

- **Foreword** (p. xxiii)
- **Preface** (p. xxv)
- **Chapter 1 Understanding LEGO[Registered] Geometry** (p. 1)
- **Introduction** (p. 2)
- **Expressing Sizes and Units** (p. 2)
- **Squaring the LEGO World: Vertical Bracing** (p. 4)
- **Tilting the LEGO World: Diagonal Bracing** (p. 6)
- **TECHNIC Liftarms: Angles Built In** (p. 9)
- **Summary** (p. 11)
- **Chapter 2 Playing with Gears** (p. 13)
- **Introduction** (p. 14)
- **Counting Teeth** (p. 14)
- **Gearing Up and Down** (p. 15)
- **Riding That Train: The Geartrain** (p. 17)
- **Worming Your Way: The Worm Gear** (p. 19)
- **Limiting Strength with the Clutch Gear** (p. 20)
- **Placing and Fitting Gears** (p. 23)
- **Using Pulleys, Belts, and Chains** (p. 30)
- **Pulleys and Belts** (p. 31)
- **Chains** (p. 33)
- **Making a Difference: The Differential** (p. 35)
- **Summary** (p. 38)
- **Chapter 3 Controlling Motors** (p. 41)
- **Introduction** (p. 42)
- **Pacing, Trotting, and Galloping** (p. 43)
- **Internals of NXT Servo Motor** (p. 47)
- **Mounting Motors** (p. 48)
- **Wiring Motors** (p. 51)
- **Using Power Function Motors with the NXT** (p. 52)
- **Controlling Power** (p. 54)
- **Detecting Motor Overload** (p. 55)
- **Braking the Motor** (p. 56)
- **Coupling Motors** (p. 57)
- **Summary** (p. 59)
- **Chapter 4 Reading Sensors** (p. 61)
- **Introduction** (p. 62)
- **Digital Sensor Ports with the I²C (Inter-Integrated Circuit) Interface** (p. 62)
- **The Touch Sensor** (p. 65)
- **The Light Sensor** (p. 71)
- **Measuring Reflected Light** (p. 73)
- **Line Following** (p. 74)
- **The Ultrasonic Sensor** (p. 77)
- **Proximity Detection** (p. 79)
- **The Servo Motor Encoder (Rotation Sensor)** (p. 79)
- **Sensor Tips and Tricks** (p. 83)

- **Emulating a Rotation Sensor** (p. 84)
- **Connecting Multiple Sensors to the Same Port-Multiplexing** (p. 86)
- **Other Sensors** (p. 88)
- **The Passive Infrared Sensor** (p. 89)
- **The Pressure Sensor** (p. 90)
- **The Acceleration Sensor** (p. 92)
- **The Compass Sensor** (p. 94)
- **The NXT-to-RCX Communication Bridge** (p. 95)
- **The Color Sensor** (p. 96)
- **Summary** (p. 98)
- **Chapter 5 What's New with the NXT?** (p. 99)
- **Introduction** (p. 100)
- **Notable Enhancements** (p. 100)
- **Studless Construction** (p. 100)
- **Electrical Connectors** (p. 100)
- **Rechargeable Battery Pack** (p. 100)
- **Flash Memory** (p. 101)
- **Multiple Types of Sensors** (p. 101)
- **The NXT File System** (p. 101)
- **File-Handling Functions** (p. 102)
- **Using File Space Efficiently** (p. 103)
- **The LCD Screen** (p. 103)
- **Games** (p. 104)
- **Digital Interfaces and Bluetooth** (p. 105)
- **Bluetooth Communication** (p. 106)
- **A Surveillance Robot Using NXT and Bluetooth** (p. 106)
- **A Bluetooth-Based Remote Controller** (p. 107)
- **Spatial Motion Controllers** (p. 108)
- **I²C for Spatial Motion Controllers** (p. 109)
- **Future Possibilities** (p. 109)
- **An NXT Robot Controlled from a Web Server** (p. 109)
- **NXT Puppet Show** (p. 110)
- **GPS and the NXT** (p. 110)
- **Summary** (p. 111)
- **Chapter 6 Building Strategies** (p. 113)
- **Introduction** (p. 114)
- **Studless Building Techniques** (p. 114)
- **Maximizing Modularity** (p. 118)
- **Loading the Structure** (p. 121)
- **Putting It All Together: Chassis, Modularity, and Load** (p. 124)
- **Hybrid Robots: Using Studless and Studded LEGO Pieces** (p. 129)
- **Summary** (p. 131)
- **Chapter 7 Programming the NXT** (p. 133)
- **Introduction** (p. 134)
- **What Is the NXT Programmable Brick?** (p. 134)
- **MINDSTORMS: A Family of Programmable Bricks** (p. 136)

- **Introduction to Programming the NXT Brick** (p. 137)
- **How Does a Program Run?** (p. 138)
- **Using NXT-G** (p. 139)
- **Using RobotC** (p. 141)
- **Using Other Programming Languages** (p. 142)
- **Using NBC/NXC** (p. 143)
- **Using pbLUA** (p. 144)
- **Using LeJOS NXJ** (p. 144)
- **Using Other Programming Tools and Environments** (p. 144)
- **Code Samples** (p. 145)
- **Code Sample: A Simple Clock** (p. 145)
- **Code Sample: Following a Line** (p. 151)
- **Running Independent Tasks** (p. 157)
- **Summary** (p. 158)
- **Chapter 8 Playing Sounds and Music** (p. 159)
- **Introduction** (p. 160)
- **Communicating through Tones** (p. 160)
- **Playing Music** (p. 161)
- **Converting Sound and Music Files** (p. 163)
- **MIDI and MIDIBatch** (p. 163)
- **WAV2RSO** (p. 165)
- **The Sound Sensor** (p. 166)
- **Summary** (p. 167)
- **Chapter 9 Becoming Mobile** (p. 169)
- **Introduction** (p. 170)
- **Building the Simple Differential Drive** (p. 170)
- **Keeping a Straight Path** (p. 172)
- **Using Servo Motor Encoders to Go Straight** (p. 172)
- **Using Gears to Go Straight** (p. 173)
- **Using Casters to Go Straight** (p. 177)
- **Building a Skid-Steer Drive** (p. 180)
- **Building a Steering Drive** (p. 183)
- **Building a Synchro Drive** (p. 187)
- **Other Configurations** (p. 191)
- **Summary** (p. 192)
- **Chapter 10 Getting Pumped: Pneumatics** (p. 193)
- **Introduction** (p. 194)
- **Recalling Some Basic Science** (p. 194)
- **Pumps and Cylinders** (p. 195)
- **Controlling the Airflow** (p. 200)
- **Building Air Compressors** (p. 202)
- **Building a Pneumatic Engine** (p. 206)
- **Summary** (p. 210)
- **Chapter 11 Finding and Grabbing Objects** (p. 211)
- **Introduction** (p. 212)
- **Operating Hands and Grabbers** (p. 212)

- **Using Pneumatics to Drive Your Grabber** (p. 218)
- **Finding Objects** (p. 222)
- **Positioning the Grabber** (p. 225)
- **Distinguishing Objects and Obstacles** (p. 225)
- **Summary** (p. 228)
- **Chapter 12 Doing the Math** (p. 229)
- **Introduction** (p. 230)
- **Multiplying and Dividing** (p. 231)
- **Averaging Data** (p. 233)
- **Simple Averages** (p. 233)
- **Weighted Averages** (p. 237)
- **Using Interpolation** (p. 240)
- **Understanding Hysteresis** (p. 243)
- **Higher Math** (p. 245)
- **Summary** (p. 248)
- **Chapter 13 Knowing Where You Are** (p. 249)
- **Introduction** (p. 250)
- **Choosing Internal or External Guidance** (p. 250)
- **Looking for Landmarks: Absolute Positioning** (p. 251)
- **Following the Beam** (p. 255)
- **Map Matching Using Ultrasonic Sensor** (p. 259)
- **Combining Compass Sensor to Increase Precision** (p. 260)
- **Measuring Movement: Relative Positioning** (p. 260)
- **Measuring Movement: Acceleration Sensor** (p. 262)
- **Summary** (p. 263)
- **Chapter 14 Classic Projects** (p. 265)
- **Introduction** (p. 266)
- **Exploring Your Room** (p. 266)
- **Detecting Edges** (p. 269)
- **Variations on Obstacle Detection** (p. 270)
- **Following a Line** (p. 271)
- **Further Optimization of Line Following** (p. 277)
- **Summary** (p. 278)
- **Chapter 15 Building Robots That Walk** (p. 279)
- **Introduction** (p. 280)
- **The Theory behind Walking** (p. 280)
- **Building Legs** (p. 286)
- **Building a Four-Legged Robot** (p. 288)
- **Building a Six-Legged Steering Robot** (p. 291)
- **Designing Biped**s (p. 296)
- **Interlacing Legs** (p. 297)
- **COG Shifting** (p. 300)
- **Making Biped**s Turn (p. 302)
- **Summary** (p. 303)
- **Chapter 16 Robotic Animals** (p. 305)
- **Introduction** (p. 306)

- **Creating a Monkey** (p. 306)
- **Step 1 Center Motor Assembly** (p. 307)
- **Step 2 Shoulder Assembly** (p. 308)
- **Step 3 Shoulder/NXT Brick Bracing** (p. 309)
- **Step 4 Shoulder-to-Arms Support** (p. 310)
- **Step 5 Arm Motors** (p. 311)
- **Step 6 Monkey Fingers** (p. 312)
- **Step 7 NXT Brick Backbracing and Ultrasonic Sensor** (p. 313)
- **The Final Step: Wiring Your Monkey** (p. 314)
- **Programming Your Monkey** (p. 314)
- **Creating a Mouse** (p. 316)
- **Step 1 Mouse Frame and Motor Assembly** (p. 316)
- **Step 2 Castor Bottom** (p. 318)
- **Step 3 Tail Assembly** (p. 318)
- **Step 4 The Mouse Head Frame** (p. 319)
- **Step 5 Motorized Mouse Head Assembly** (p. 320)
- **Step 6 Mounting the Mouse Head to the Body** (p. 321)
- **Step 7 A Programming Example** (p. 322)
- **Creating Other Animals** (p. 324)
- **Summary** (p. 325)
- **Chapter 17 Solving a Maze** (p. 327)
- **Introduction** (p. 328)
- **Finding the Way Out** (p. 328)
- **Using the Left Side-Right Side Strategy** (p. 330)
- **Applying Other Strategies** (p. 332)
- **Building a Maze Runner** (p. 333)
- **Constructing the Maze Runner** (p. 333)
- **Programming the Runner** (p. 336)
- **Creating the Maze** (p. 339)
- **Building a Maze Solver** (p. 339)
- **Constructing the Maze Solver** (p. 339)
- **Programming the Solver** (p. 341)
- **Improving the Program** (p. 347)
- **Summary** (p. 348)
- **Chapter 18 Drawing and Writing** (p. 349)
- **Introduction** (p. 350)
- **Creating a Logo Turtle** (p. 350)
- **Building the Turtle** (p. 350)
- **Programming the Turtle** (p. 355)
- **Tape Writer** (p. 361)
- **Building the Writer** (p. 361)
- **Programming the Writer** (p. 366)
- **What to Write** (p. 369)
- **Further Suggestions** (p. 369)
- **Copying** (p. 369)
- **Emulating Handwriting** (p. 370)

- **Learning by Example** (p. 370)
- **Summary** (p. 371)
- **Chapter 19 Racing Against Time** (p. 373)
- **Introduction** (p. 374)
- **Hosting and Participating in Contests** (p. 374)
- **Optimizing Speed** (p. 376)
- **Drag Racing** (p. 376)
- **Combining Speed with Precision** (p. 377)
- **Line Following** (p. 378)
- **Wall Following** (p. 379)
- **Other Races** (p. 380)
- **Summary** (p. 381)
- **Chapter 20 Hand-to-Hand Combat** (p. 383)
- **Introduction** (p. 384)
- **Building a Robotic Sumo** (p. 384)
- **Setting the Rules** (p. 385)
- **Maximizing Strength and Traction** (p. 386)
- **Attack Strategies** (p. 388)
- **Finding the Enemy** (p. 388)
- **Using Speed** (p. 389)
- **Using a Transmission** (p. 390)
- **Other Sumo Tricks** (p. 391)
- **Getting Defensive** (p. 391)
- **Testing Your Sumo** (p. 392)
- **Summary** (p. 393)
- **Chapter 21 Searching for Precision** (p. 395)
- **Introduction** (p. 396)
- **Precise Positioning** (p. 396)
- **Shooting with Precision** (p. 397)
- **Fine Motor Skills of Your Robot** (p. 398)
- **Removing the Bricks** (p. 398)
- **Freeing the Magnets** (p. 399)
- **Fire Fighting in a Maze** (p. 401)
- **Playing Soccer** (p. 402)
- **Summary** (p. 403)
- **Appendix A Resources** (p. 405)
- **Introduction** (p. 406)
- **Bibliography** (p. 406)
- **General Interest Sites** (p. 407)
- **Chapter 1 Understanding LEGO Geometry** (p. 408)
- **Chapter 2 Playing with Gears** (p. 408)
- **Chapter 3 Controlling Motors** (p. 409)
- **Chapter 4 Reading Sensors** (p. 409)
- **Chapter 5 What's New with the NXT** (p. 411)
- **Chapter 6 Building Strategies** (p. 412)
- **Chapter 7 Programming the NXT** (p. 412)

- **Chapter 8 Playing Sounds and Music** (p. 413)
- **Chapter 9 Becoming Mobile** (p. 413)
- **Chapter 10 Getting Pumped: Pneumatics** (p. 414)
- **Chapter 11 Finding and Grabbing Objects** (p. 415)
- **Chapter 12 Doing the Math** (p. 415)
- **Chapter 13 Knowing Where You Are** (p. 416)
- **Chapter 14 Classic Projects** (p. 417)
- **Chapter 15 Building Robots that Walk** (p. 417)
- **Chapter 16 Robotic Animals** (p. 417)
- **Chapter 17 Solving a Maze** (p. 418)
- **Chapter 18 Drawing and Writing** (p. 418)
- **Chapter 19 Racing Against Time** (p. 419)
- **Chapter 20 Hand-to-Hand Combat** (p. 419)
- **Chapter 21 Searching for Precision** (p. 420)
- **Appendix B Matching Distances** (p. 421)
- **Appendix C Note Frequencies** (p. 427)
- **Appendix D Math Cheat Sheet** (p. 429)
- **Sensors** (p. 430)
- **Averages** (p. 430)
- **Interpolation** (p. 430)
- **Gears, Wheels, and Navigation** (p. 431)
- **Index** (p. 433)