

TABLE OF CONTENTS

| | |
|--|------------|
| Acknowledgments | xix |
| Introduction | 1 |
| The Great Game of Programming | 1 |
| Book Features | 2 |
| I Want Your Feedback | 6 |
| An Overview | 6 |
| PART 1: THE BASICS | |
| 1. The C# Programming Language | 9 |
| What is C#? | 9 |
| What is .NET? | 10 |
| 2. Getting an IDE | 11 |
| A Comparison of IDEs | 11 |
| Installing Visual Studio | 13 |
| 3. Hello World: Your First Program | 15 |
| Creating a New Project | 15 |
| A Brief Tour of Visual Studio | 17 |
| Compiling and Running Your Program | 18 |
| Syntax and Structure | 19 |
| Beyond Hello World | 24 |
| Compiler Errors, Debuggers, and Configurations | 27 |
| 4. Comments | 29 |
| How to Make Good Comments | 30 |

| | |
|---|-----------|
| 5. Variables | 32 |
| What is a Variable? | 32 |
| Creating and Using Variables in C# | 33 |
| Integers | 34 |
| Reading from a Variable Does Not Change It | 35 |
| Clever Variable Tricks | 35 |
| Variable Names | 36 |
| 6. The C# Type System | 38 |
| Representing Data in Binary | 38 |
| Integer Types | 39 |
| Text: Characters and Strings | 42 |
| Floating-Point Types | 43 |
| The bool Type | 45 |
| Type Inference | 46 |
| The Convert Class and the Parse Methods | 47 |
| 7. Math | 50 |
| Operations and Operators | 50 |
| Addition, Subtraction, Multiplication, and Division | 51 |
| Compound Expressions and Order of Operations | 52 |
| Special Number Values | 54 |
| Integer Division vs. Floating-Point Division | 54 |
| Division by Zero | 55 |
| More Operators | 55 |
| Updating Variables | 56 |
| Working with Different Types and Casting | 58 |
| Overflow and Roundoff Error | 60 |
| The Math and MathF Classes | 61 |
| 8. Console 2.0 | 63 |
| The Console Class | 63 |
| Sharpening Your String Skills | 65 |
| 9. Decision Making | 69 |
| The if Statement | 69 |
| The else Statement | 73 |
| else if Statements | 73 |
| Relational Operators: == , != , < , > , <= , >= | 74 |
| Using bool in Decision Making | 75 |
| Logical Operators | 76 |
| Nesting if Statements | 77 |
| The Conditional Operator | 77 |
| 10. Switches | 79 |

| | |
|--|------------|
| Switch Statements | 80 |
| Switch Expressions | 81 |
| Switches as a Basis for Pattern Matching | 82 |
| 11. Looping | 84 |
| The while Loop | 84 |
| The do/while Loop | 86 |
| The for Loop | 86 |
| break Out of Loops and continue to the Next Pass | 87 |
| Nesting Loops | 88 |
| 12. Arrays | 90 |
| Creating Arrays | 91 |
| Getting and Setting Values in Arrays | 91 |
| Other Ways to Create Arrays | 93 |
| Some Examples with Arrays | 94 |
| The foreach Loop | 95 |
| Multi-Dimensional Arrays | 95 |
| 13. Methods | 97 |
| Defining a Method | 97 |
| Calling a Method | 99 |
| Passing Data to a Method | 101 |
| Returning a Value from a Method | 103 |
| Method Overloading | 104 |
| Simple Methods with Expressions | 105 |
| XML Documentation Comments | 106 |
| The Basics of Recursion | 107 |
| 14. Memory Management | 109 |
| Memory and Memory Management | 110 |
| The Stack | 110 |
| Fixed-Size Stack Frames | 115 |
| The Heap | 115 |
| Cleaning Up Heap Memory | 122 |
| PART 2: OBJECT-ORIENTED PROGRAMMING | |
| 15. Object-Oriented Concepts | 129 |
| Object-Oriented Concepts | 129 |
| 16. Enumerations | 132 |
| Enumeration Basics | 133 |
| Underlying Types | 136 |
| 17. Tuples | 137 |

| | |
|--|------------|
| The Basics of Tuples | 138 |
| Tuple Element Names | 139 |
| Tuples and Methods | 139 |
| More Tuple Examples | 140 |
| Deconstructing Tuples | 141 |
| Tuples and Equality | 142 |
| 18. Classes | 144 |
| Defining a New Class | 145 |
| Instances of Classes | 147 |
| Constructors | 148 |
| Object-Oriented Design | 153 |
| 19. Information Hiding | 155 |
| The public and private Accessibility Modifiers | 156 |
| Abstraction | 159 |
| Type Accessibility Levels and the internal Modifier | 160 |
| 20. Properties | 163 |
| The Basics of Properties | 163 |
| Auto-Implemented Properties | 166 |
| Immutable Fields and Properties | 167 |
| Object_INITIALIZER Syntax and Init Properties | 168 |
| Anonymous Types | 169 |
| 21. Static | 170 |
| Static Members | 170 |
| Static Classes | 173 |
| 22. Null References | 174 |
| Null or Not? | 175 |
| Checking for Null | 176 |
| 23. Object-Oriented Design | 178 |
| Requirements | 179 |
| Designing the Software | 180 |
| Creating Code | 185 |
| How to Collaborate | 187 |
| Baby Steps | 189 |
| 24. The Catacombs of the Class | 190 |
| The Five Prototypes | 190 |
| Object-Oriented Design | 193 |
| Tic-Tac-Toe | 195 |
| 25. Inheritance | 197 |
| Inheritance and the object Class | 198 |
| Choosing Base Classes | 200 |

| | |
|---|------------|
| Constructors | 201 |
| Casting and Checking for Types | 203 |
| The protected Access Modifier | 204 |
| Sealed Classes | 204 |
| 26. Polymorphism | 206 |
| Abstract Methods and Classes | 208 |
| New Methods | 209 |
| 27. Interfaces | 211 |
| Defining Interfaces | 212 |
| Implementing Interfaces | 213 |
| Interfaces and Base Classes | 214 |
| Explicit Interface Implementations | 214 |
| Default Interface Methods | 215 |
| 28. Structs | 218 |
| Memory and Constructors | 219 |
| Classes vs. Structs | 220 |
| Built-In Type Aliases | 224 |
| Boxing and Unboxing | 225 |
| 29. Records | 227 |
| Records | 227 |
| Advanced Scenarios | 229 |
| Struct- and Class-Based Records | 230 |
| When to Use a Record | 231 |
| 30. Generics | 232 |
| The Motivation for Generics | 232 |
| Defining a Generic Type | 235 |
| Generic Methods | 237 |
| Generic Type Constraints | 237 |
| The default Operator | 239 |
| 31. The Fountain of Objects | 241 |
| The Main Challenge | 242 |
| Expansions | 244 |
| 32. Some Useful Types | 247 |
| The Random Class | 248 |
| The DateTime Struct | 249 |
| The TimeSpan Struct | 250 |
| The Guid Struct | 251 |
| The List<T> Class | 252 |
| The IEnumerable<T> Interface | 255 |
| The Dictionary<TKey, TValue> Class | 256 |

| | |
|--|------------|
| The Nullable<T> Struct | 258 |
| ValueTuple Structs | 258 |
| The StringBuilder Class | 259 |
| PART 3: ADVANCED TOPICS | |
| 33. Managing Larger Programs | 263 |
| Using Multiple Files | 263 |
| Namespaces and using Directives | 264 |
| Traditional Entry Points | 268 |
| 34. Methods Revisited | 271 |
| Optional Arguments | 271 |
| Named Arguments | 272 |
| Variable Number of Parameters | 272 |
| Combinations | 273 |
| Passing by Reference | 273 |
| Deconstructors | 276 |
| Extension Methods | 277 |
| 35. Error Handling and Exceptions | 280 |
| Handling Exceptions | 281 |
| Throwing Exceptions | 283 |
| The finally Block | 284 |
| Exception Guidelines | 285 |
| Advanced Exception Handling | 288 |
| 36. Delegates | 291 |
| Delegate Basics | 291 |
| The Action , Func , and Predicate Delegates | 294 |
| MulticastDelegate and Delegate Chaining | 295 |
| 37. Events | 296 |
| C# Events | 296 |
| Event Leaks | 300 |
| EventHandler and Friends | 300 |
| Custom Event Accessors | 301 |
| 38. Lambda Expressions | 303 |
| Lambda Expression Basics | 303 |
| Lambda Statements | 305 |
| Closures | 306 |
| 39. Files | 308 |
| The File Class | 308 |
| String Manipulation | 310 |
| File System Manipulation | 312 |

| | |
|---|------------|
| Other Ways to Access Files | 313 |
| 40. Pattern Matching | 316 |
| The Constant Pattern and the Discard Pattern | 317 |
| The Monster Scoring Problem | 317 |
| The Type and Declaration Patterns | 318 |
| Case Guards | 319 |
| The Property Pattern | 319 |
| Relational Patterns | 320 |
| The and , or , and not Patterns | 321 |
| The Positional Pattern | 321 |
| The var Pattern | 322 |
| Parenthesized Patterns | 322 |
| Patterns with Switch Statements and the is Keyword | 322 |
| Summary | 323 |
| 41. Operator Overloading | 325 |
| Operator Overloading | 326 |
| Indexers | 327 |
| Custom Conversions | 329 |
| 42. Query Expressions | 333 |
| Query Expression Basics | 334 |
| Method Call Syntax | 336 |
| Advanced Queries | 338 |
| Deferred Execution | 340 |
| LINQ to SQL | 341 |
| 43. Threads | 343 |
| The Basics of Threads | 343 |
| Using Threads | 344 |
| Thread Safety | 347 |
| 44. Asynchronous Programming | 351 |
| Threads and Callbacks | 352 |
| Using Tasks | 353 |
| Who Runs My Code? | 356 |
| Some Additional Details | 358 |
| 45. Dynamic Objects | 361 |
| Dynamic Type Checking | 362 |
| Dynamic Objects | 362 |
| Emulating Dynamic Objects with Dictionaries | 363 |
| Using ExpandoObject | 363 |
| Extending DynamicObject | 364 |
| When to Use Dynamic Object Variations | 365 |

| | |
|--|------------|
| 46. Unsafe Code | 367 |
| Unsafe Contexts | 368 |
| Pointer Types | 368 |
| Fixed Statements | 369 |
| Stack Allocations | 370 |
| Fixed-Size Arrays | 370 |
| The sizeof Operator | 370 |
| The nint and nuint Types | 371 |
| Calling Native Code with Platform Invocation Services | 371 |
| 47. Other Language Features | 373 |
| Iterators and the yield Keyword | 374 |
| Constants | 375 |
| Attributes | 376 |
| Reflection | 378 |
| The nameof Operator | 379 |
| Nested Types | 379 |
| Even More Accessibility Modifiers | 380 |
| Bit Manipulation | 380 |
| using Statements and the IDisposable Interface | 384 |
| Preprocessor Directives | 385 |
| Command-Line Arguments | 387 |
| Partial Classes | 387 |
| The Notorious goto Keyword | 388 |
| Generic Covariance and Contravariance | 389 |
| Checked and Unchecked Contexts | 391 |
| Volatile Fields | 392 |
| 48. Beyond a Single Project | 393 |
| Outgrowing a Single Project | 393 |
| NuGet Packages | 396 |
| 49. Compiling in Depth | 399 |
| Hardware | 399 |
| Assembly | 401 |
| Programming Languages | 401 |
| Instruction Set Architectures | 402 |
| Virtual Machines and Runtimes | 402 |
| 50. .NET | 404 |
| The History of .NET | 404 |
| The Components of .NET | 405 |
| Common Infrastructure | 405 |
| Base Class Library | 406 |
| App Models | 407 |

| | |
|---|------------|
| 51. Publishing | 409 |
| Build Configurations | 409 |
| Publish Profiles | 410 |
| PART 4: THE ENDGAME | |
| 52. The Final Battle | 417 |
| Overview | 418 |
| Core Challenges | 419 |
| Expansions | 423 |
| 53. Into Lands Uncharted | 429 |
| Keep Learning | 429 |
| Where Do I Go to Get Help? | 430 |
| Parting Words | 431 |
| PART 5: BONUS LEVELS | |
| A. Visual Studio | 435 |
| Windows | 435 |
| The Options Dialog | 441 |
| B. Compiler Errors | 442 |
| Code Problems: Errors, Warnings, and Messages | 442 |
| How to Resolve Compiler Errors | 443 |
| Common Compiler Errors | 445 |
| C. Debugging Your Code | 447 |
| Print Debugging | 448 |
| Using a Debugger | 448 |
| Breakpoints | 449 |
| Stepping Through Code | 450 |
| Breakpoint Conditions and Actions | 451 |
| Glossary | 452 |
| Index | 468 |

