

- Introduction p. xvii
- Part I The Basics p. 1
- Chapter 1 Electricity p. 3
 - Transduction: Electrical Basics p. 3
 - Electricity versus Electronics p. 5
 - How Electricity Flows p. 6
- Chapter 2 Shopping p. 9
 - Solderless Breadboard p. 9
 - Microcontrollers p. 10
 - Microcontroller Features (in Order of Priority) p. 10
 - High-Level Microcontroller Modules p. 12
 - Mid-Level Microcontroller Modules p. 12
 - Low-Level Solutions p. 13
 - Common Components p. 13
 - Switches p. 14
 - Resistors p. 15
 - Variable Resistors p. 15
 - Capacitors p. 16
 - Diodes p. 17
 - Transistors and Relays p. 18
 - Wires p. 19
 - Power Supply p. 20
 - Power Connector p. 21
 - Voltage Regulator p. 21
 - RC Servomotor p. 21
 - Serial Connector p. 22
 - Serial Cable p. 22
 - Project Box p. 23
 - Clock Crystals p. 23
 - Headers p. 23
 - Cable Ties p. 24
 - USB-to-Serial Adaptor p. 24
 - Tools p. 25
 - Shopping List p. 28
 - Bringing It All Back Home p. 32
- Chapter 3 Building Circuits p. 33
 - Schematics p. 33
 - Connection Symbols p. 34
 - Power Symbols p. 34
 - Finding Schematics p. 35
 - Breadboards p. 35
 - Where Does the Microcontroller Fit In? p. 36
 - Translating Schematics into Circuits p. 37
 - Using a Multimeter p. 39
 - Soldering p. 41
 - Powering the Breadboard p. 42

- Connecting the Quick and Dirty Way p. 42
- Connecting the Professional Way p. 44
- Voltage Regulators p. 44
- Be Neat p. 47
- Chapter 4 The Microcontroller p. 49
 - "Hello World!" Is the Hard Part p. 49
 - Where Does the Microcontroller Fit In? p. 49
 - Input p. 50
 - Output p. 50
 - Routing Inputs to Outputs p. 51
 - Identifying the Pins of the Microcontroller p. 51
 - Lower-Level Microcontrollers: External Clock p. 53
 - Your First Microcontroller-Based Circuit p. 53
 - Getting Your Program to the Chip p. 54
 - Programming Stamp-Like Modules p. 55
 - Stamp-Like Programming Hardware Connection p. 56
 - Stamp-Like Programming Software Environments p. 56
 - Programming Lower-Level Chips p. 59
 - The Hardware Programmer p. 59
 - Lower-Level Programming Software Environments p. 59
 - Debugging p. 62
- Chapter 5 Programming p. 65
 - The Good News p. 65
 - Flow Control: How a Computer "Reads" a Program p. 65
 - Loops p. 66
 - If Statements p. 67
 - Variables p. 68
 - Built-In Routines: Subroutines and Functions p. 72
 - Homemade Routines p. 75
 - Advanced Loops: While-Wend and For-Next p. 76
 - While-Wend or Do-While p. 77
 - For-Next p. 78
 - Pseudocode p. 80
 - Comments p. 81
 - Debugging p. 82
 - Good Debugging Habits p. 84
 - The Bad News p. 86
- Chapter 6 The "Big Four" Schematics, Programs, and Transducers p. 87
 - Digital Input p. 87
 - Transducers: Switches p. 87
 - Digital Input Circuit p. 90
 - Programming p. 91
 - Digital Output p. 96
 - Transducers p. 96
 - Circuit p. 99
 - Programming p. 101

- Analog Input p. 102
- Transducers p. 103
- Circuit p. 104
- Programming p. 108
- Pulsewidth Modulation for Input p. 111
- Analog Output p. 112
- Pulsewidth Modulation for Output p. 112
- LED Dimming p. 114
- DC Motor Speed Control p. 114
- Generating Tones p. 117
- RC Servo Motors p. 121
- From Analog In to Analog Out: Scaling Functions p. 127
- Conclusion p. 136
- Chapter 7 Communicating between Computers p. 137
 - Physical Agreement p. 138
 - Timing Agreement p. 139
 - Electrical Agreement p. 140
 - Package Size p. 140
 - Testing with an LED p. 149
 - Numbers or Letters: Using ASCII p. 141
 - Software for the Microcontroller p. 142
 - Serial Output from a Microcontroller p. 143
 - Testing with Terminal Software p. 149
 - Serial Input to a Microcontroller p. 150
 - Serial Freeze and Blocking Functions p. 153
 - Your Private Protocol p. 155
 - Punctuation p. 155
 - Call and Response p. 157
 - Sending Bigger Numbers p. 160
 - Send Your Numbers as Text p. 160
 - Scaling Your Numbers p. 160
 - Sending Big Numbers in Many Bytes p. 161
 - Serial Communication on a Multimedia Computer p. 162
 - Serial in Lingo p. 163
 - Serial in Processing p. 169
 - Serial in Java p. 171
 - Serial in Max/MSP p. 176
 - Conclusion p. 178
- Part II Advanced Methods p. 179
 - Chapter 8 Physical Interaction Design, or Techniques for Polite Conversation p. 181
 - The Conversation: Listening, Speaking, and Thinking p. 181
 - Listening p. 181
 - Speaking p. 184
 - Complex Responses p. 187
 - Random Numbers p. 188
 - Edge Detection p. 195

- Thinking p. 189
- Techniques for Effective Interaction p. 189
- Multitasking p. 189
- Analog Sensors: Thresholds, Edges, and Peaks p. 199
- Debouncing p. 205
- Smoothing, Sampling, and Averaging p. 207
- Conclusion p. 216
- Chapter 9 Sensing Movement p. 217
 - Assessing the Problem p. 217
 - How Ranging Sensors Work p. 219
 - Detecting Presence p. 220
 - Foot Switches p. 220
 - Photoelectric Switches p. 220
 - Motion Detectors p. 221
 - Magnetic Switches p. 222
 - Determining Position p. 223
 - IR Sensors p. 223
 - Ultrasonic Sensors p. 225
 - Other Position Sensors p. 227
 - Determining Rotation p. 228
 - Potentiometers p. 228
 - Accelerometers p. 229
 - Compass p. 233
 - Encoders p. 233
 - Speed of Rotation p. 234
 - Gyroscopes p. 234
 - Video Tracking p. 234
 - Video Tracking in Director MX p. 237
 - Video Tracking in Max/MSP p. 239
 - Video Tracking in Processing p. 240
 - Video Tracking in Java p. 242
 - CMUcam p. 245
 - Identity p. 246
 - Conclusion p. 248
- Chapter 10 Making Movement p. 249
 - Types of Motion, Types of Motors p. 249
 - Characteristics of Motors p. 251
 - Special Electrical Needs of Motors p. 252
 - Inductive Loads and Back Voltage p. 252
 - Smoothing Current Drops Using Decoupling Capacitors p. 254
 - Controlling DC Motors and Gearhead Motors p. 255
 - Controlling Motors p. 255
 - Controlling RC Servos p. 259
 - Controlling Stepper Motors p. 259
 - Unipolar Stepper Motors p. 260
 - Bipolar Stepper Motors p. 263

- Controlling Solenoids p. 269
- Basic Mechanics: Converting Motor Motion to Usable Motion p. 271
- Simple Machines p. 272
- Joints p. 278
- Linkages p. 279
- Construction p. 281
- Foamcore p. 282
- Tupperware p. 282
- Wood p. 282
- Plexiglas p. 282
- Adhesives p. 282
- Erector, Meccano, K'nex p. 283
- Black Cloth p. 283
- Conclusion p. 283
- Chapter 11 Touch Me p. 285
 - Force-Sensitive Resistors p. 285
 - Homegrown FSRs p. 286
 - Flex Sensors p. 287
 - Pressure Sensors p. 287
 - Sensing Touch Using Capacitance Sensors p. 287
 - Off-the-Shelf Touch Interfaces p. 289
 - Sensing Vibrations Using Piezoelectric Sensors p. 289
 - Creating Vibrations p. 291
 - Taking Your Temperature p. 291
 - Cooling Things Off and Heating Them Up p. 292
 - Getting Under Your Skin p. 293
 - Force Feedback p. 294
 - Conclusion p. 294
- Chapter 12 More Communication between Devices p. 295
 - Synchronous and Asynchronous Communication p. 296
 - Asynchronous Serial Protocols p. 296
 - Learning a Protocol p. 297
 - RS-232 Boxes p. 298
 - Global Positioning System Data p. 299
 - Finding a GPS Receiver p. 299
 - Learning the GPS Protocol p. 299
 - MIDI p. 302
 - MIDI Physical and Electrical Connections p. 303
 - Sending MIDI Messages p. 305
 - Connecting to the Internet p. 314
 - Network Connection Using the CoBox Micro p. 316
 - Network Connection in Lingo p. 327
 - Network Connection in Processing p. 330
 - Connecting over Telephone Lines Using Modems p. 332
 - Special-Function ICs and Modules p. 333
 - Synchronous Serial Protocols p. 336

- Wireless Serial Communication p. 344
- Infrared Serial Communication p. 345
- RF Serial Communication p. 345
- Bluetooth p. 349
- Wireless Ethernet p. 350
- Wireless Ethernet Security p. 351
- Conclusion p. 352
- Chapter 13 Controlling Sound and Light p. 353
 - Sound p. 353
 - Sound Input p. 354
 - Synthesizing Sound on a Microcontroller p. 359
 - Speech p. 360
 - Telephone Sounds p. 361
 - Light p. 364
 - BX-Basic p. 364
 - Light Sensors p. 365
 - DC Lighting Control p. 366
 - Controlling Video Displays p. 370
 - AC Lighting Control p. 367
 - Screen Graphics p. 370
 - Controlling Character Displays p. 370
 - Linear Media on a Multimedia Computer p. 376
 - Linear Media on a Microcontroller p. 376
 - Single-Board Computers p. 379
 - Conclusion p. 380
- Chapter 14 Managing Multiple Inputs and Outputs p. 381
 - Setting Groups of Pins in Parallel p. 381
 - Bitwise Operations p. 385
 - Running Out of Pins p. 388
 - Resistor Ladders as Analog Input p. 388
 - Row-Column Scanning p. 389
 - Row-Column Scanning Analog Inputs p. 396
 - Row-Column Scanning Outputs p. 396
 - Shift Registers p. 397
 - Multiplexers p. 404
 - Latches p. 409
 - Conclusion p. 414
- Appendix A Choosing a Microcontroller p. 415
 - Costs p. 415
 - Time p. 416
 - Expandability/Compatibility p. 416
 - Physical and Electrical Characteristics p. 416
 - The Microcontrollers Covered in This Book p. 417
 - Parallax Basic Stamp 2 p. 417
 - NetMedia BX-24 p. 418
 - Basic Micro Basic Atom Pro24 p. 418

- Microchip PIC p. 418
- PIC Programmers p. 420
- Appendix B Recommended Suppliers p. 423
- The Staples p. 423
- Microcontrollers p. 423
- Electronics Parts p. 424
- Software p. 424
- The Extras p. 425
- Hardware p. 425
- Software p. 432
- Appendix C Schematic Glossary p. 433
- Common Schematic Terms and Abbreviations p. 441
- Index p. 443