx drivers, 15
touch-on-tube monitors, 261
touch screen monitors, 260-261
installing, 262
interfacing, 261
surface treatments, 261
troubleshooting, 262-263
touch tablets, 253
touchpads, 357-358
Tracert command, 484
transfer belts/rollers (laser printers), 450
transferring data, 589
USMT, 590-591
Windows Easy Transfer, 590
transferring (laser printers EP process), 453
transient voltage surge suppressor (TVSS), 156
Transport Control Protocol/Internet Protocol. See TCP/IP
Transport Layer Security (TLS), 792
triple-channel memory, 180
Trojan horses, 880, 915
troubleshooting
Bluetooth connections, 420-421
BSOD (Blue Screen of Death) errors, 706-709
chip creep, 56
CMOS Checksum errors, 119
displays
  3D games, 300
  color fringes around text/graphics, 301
color quality, 301
flickers, 300-301
icon size, 300
monitors/projectors, 300-302
mouse pointers, 300
no picture with replacement video cards, 301
picture quality, 299-301
picture size changes, 301
preventative maintenance, 302-303
projectors, 301-302
refresh rates, 301
resolution, 301
screen/print colors not matching, 300
text size, 300
video cards, 300-302
wavy lines, 301
DSL telephone interference, 787
fatal errors, 110
IEEE 1394, 220-221
keyboards, 258
laptops
  Bluetooth connectivity, 386
displays, 382-384
keyboards, 385
power problems, 384-385
Wi-Fi connectivity, 386
memory
  cache RAM, 195
  compatibility, 192
  overclocking, 192-193
  parity errors, 194
  preventative maintenance, 196
  sizing errors, 194
  speed mismatches, 193-194
  testing programs, 196
mice/pointing devices, 253-256
  double-clicking icons, 256
  jerky pointer movement, 256
  pointer does not move, 254-256
mobile devices
  displays, 411
  email connections, 423
  hard resets, 437
  soft resets, 436
  turning off applications, 435-436
  Wi-Fi, 416-418
motherboards
  BIOS time and settings resets, 53
  blank screen on bootup, 54
  continuous reboots, 53
  POST code beeps at startup, 54
  smoke/burning smells, 55
  system lockups, 54
  system not starting, 55-58
  unexpected shutdowns, 52
networks
  Duplicate Computer Names/Duplicate IP Address errors, 851
  entire network failure, 853
  interference, 852
  IPconfig command, 849
  low radio frequency signals, 852
  NBTSTAT command, 850
  Net command, 847
  netstat command, 849
  NSLookup command, 849
  performance, 851-852
  ping command, 847-848
  power management, 852
  printing, 853-854
  shared resources, 853
  Tracert command, 848
  web pages, displaying, 854
parallel ports, 247
points of failure, 12-13
power supplies
  AC power flow problems, 156
  dead systems, 143-144
  defective, 149-152
  fans, 149
  loud noises, 142
  overheating, 144-148
  overload, 141
printers
  access denied messages, 492
  backed up queues, 489-490
  colors, 492
  connectivity, 488
  creased paper, 487
  faded prints, 485-486
  garbled characters, 488
  ghost images, 486
  HP LaserJet error codes, 492-493
  installation, 492
  low memory errors, 490-491
  not printing, 492
  paper jams, 487-488
  paper not feeding, 487
  streaks/smudges, 484-485
  toner not fused to paper, 486
  vertical lines on pages, 489
Problem Reports and Solutions
  (Windows Control Panel), 689
RAID, 549
RJ-11 cords, 782
SCSI, 230-231
serial ports, 238-239
six-step methodology, 14
software firewalls, 903-904
storage devices

- boot failures, 547
- drive-recognition problems, 548
- hard drive slow performance, 543-545
- loud noises, 546
- operating system not found, 548
- read/write failures, 543
- SSD slow performance, 546

touch screen monitors, 262-263

unused wireless connections, 910-912

USB ports

- 2.0 devices not operating at maximum speed, 217
- black exclamation point on yellow field, 217
- device drivers not installed, 216
- improper designs, 215
- not BIOS enabled, 215
- power problems, 216-217
- too many connected devices, 217

Windows

- Blue Screen of Death errors, 706-709
- boot failures, 709-714
- compatibility errors, 716
- devices failing to start, 715
- DLL messages, missing, 715
- files not opening, 717
- improper shutdowns, 714
- service failures, 715-717
- slow performance, 716

wireless clients, 909-910

**Types**

- battery backup units, 158
- Blu-ray media, 532
- displays, 276
  - CRT monitors, 277
  - data projectors, 280-281
  - LCD monitors, 278-279
  - LED monitors, 279
  - OLED, 281
  - plasma, 279
- DSL, 786
- DVD media, 532
- Ethernet networks, 810
- ExpressCards, 350
- fiber-optic cabling, 805
- flash memory cards, 520-523
  - CompactFlash, 521
  - memory sticks, 521-522
  - microSD, 522
  - microSDHC, 522
  - miniSD, 522
  - miniSDHC, 522
  - MultiMedia, 521
  - Secure Digital, 522
  - Secure Digital Extended Capacity, 522
  - Secure Digital High Capacity, 522
  - SmartMedia, 521
  - xD-Picture Card, 523
- malware, 914-915
- memory, 177-178
- mini-PCI cards, 363
- modems, 779

**Turning on/off**

- applications (mobile devices), 435-436
- inkjet printers, 457

**TVSS (transient voltage surge suppressor)**, 156

**Type command**, 623, 738

**Type I PC Cards**, 347

**Type II PC Cards**, 347

**Type III PC Cards**, 347
network cables, 801
  coaxial, 805-806
  connectors, 806-807
  fiber-optic, 805
  plenum, 806
  PVC, 806
  STP, 801-803
  UTP, 801-803
parallel cables, 244-245
permissions, 895
printer interfaces, 469-471
unicast addresses, 828
video cards, 274
video connectors
  component, 289
  composite, 289
  DisplayPort, 288
  DVI, 286
  HDMI, 286-288
  RGB, 289
  SVGA, 286
  S-video, 289
  VGA, 285
Windows installations, 570
  clean, 571-573
  multiboot, 573
  repair, 574-575
  upgrade, 571

UEFI (Unified Extensible Firmware Initiative), 91, 659
Ultimate Boot CD, 569
Ultimate edition
  Windows 7, 609
  Windows Vista, 608
Ultra 160 SCSI, 225
Ultra 320 SCSI, 225
Ultra Extended Graphics Array (UXGA), 370
Ultra SCSI, 225
Ultra-Wide SCSI, 225
Ultra-X website, 113
Ultra2 SCSI, 225
Ultra2Wide SCSI, 225
unattended Windows installation, 576
unbuffered memory, 188
UNC (Universal Naming Convention), 838-839
unexpected shutdowns, troubleshooting, 52
unicast addresses, 828
Unified Extensible Firmware Initiative (UEFI), 91, 659
universal asynchronous receiver transmitter (UART), 779
Universal Naming Convention (UNC), 838-839
Universal Serial Bus. See USB
Unshielded Twisted Pair. See UTP
updates
  access point firmware, 890
  Automatic Updates (Windows control panel), 688
  BIOS, 114-115
    failure recovery, 117
    Flash, 115-117
    replacing, 118-119
mobile device operating systems, 433
printer drivers, 464
Windows
  compatibility, 617
  firmware, 760
  hotfixes, 595
  service packs, installing, 593-595
  Windows Update, 592-593
upgrading
  printer firmware, 469
  smartphone memory cards, 400-403
  Windows, 571
UPS (battery backup units), 158-160
  automatic shutdown, 159
  laser printers, 160
  network support, 158
  runtimes, 158
  size, determining, 159-160
  surge suppression features, 159
  types, 158
upstream, 786
USB (Universal Serial Bus), 209
  1.1/2.0, 210
  3.0, 211
  adding, 213-214
  BIOS settings, configuring, 93
  cable length, 212
  defined, 209
  flash memory drives, 524
  generic hubs, 214
  host adapters, configuring, 102
  Implementers Forum website, 350
  laptops, 352
  legacy settings, configuring, 93
  logos, 212
  network adapters, installing, 816
  printers, 469
  root hubs, 212
  speeds, 211
  standards, 209
  troubleshooting, 215-217
    2.0 devices not operating at maximum speed, 217
    black exclamation point on yellow field, 217
    device drivers not installed, 216
    improper designs, 215
    not BIOS enabled, 215
    power problems, 216-217
    too many connected devices, 217
User Account Control (UAC), 893
User Datagram Protocol (UDP), 799-800
user/group permissions, 832-834
user/power-on password, 94
username authentication, 871
USMT (User State Migration Tool), 590-591
utilities. See also commands
  Add/Remove Programs, 686
  Chkdsk, 754-755
  CONVERT.EXE, 660
  Defrag, 755
  Disk Management. See Disk Management
  Diskpart, 633-635
  file copy, 753
  FORMAT.EXE, 631-632
  NTBackup, 745-747
  Performance Monitor, 641-642
  POWERCFG.EXE, 684
  Print Management, 648
  Process Explorer, 638
  RichCopy, 628
  ROBOCOPY.EXE, 627-628
run-line, 661
  CMD, 661
  DXDiag, 661, 672
  Explorer. See Explorer
  MMC, 661
  MSConfig, 661
  MSInfo32, 661, 670
  Notepad, 661-662
  Regedit, 661
  SERVICES.MSC, 661
  System Monitor, 641-642
  Task Manager, 648-649
  Task Scheduler, 645-646
  Taskkill, 638-640
  Tasklist, 636-638

UTP (Unshielded Twisted Pair)
cabling
  categories, 802-803
  connectors, 803
  grades, 801
  overview, 801-803
  standard, 803

UXGA (Ultra Extended Graphics Array), 370

V

variables (memory)
  chips, 179
  dual-channel, 180
  error checking, 179
  modules
    per bank requirements, 179
    types, 178
  number of modules, 180
  sizes, 179
  speed, 179
  triple-channel, 180

VDI (virtual desktop infrastructure), 692

vendor-supplied print drivers, installing, 467

ventilation, 936

VER command, 623

versions
  Android, 405
  IEEE 1394, 218
  iOS, 406
  Windows
    7, 608-609
    hardware requirements, 606-607
    Vista, 607-608
    XP, 607

vertical lines (printed pages), troubleshooting, 489

vertical refresh rates, 296

VESA (Video Electronics Standards Association), 288

VGA cards, 285

video
cards
  AGP slots, 274
  capture, 335-336
  cooling, 163, 275-276
  defined, 274
  GPUs, 275
  installing, 282-284
  PCI Express x16 slots, 274
  troubleshooting, 300-302
  TV tuner cards, 336
  types, 274

connectors
  component, 289
  composite, 289
  DisplayPort, 288
  DVI, 286
**HDMI**, 286-288
**RGB**, 289
**SVGA**, 286
**S-video**, 289
**VGA**, 285
editing systems, configuring, 316-317
Electronics Standards Association (VESA), 288
webcams, 327
Windows requirements, 567
Zoomed Video (ZV) cards, 349
**viewing**
desktop components, 5
disk status, 655
**virtual desktop infrastructure (VDI)**, 692
**virtual memory**, 178, 681-682
Virtual Memory (VMM) dialog box, 682
**virtualization**, 692
benefits, 693
BIOS settings, 93, 106-107
client-side, 692
configuring, 318-319
defined, 692
guest virtual machines (VMMs), 692
features, 693
hardware assisted, 326
host/guest, 692
hypervisor, 692
machine manager (VMM), 692
processors, 73
resource requirements, 693
security requirements, 694
**viruses**, 872-873, 914. See also malware
**Vista editions** (Windows), 607-608
**VM (virtual machine)**, 692
VMM (virtualization machine man-
AMI BIOS beep codes, 111
Answers That Work Task List Programs, 644
Belarc, 115, 325
BlackBerry Desktop Software, 428
clean boot, 714
CompTIA A+ certification, 18
Computer Protection Program, 874
CPU-Z, 326
DDR comparisons, 185
Dell
beep codes, 111
power connectors, 137
Depot International, 479
device failures, 715
Device Manager error codes, 734
digital TV vendors, 322
disk defragmentation, 755
“Disk Status Descriptions,” 655
Diskpart utility, 635
DMA/UDMA transfers, 545
Ecova Plug Load Solutions, 133
EFS data recovery, 875
The Elder Geek’s Windows Services Guide, 644
Elston Systems, 113
eSupport, 115
Ethernet cable color coding diagram, 803
FAT64 file systems, 658
FTP products, 794
Gibson Research Corporation
Perfect Passwords, 884
SecurAble, 326
GoldMemory, 196
hardware profile alternatives, 681
Hitachi Feature Tool, 547
hotfixes, 595
HP LaserJet Error Codes, 493
HP MSDS documents, 937
IBM beep codes, 111
Intel Processor Identification Utility, 326
Intel processors, 70
IPv6 addressing, 829
Kernel memory dumps, 709
Laplink, 571
Laptop Repair Help, 353
laser printer maintenance kits, 479
Live File System, 535
LoJack for Laptops, 109
MaximumPC, 193
MemTest86, 196
Microsoft support, 18, 53
NTBackup utility, 746
OSHA, 934
overclocking, 193
PC Check, 569
PC-Diagnosys, 196
Phoenix BIOS beep codes, 111
POWERCFG.EXE, 684
PrinterTechs.com, 479
Process Explorer utility, 638
REGSVR32, 721
resources, 18
RichCopy utility, 628
Seagate, 747
SiSoftware Sandra 2012, 569
SSID broadcasting, 886
Standard Certification Marks, 132
surge suppressor standards, 157
Symantec Ghost Solution Suite, 578
System File Checker, 719
System Image Manager, 576
TuffTEST, 569
Ultimate Boot CD, 569
Ultra-X, 113
USB
  device conflicts, 217
  Implementers Forum, 350
USMT, 591
virtualization security, 694
Western Digital, 747
Wim’s BIOS, 115
Windows
  7, 608-609
  Easy Transfer, 590
  hardware requirements, 567
  Memory Diagnostic program, 196
  repair installation, 575
  Virtual PC, 618
  Vista, 608, 711
  XP security checklist, 874
WinRE, installing, 742
WEP (Wireless Equivalent Privacy), 818, 883-884
Western Digital website, 747
wide area networks (WANs), 769, 773
Wide SCSI device ID settings, 224
Wide Ultra Extended Graphics Array (WUXGA), 370
Wide XGA (WXGA), 370
Wide XGA Plus (WXGA+), 370
Wi-Fi
  Bluetooth, 812
  cellular, 813
  Ethernet, 811-812
  infrared, 813
  laptops
    antennas, 373
    troubleshooting, 386
  mobile devices, 414-418
  Android, 414
  icon, 415
  iOS, 415
  tethering, 416
  troubleshooting, 416-418
  printers, 469-471
  Protected Access (WPA), 818, 884
  Protected Setup (WPS), 819
  security
    access point firmware, updating, 890
    default administrator passwords, changing, 890
    default SSIDs, changing, 886
    DHCP versus static IP addresses, 885
    firewalls, 891
    MAC addresses, filtering, 887-890
    radio levels, 891
    SSID broadcasting, disabling, 886
    WAP location, 891
    WEP/WPA, 883-884
    unused connections, 910-912
  VoIP, 813-814
wildcards (Windows), 624
WiMAX (Worldwide Interoperability for Microwave Access), 791
Wim’s BIOS website, 115
windowboxing, 372
Windows
  7
    Action Center, 691
    Backup and Restore Center, 750-753
    boot errors, 710-711
    editions, 608-609
    Explorer, 665-667
    HomeGroup, 690
    libraries, 668
    power schemes, 685-686
    Problem Reports and Solutions, 689
Programs and Features, 687
restore points, creating, 757
restoring systems to earlier conditions, 758
Tablet PC Settings, 688
versions, 608-609
WinRE, 741-744
administrative features
computer management (MMC), 640-641
Performance Monitor, 641-642
print management, 648
services, 642-644
System Monitor, 641-642
Task Manager, 648-649
Task Scheduler, 645-646
backups
Backup and Restore Center (7), 750-753
Backup and Restore Center (Vista), 748-750
file copy utilities, compared, 753
image (7), 752
image (Vista), 749
image (XP), 747
NTBackup, 745-747
restoring, 746, 750-752
Blue Screen Of Death errors, 706
causes, 707
recording, 707
researching causes, 707
spontaneous shutdown/restart, 708-709
boot failures, 709
GUI not loading, 714
missing GUI, 714
Missing Operating System, 713
Vista/7, 710-711
XP, 712-713
booting to safe mode, 717
CE devices, synchronizing to PCs, 428
command-line tools
CD command, 629
command prompts, starting, 621-622
COPY command, 624-625
DEL command, 635-636
Diskpart, 633-635
Format command, 629-632
internal commands, 622-623
MD command, 629
RD command, 629
ROBOCOPY.EXE, 627-628
Taskkill utility, 638-640
Tasklist.exe, 636-638
wildcards, 624
XCOPY command, 625-627
compatibility errors, 716
Complete PC Restore option (WinRE), 743
control panel
Action Center, 691
Add/Remove Programs, 686
All Control Panel Items view, 676
Automatic Updates, 688
Category view, 674
Devices and Printers, 689
display settings, configuring, 678
features, 673-674
folder options, 679
function access via property sheets, 678
HomeGroup, 690
Pen and Input Devices, 689
power options, 682-686
Problem Reports and Solutions, 689
Programs and Features, 687
starting, 674
switching views, 676
System properties sheet, 680-682
Tablet PC Settings, 688
data transfers, 589-591
Defender, 916
devices failing to start, 715
diagnostic/repair tools, 717-719
Advanced Boot Options, 726-729
Automated System Recovery, 718, 739-741
Defrag, 718
Device Manager, 718, 729-735
Event Viewer, 718, 724
Fixboot, 718
Fixmbr, 718
MSConfig, 718-721
Recovery Console, 718, 735-739
REGEDIT, 718, 722-724
REGSVR32, 718, 721
Repair Discs, 719
Safe Mode, 718
System File Checker, 718-719
WinRE, 718, 741-744
disk defragmentation, 755
disk drive errors, checking, 754-755
Disk Management. See Disk
Management
disk tools, 551
DLL messages, missing, 715
Easy Transfer, 590
Explorer, 662
Common Tasks View, 664-665
display options, 666-667
drives, viewing, 664
Favorite Links View, 665
libraries, 668
My Computer window, 669
starting, 662
Windows 7 View, 665
features, 609-610
administrative tools, 618-619
Aero/Aero Glass, 610
compatibility mode, 615-617
file structures and paths, 620
gadgets, 611
ReadyBoost, 613-614
Shadow Copy, 612
Sidebar, 611
Start menu, customizing, 612
XP Mode, 618
file systems
converting, 660
defined, 657
determining, 659
FAT32, 657
FAT64, 658
NTFS, 658-660
files not opening, 717
firmware updates, 760
hardware requirements, 606-607
improper shutdowns, 714
installing
boot methods, 570
clean, 571-573
file systems, 586-588
hard drive partitions. See hard drives, partitions
hardware requirements, 566-569
image deployment, 577-579
multiboot, 573
remote network, 577
repair, 574-575
third-party drivers, 588
time/date/language/region settings, 579

types, 570
unattended, 576
upgrade installations, 571
without DVD drive, 570
workgroups versus domain setup, 589

Internet Naming Service (WINS), 826
maintenance, 744
Memory Diagnostic tool, 196, 744
mobile devices, synchronizing to PCs, 428

Mobility Center, 379
Recovery Environment. See WinRE
restoring, 595-596
run-line utilities, 661

CMD, 661
DXDiag, 661, 672
Explorer. See Explorer
MMC, 661
MSConfig, 661
MSInfo32, 661, 670
Notepad, 661-662
Regedit, 661
SERVICES.MSC, 661

service failures, 715
slow performance, 716
System Restore, 756-760
  configuring, 759
  restore points, creating, 757
  restoring to earlier conditions, 758
  tasks to try first, 759

updating
  hotfixes, 595
  service packs, installing, 593-595
  Windows Update, 592-593

virtualization
  benefits, 693
  client-side, 692
  defined, 692
  emulator requirements, 693
  features, 693
  host/guest, 692
  hypervisor, 692
  resource requirements, 693
  security requirements, 694

Virtual PC, 618

Vista
  Backup and Restore Center, 748-750
  boot errors, 710-711
  Explorer, 667
  Pen and Input Devices, 689
  power schemes, 685-686
  Problem Reports and Solutions, 689
  Programs and Features, 687
  restore points, creating, 757
  restoring systems to earlier conditions, 758
  Tablet PC Settings, 688
  versions, 607-608
  WinRE, 741-744

XP
  Add/Remove Programs, 686
  ASR, 739-741
  Automatic Updates, 688
  boot errors, 712-713
  editions, 607
  Explorer, 666
  hardware profiles, 681
  mode, 618
  power schemes, 683-684
  Recovery Console, 735-739
  restore points, creating, 757
restoring systems to earlier conditions, 758

security checklist website, 874

WinRE (Windows Recovery Environment), 718, 741-744, 916
accessing, 741-742
options, 743-744

WINS (Windows Internet Naming Service), 826
wire strippers, 18, 808
wired networks, 810
wireless
Access Points (WAPs), 776
cards (laptops), removing, 362-365
clients, configuring, 904
troubleshooting, 909-910
Windows 7, 908-909
Windows Vista, 908
Windows XP SP2/SP3, 905-908
Equivalent Privacy (WEP), 818, 883-884
LANs (WLANs), configuring, 818-819
networks. See Wi-Fi

wizards
Add Printer, 465-466
Automated System Recovery, 739
Files and Settings Transfer (FAST), 590
Program Compatibility
Windows 7, 615
Windows XP/Vista, 616-617

WLANs (Wireless LANs), configuring, 818-819
WOL (Wake on LAN), 94
Worldwide Interoperability for Microwave Access (WiMAX), 791
worms, 914
WPA (Wi-Fi Protected Access), 818, 883-884

WPS (Wi-Fi Protected Setup), 819
write-protect boot sector BIOS settings, 94
writeable/nonerasable Blu-ray media (BD-R), 532
writeable/nonerasable DVDs (DVD-R/DVD+R), 532
WS_FTP Pro, 794
WUXGA (Wide Ultra Extended Graphics Array), 370
WXGA (Wide XGA), 370
WXGA+ (Wide XGA Plus), 370

X - Z

x84, 606
x86, 606
XCOPY command, 625-627
xD-Picture Card cards, 523
XGA (Extended Graphics Array), 370
XP editions (Windows), 607

ZV (Zoomed Video) cards, 349