Table of Contents

Preface **17**
About the Authors 19
How This Book is Organized 20
Who Should Buy This Book? 20
Where to Find Answers to Review Questions and Exercises 20
How to Report Errata 20
Conventions Used in This Book 21

Section 1 Introductory Knowledge **23**

Chapter 1 How a Computer Works ***25***
1.1 Introduction 25
1.2 What is Hardware? 25
1.3 What is Software? 26
1.4 How a Computer Executes (Runs) a Program 26
1.5 Compilers and Interpreters 26
1.6 What is Source Code? 27
1.7 Review Questions: True/False 27
1.8 Review Questions: Multiple Choice 28

Chapter 2 C++ ***31***
2.1 What is C++? 31
2.2 What is the Difference Between a Script and a Program? 31
2.3 Why You Should Learn C++ 31
2.4 How C++ Works 31

Chapter 3 Software Packages to Install ***33***
3.1 Boost C++ Libraries 33
3.2 How to Set Up Boost C++ Libraries 33
3.3 Installing the C++ Compiler and the Debugger for Windows 33
3.4 NetBeans IDE 38
3.5 How to Set Up NetBeans IDE 38

Review Questions in "Introductory Knowledge" ***45***

Section 2 Getting Started with C++ **47**

Chapter 4 Introduction to Basic Algorithmic Concepts ***49***
4.1 What is an Algorithm? 49
4.2 The Algorithm for Making a Cup of Tea 49
4.3 Properties of an Algorithm 49
4.4 Okay About Algorithms. But What is a Computer Program Anyway? 50
4.5 The Party of Three! 50
4.6 The Three Main Stages Involved in Creating an Algorithm 50
4.7 Flowcharts 51
Exercise 4.7-1 Finding the Average Value of Three Numbers 52
4.8 What are "Reserved Words"? 53

4.9 What is the Difference Between a Statement and a Command? 54
4.10 What is Structured Programming? 54
4.11 The Three Fundamental Control Structures 54
Exercise 4.11-1 Understanding Control Structures Using Flowcharts 54
4.12 Your First C++ Program 55
4.13 What is the Difference Between Syntax Errors and Logic Errors? 56
4.14 Commenting Your Code 56
4.15 User-Friendly Programs 57
4.16 Review Questions: True/False 58
4.17 Review Questions: Multiple Choice 59

Chapter 5 Variables and Constants 61
5.1 What is a Variable? 61
5.2 What is a Constant? 63
5.3 How Many Types of Variables and Constants Exist in C++? 65
5.4 Rules for Naming Variables in C++ 66
5.5 Rules for Naming Constants in C++ 66
5.6 What Does the Phrase "Declare a Variable" Mean? 66
5.7 How to Declare Variables in C++ 67
5.8 How to Declare Constants in C++ 68
5.9 Review Questions: True/False 68
5.10 Review Questions: Multiple Choice 69
5.11 Review Exercises 70

Chapter 6 Handling Input and Output 71
6.1 Which Statement Outputs Messages and Results on a User's Screen? 71
6.2 How to Output Special Characters 72
6.3 Which Statement Lets the User Enter Data? 74
6.4 Review Questions: True/False 76
6.5 Review Questions: Multiple Choice 76

Chapter 7 Operators 77
7.1 The Value Assignment Operator 77
7.2 Arithmetic Operators 79
7.3 What is the Precedence of Arithmetic Operators? 80
7.4 Compound Assignment Operators 81
Exercise 7.4-1 Which C++ Statements are Syntactically Correct? 81
Exercise 7.4-2 Finding Variable Types 82
7.5 Incrementing/Decrementing Operators 82
7.6 String Operators 84
Exercise 7.6-1 Concatenating Names 84
7.7 Review Questions: True/False 85
7.8 Review Questions: Multiple Choice 85
7.9 Review Exercises 87

Chapter 8 Trace Tables 89
8.1 What is a Trace Table? 89
Exercise 8.1-1 Creating a Trace Table 90

Exercise 8.1-2 Swapping Values of Variables ... 90
Exercise 8.1-3 Swapping Values of Variables – A Second Approach ... 93
Exercise 8.1-4 Creating a Trace Table ... 93
Exercise 8.1-5 Creating a Trace Table ... 94
8.2 Review Questions: True/False ... 95
8.3 Review Exercises ... 95

Chapter 9 Using NetBeans IDE ... 97
9.1 Creating a New C++Project ... 97
9.2 Writing and Executing a C++ Program ... 99
9.3 What "Debugging" Means ... 102
9.4 Debugging C++ Programs with NetBeans IDE ... 103
9.5 Review Exercises ... 108

Review Questions in "Getting Started with C++" ... 111

Section 3 Sequence Control Structures ... 113

Chapter 10 Introduction to Sequence Control Structures ... 115
10.1 What is the Sequence Control Structure? ... 115
Exercise 10.1-1 Calculating the Area of a Parallelogram ... 115
Exercise 10.1-2 Calculating the Area of a Circle ... 116
Exercise 10.1-3 Calculating Fuel Economy ... 117
Exercise 10.1-4 Where is the Car? Calculating Distance Traveled ... 117
Exercise 10.1-5 Kelvin to Fahrenheit ... 118
Exercise 10.1-6 Calculating Sales Tax ... 119
Exercise 10.1-7 Calculating a Sales Discount ... 119
Exercise 10.1-8 Calculating the Sales Tax Rate and Discount ... 120
10.2 Review Exercises ... 121

Chapter 11 Manipulating Numbers ... 123
11.1 Introduction ... 123
11.2 Useful Mathematical Functions ... 124
Exercise 11.2-1 Calculating the Distance Between Two Points ... 130
Exercise 11.2-2 How Far Did the Car Travel? ... 131
11.3 Review Questions: True/False ... 132
11.4 Review Questions: Multiple Choice ... 133
11.5 Review Exercises ... 134

Chapter 12 Complex Mathematical Expressions ... 137
12.1 Writing Complex Mathematical Expressions ... 137
Exercise 12.1-1 Representing Mathematical Expressions in C++ ... 137
Exercise 12.1-2 Writing a Mathematical Expression in C++ ... 138
Exercise 12.1-3 Writing a Complex Mathematical Expression in C++ ... 138
12.2 Review Exercises ... 140

Chapter 13 Exercises With a Quotient and a Remainder ... 143
13.1 Introduction ... 143
Exercise 13.1-1 Calculating the Quotient and Remainder of Integer Division ... 143
Exercise 13.1-2 Finding the Sum of Digits ... 144
Exercise 13.1-3 Displaying an Elapsed Time ... 148
Exercise 13.1-4 Reversing a Number ... 150

13.2 Review Exercises 150

Chapter 14 Manipulating Strings 153
14.1 Introduction 153
14.2 The Position of a Character in a String 154
14.3 Retrieving an Individual Character From a String 154
Exercise 14.3-1 Displaying a String Backwards 155
14.4 Useful String Functions 156
Exercise 14.4-1 Switching the Order of Names 160
Exercise 14.4-2 Creating a Login ID 161
Exercise 14.4-3 Creating a Random Word 162
14.5 Review Questions: True/False 162
14.6 Review Questions: Multiple Choice 163
14.7 Review Exercises 165

Review Questions in "Sequence Control Structures" 167

Section 4 Decision Control Structures 169

Chapter 15 Introduction to Decision Control Structures 171
15.1 What is a Decision Control Structure? 171
15.2 What is a Boolean Expression? 171
15.3 How to Write Boolean Expressions 171
Exercise 15.3-1 Filling in the Table 172
15.4 Logical Operators and Complex Boolean Expressions 173
15.5 What is the Order of Precedence of Logical Operators? 174
15.6 What is the Order of Precedence of Arithmetic, Comparison, and Logical Operators? 174
Exercise 15.6-1 Filling in the Truth Table 174
Exercise 15.6-2 Calculating the Results of Complex Boolean Expressions 176
Exercise 15.6-3 Converting English Sentences to Boolean Expressions 176
15.7 How to Negate Boolean Expressions 178
Exercise 15.7-1 Negating Boolean Expressions 179
15.8 Review Questions: True/False 179
15.9 Review Questions: Multiple Choice 181
15.10 Review Exercises 182

Chapter 16 The Single-Alternative Decision Structure 185
16.1 The Single-Alternative Decision Structure 185
Exercise 16.1-1 Trace Tables and Single-Alternative Decision Structures 186
Exercise 16.1-2 The Absolute Value of a Number 187
16.2 Review Questions: True/False 188
16.3 Review Questions: Multiple Choice 189
16.4 Review Exercises 190

Chapter 17 The Dual-Alternative Decision Structure 193
17.1 The Dual-Alternative Decision Structure 193
Exercise 17.1-1 Finding the Output Message 193
Exercise 17.1-2 Trace Tables and Dual-Alternative Decision Structures 194
Exercise 17.1-3 Who is the Greatest? 195
Exercise 17.1-4 Finding Odd and Even Numbers 197

Exercise 17.1-5 Weekly Wages ... 198
17.2 Review Questions: True/False ... 200
17.3 Review Questions: Multiple Choice ... 200
17.4 Review Exercises ... 201

Chapter 18 The Multiple-Alternative Decision Structure ... 205
18.1 The Multiple-Alternative Decision Structure ... 205
Exercise 18.1-1 Trace Tables and Multiple-Alternative Decision Structures ... 206
Exercise 18.1-2 Counting the Digits ... 208
18.2 Review Questions: True/False ... 209
18.3 Review Exercises ... 209

Chapter 19 The Case Decision Structure ... 213
19.1 The Case Decision Structure ... 213
Exercise 19.1-1 The Days of the Week ... 215
19.2 Review Questions: True/False ... 217
19.3 Review Exercises ... 217

Chapter 20 Nested Decision Control Structures ... 221
20.1 What are Nested Decision Control Structures? ... 221
Exercise 20.1-1 Trace Tables and Nested Decision Control Structures ... 222
Exercise 20.1-2 Positive, Negative or Zero? ... 224
20.2 A Mistake That You Will Probably Make! ... 225
20.3 Review Questions: True/False ... 229
20.4 Review Exercises ... 229

Chapter 21 Tips and Tricks with Decision Control Structures ... 233
21.1 Introduction ... 233
21.2 Choosing a Decision Control Structure ... 233
21.3 Streamlining the Decision Control Structure ... 233
Exercise 21.3-1 "Shrinking" the Algorithm ... 235
Exercise 21.3-2 "Shrinking" the C++ Program ... 235
Exercise 21.3-3 "Shrinking" the Algorithm ... 236
21.4 Merging Two or More Single-Alternative Decision Structures ... 239
Exercise 21.4-1 Merging the Decision Control Structures ... 240
Exercise 21.4-2 Merging the Decision Control Structures ... 240
21.5 Replacing Two Single-Alternative Decision Structures with a Dual-Alternative One ... 242
Exercise 21.5-1 "Merging" the Decision Control Structures ... 243
21.6 What is Code Indentation and Why is it so Important? ... 244
21.7 Using the "From Inner to Outer" Method in Decision Control Structures ... 245
21.8 Review Questions: True/False ... 247
21.9 Review Questions: Multiple Choice ... 247
21.10 Review Exercises ... 249

Chapter 22 Flowcharts with Decision Control Structures ... 253
22.1 Introduction ... 253
22.2 Converting C++ Programs to Flowcharts ... 253
Exercise 22.2-1 Designing the Flowchart ... 254
Exercise 22.2-2 Designing the Flowchart ... 255
Exercise 22.2-3 Designing the Flowchart ... 256

Exercise 22.2-4 Designing the Flowchart ... 257
22.3 Converting Flowcharts to C++ Programs ... 258
Exercise 22.3-1 Writing the C++ Program ... 259
Exercise 22.3-2 Writing the C++ Program ... 260
Exercise 22.3-3 Writing the C++ Program ... 261
Exercise 22.3-4 Writing the C++ Program ... 263
Exercise 22.3-5 Writing the C++ Program ... 265
22.4 Review Exercises ... 266

Chapter 23 More Exercises with Decision Control Structures ... 273
23.1 Simple Exercises with Decision Control Structures ... 273
Exercise 23.1-1 Both Odds or Both Evens? ... 273
Exercise 23.1-2 Validating Data Input and Finding if a Number is Exactly Divisible by both 5 and 8. ... 273
Exercise 23.1-3 Is it an Integer? ... 276
Exercise 23.1-4 Converting Gallons to Liters, and Vice Versa ... 277
Exercise 23.1-5 Converting Gallons to Liters, and Vice Versa (with Data Validation) ... 278
Exercise 23.1-6 Where is the Tollkeeper? ... 280
Exercise 23.1-7 The Most Scientific Calculator Ever! ... 281
23.2 Finding Minimum and Maximum Values with Decision Control Structures ... 281
Exercise 23.2-1 Finding the Name of the Heaviest Person ... 283
23.3 Exercises with Series of Consecutive Ranges of Values ... 284
Exercise 23.3-1 Calculating the Discount ... 285
Exercise 23.3-2 Validating Data Input and Calculating the Discount ... 286
Exercise 23.3-3 Sending a Parcel ... 288
Exercise 23.3-4 Progressive Rates and Electricity Consumption ... 290
Exercise 23.3-5 Progressive Rates and Text Messaging Services ... 291
23.4 Exercises of a General Nature with Decision Control Structures ... 292
Exercise 23.4-1 Finding a Leap Year ... 292
Exercise 23.4-2 Displaying the Days of the Month ... 293
Exercise 23.4-3 Is the Number a Palindrome? ... 294
Exercise 23.4-4 Checking for Proper Capitalization and Punctuation ... 296
23.5 Review Exercises ... 297

Review Questions in "Decision Control Structures" ... 301

Section 5 Loop Control Structures ... 303

Chapter 24 Introduction to Loop Control Structures ... 305
24.1 What is a Loop Control Structure? ... 305
24.2 From Sequence Control to Loop Control Structures ... 305
24.3 Review Questions: True/False ... 307

Chapter 25 The Pre-Test Loop Structure ... 309
25.1 The Pre-Test Loop Structure ... 309
Exercise 25.1-1 Designing the Flowchart and Counting the Total Number of Iterations ... 310
Exercise 25.1-2 Counting the Total Number of Iterations ... 311
Exercise 25.1-3 Designing the Flowchart and Counting the Total Number of Iterations ... 312
Exercise 25.1-4 Counting the Total Number of Iterations ... 313
Exercise 25.1-5 Finding the Sum of 4 Numbers ... 313
Exercise 25.1-6 Finding the Product of 20 Numbers ... 315
Exercise 25.1-7 Finding the Product of N Numbers ... 316

Exercise 25.1-8 Finding the Sum of Odd Numbers ... 316
Exercise 25.1-9 Finding the Sum of an Unknown Quantity of Numbers ... 317
25.2 Review Questions: True/False ... 319
25.3 Review Questions: Multiple Choice ... 320
25.4 Review Exercises ... 321

Chapter 26 The Post-Test Loop Structure ... 325
26.1 The Post-Test Loop Structure ... 325
Exercise 26.1-1 Designing the Flowchart and Counting the Total Number of Iterations ... 326
Exercise 26.1-2 Counting the Total Number of Iterations ... 327
Exercise 26.1-3 Designing the Flowchart and Counting the Total Number of Iterations ... 328
Exercise 26.1-4 Counting the Total Number of Iterations ... 329
Exercise 26.1-5 Finding the Product of N Numbers ... 330
Exercise 26.1-6 Finding the Product of an Unknown Quantity of Numbers ... 331
26.2 Review Questions: True/False ... 332
26.3 Review Questions: Multiple Choice ... 333
26.4 Review Exercises ... 334

Chapter 27 Counted Loop Structures ... 339
27.1 Counted Loop Structures ... 339
Exercise 27.1-1 Designing the Flowchart and Creating the Trace Table ... 342
Exercise 27.1-2 Creating the Trace Table ... 343
Exercise 27.1-3 Counting the Total Number of Iterations ... 345
Exercise 27.1-4 Finding the Sum of 10 Numbers ... 345
Exercise 27.1-5 Finding the Square Roots from 0 to N ... 346
27.2 Rules that Apply to Counted Loop Structures ... 347
Exercise 27.2-1 Counting the Total Number of Iterations ... 347
Exercise 27.2-2 Counting the Total Number of Iterations ... 348
Exercise 27.2-3 Counting the Total Number of Iterations ... 349
Exercise 27.2-4 Counting the Total Number of Iterations ... 349
Exercise 27.2-5 Finding the Average Value of N Numbers ... 350
27.3 Review Questions: True/False ... 351
27.4 Review Questions: Multiple Choice ... 352
27.5 Review Exercises ... 354

Chapter 28 Nested Loop Control Structures ... 359
28.1 What is a Nested Loop? ... 359
Exercise 28.1-1 Say “Hello Zeus”. Designing the Flowchart and Counting the Total Number of Iterations ... 360
Exercise 28.1-2 Creating the Trace Table ... 361
28.2 Rules that Apply to Nested Loops ... 363
Exercise 28.2-1 Breaking the First Rule ... 363
Exercise 28.2-2 Counting the Total Number of Iterations ... 364
28.3 Review Questions: True/False ... 364
28.4 Review Questions: Multiple Choice ... 365
28.5 Review Exercises ... 367

Chapter 29 Tips and Tricks with Loop Control Structures ... 371
29.1 Introduction ... 371
29.2 Choosing a Loop Control Structure ... 371

29.3 The "Ultimate" Rule ... 371
29.4 Breaking Out of a Loop ... 375
29.5 Cleaning Out Your Loops ... 377
Exercise 29.5-1 Cleaning Out the Loop ... 378
Exercise 29.5-2 Cleaning Out the Loop ... 379
29.6 Endless Loops and How to Avoid Them ... 380
29.7 Using the "From Inner to Outer" Method in Loop Control Structures ... 381
29.8 Review Questions: True/False ... 382
29.9 Review Questions: Multiple Choice ... 383
29.10 Review Exercises ... 384

Chapter 30 Flowcharts with Loop Control Structures ... 387
30.1 Introduction ... 387
30.2 Converting C++ Programs to Flowcharts ... 387
Exercise 30.2-1 Designing the Flowchart ... 388
Exercise 30.2-2 Designing the Flowchart ... 389
Exercise 30.2-3 Designing the Flowchart ... 390
Exercise 30.2-4 Designing the Flowchart ... 391
Exercise 30.2-5 Designing the Flowchart ... 392
Exercise 30.2-6 Designing the Flowchart ... 394
Exercise 30.2-7 Designing the Flowchart ... 395
30.3 Converting Flowcharts to C++ Programs ... 395
Exercise 30.3-1 Writing the C++ Program ... 396
Exercise 30.3-2 Writing the C++ Program ... 397
Exercise 30.3-3 Writing the C++ Program ... 398
Exercise 30.3-4 Writing the C++ Program ... 400
30.4 Review Exercises ... 403

Chapter 31 More Exercises with Loop Control Structures ... 411
31.1 Simple Exercises with Loop Control Structures ... 411
Exercise 31.1-1 Finding the Sum of $1 + 2 + 3 + \ldots + 100$ ... 411
Exercise 31.1-2 Finding the Product of $2 \times 4 \times 6 \times 8 \times 10$ ... 412
Exercise 31.1-3 Finding the Sum of $2^2 + 4^2 + 6^2 + \ldots (2N)^2$ ... 413
Exercise 31.1-4 Finding the Sum of $3^3 + 6^6 + 9^9 + \ldots (3N)^{3N}$ ... 414
Exercise 31.1-5 Finding the Average Value of Positive Numbers ... 414
Exercise 31.1-6 Counting the Numbers According to Which is Greater ... 415
Exercise 31.1-7 Counting the Numbers According to Their Digits ... 416
Exercise 31.1-8 How Many Numbers Fit in a Sum ... 417
Exercise 31.1-9 Finding the Total Number of Positive Integers ... 418
Exercise 31.1-10 Iterating as Many Times as the User Wishes ... 418
Exercise 31.1-11 Finding the Sum of the Digits ... 420
Exercise 31.1-12 Counting the Digits ... 422
31.2 Exercises with Nested Loop Control Structures ... 422
Exercise 31.2-1 Displaying all Three-Digit Integers that Contain a Given Digit ... 422
Exercise 31.2-2 Displaying all Instances of a Specified Condition ... 424
31.3 Data Validation with Loop Control Structures ... 426
Exercise 31.3-1 Finding the Square Root - Validation Without Error Messages ... 427
Exercise 31.3-2 Finding the Square Root - Validation with One Error Message ... 429
Exercise 31.3-3 Finding the Square Root - Validation with Individual Error Messages ... 429
Exercise 31.3-4 Finding the Sum of 10 Numbers ... 430

31.4 Finding Minimum and Maximum Values with Loop Control Structures 431
Exercise 31.4-1 Validating and Finding the Maximum Value 434
Exercise 31.4-2 Validating and Finding the Maximum Temperature 435
Exercise 31.4-3 "Making the Grade" 437
31.5 Exercises of a General Nature with Loop Control Structures 438
Exercise 31.5-1 Fahrenheit to Kelvin, from 0 to 100 438
Exercise 31.5-2 Wheat on a Chessboard 439
Exercise 31.5-3 Just a Poll 440
Exercise 31.5-4 Is the Message a Palindrome? 441
31.6 Review Questions: True/False 444
31.7 Review Exercises 445

Review Questions in "Loop Control Structures" ***451***

Section 6 Arrays **453**

Chapter 32 Introduction to Arrays ***455***
32.1 Introduction 455
32.2 What is an Array? 456
Exercise 32.2-1 Designing an Array 458
Exercise 32.2-2 Designing Arrays 459
Exercise 32.2-3 Designing Arrays 460
32.3 Review Questions: True/False 461
32.4 Review Exercises 461

Chapter 33 One-Dimensional Arrays ***463***
33.1 Creating One-Dimensional Arrays in C++ 463
33.2 How to Get Values from One-Dimensional Arrays 464
Exercise 33.2-1 Creating the Trace Table 464
Exercise 33.2-2 Using a Non-Existing Index 465
33.3 How to Add Values Entered by the User to a One-Dimensional Array 465
33.4 How to Iterate Through a One-Dimensional Array 465
Exercise 33.4-1 Displaying Words in Reverse Order 466
Exercise 33.4-2 Displaying Positive Numbers in Reverse Order 467
Exercise 33.4-3 Displaying Even Numbers in Odd–Numbered Index Positions 468
Exercise 33.4-4 Finding the Sum 469
33.5 Review Questions: True/False 470
33.6 Review Questions: Multiple Choice 472
33.7 Review Exercises 474

Chapter 34 Two-Dimensional Arrays ***477***
34.1 Creating Two-Dimensional Arrays in C++ 477
34.2 How to Get Values from Two-Dimensional Arrays 478
Exercise 34.2-1 Creating the Trace Table 479
34.3 How to Add Values Entered by the User to a Two-Dimensional Array 480
34.4 How to Iterate Through a Two-Dimensional Array 480
Exercise 34.4-1 Displaying Reals Only 483
Exercise 34.4-2 Displaying Odd Columns Only 484
34.5 What's the Story on Variables `i` and `j`? 485
34.6 Square Arrays 485

Exercise 34.6-1 Finding the Sum of the Elements of the Main Diagonal ... 485
Exercise 34.6-2 Finding the Sum of the Elements of the Antidiagonal ... 487
Exercise 34.6-3 Filling in the Array ... 489
34.7 Review Questions: True/False ... 490
34.8 Review Questions: Multiple Choice ... 492
34.9 Review Exercises ... 495

Chapter 35 Tips and Tricks with Arrays ... 499
35.1 Introduction ... 499
35.2 Processing Each Row Individually ... 499
Exercise 35.2-1 Finding the Average Value ... 500
35.3 Processing Each Column Individually ... 503
Exercise 35.3-1 Finding the Average Value ... 504
35.4 How to Use One-Dimensional Along with Two-Dimensional Arrays ... 506
Exercise 35.4-1 Finding the Average Value ... 507
35.5 Creating a One-Dimensional Array from a Two-Dimensional Array ... 510
35.6 Creating a Two-Dimensional Array from a One-Dimensional Array ... 511
35.7 Review Questions: True/False ... 512
35.8 Review Questions: Multiple Choice ... 513
35.9 Review Exercises ... 514

Chapter 36 More Exercises with Arrays ... 517
36.1 Simple Exercises with Arrays ... 517
Exercise 36.1-1 Creating an Array that Contains the Average Values of its Neighboring Elements ... 517
Exercise 36.1-2 Creating an Array with the Greatest Values ... 519
Exercise 36.1-3 Merging One-Dimensional Arrays ... 521
Exercise 36.1-4 Merging Two-Dimensional Arrays ... 522
Exercise 36.1-5 Creating Two Arrays – Separating Positive from Negative Values ... 523
Exercise 36.1-6 Creating an Array with Those who Contain Digit 5 ... 526
36.2 Data Validation with Arrays ... 528
Exercise 36.2-1 Displaying Odds in Reverse Order – Validation Without Error Messages ... 529
Exercise 36.2-2 Displaying Odds in Reverse Order – Validation with One Error Message ... 530
Exercise 36.2-3 Displaying Odds in Reverse Order – Validation with Individual Error Messages ... 531
36.3 Finding Minimum and Maximum Values in Arrays ... 532
Exercise 36.3-1 Which Depth is the Greatest? ... 532
Exercise 36.3-2 Which Lake is the Deepest? ... 534
Exercise 36.3-3 Which Lake, in Which Country, Having Which Average Area, is the Deepest? ... 534
Exercise 36.3-4 Which Students Have got the Greatest Grade? ... 537
Exercise 36.3-5 Finding the Minimum Value of a Two-Dimensional Array ... 538
Exercise 36.3-6 Finding the City with the Coldest Day ... 539
Exercise 36.3-7 Finding the Minimum and the Maximum Value of Each Row ... 541
Exercise 36.3-8 Finding the Minimum and the Maximum Value of Each Column ... 544
36.4 Sorting Arrays ... 546
Exercise 36.4-1 The Bubble Sort Algorithm – Sorting One-Dimensional Arrays with Numeric Values ... 547
Exercise 36.4-2 Sorting One-Dimensional Arrays with Alphanumeric Values ... 551

Exercise 36.4-3 Sorting One-Dimensional Arrays While Preserving the Relationship with a Second Array ... 552
Exercise 36.4-4 Sorting Last and First Names ... 553
Exercise 36.4-5 Sorting a Two-Dimensional Array ... 556
Exercise 36.4-6 Finding the Three Heaviest Weights and the Three Lightest Weights ... 557
Exercise 36.4-7 The Five Best Scorers ... 558
36.5 Searching Elements in Arrays ... 560
Exercise 36.5-1 The Linear Search Algorithm – Searching in a One-Dimensional Array that may Contain the Same Value Multiple Times ... 560
Exercise 36.5-2 Display the Last Names of All Those People Who Have the Same First Name ... 561
Exercise 36.5-3 Searching in a One-Dimensional Array that Contains Unique Values ... 562
Exercise 36.5-4 Searching for a Given Social Security Number ... 564
Exercise 36.5-5 Searching in a Two-Dimensional Array that may Contain the Same Value Multiple Times ... 565
Exercise 36.5-6 Searching in a Two-Dimensional Array that Contains Unique Values ... 566
Exercise 36.5-7 Checking if a Value Exists in all Columns ... 568
Exercise 36.5-8 The Binary Search Algorithm – Searching in a Sorted One-Dimensional Array ... 571
Exercise 36.5-9 Display all the Historical Events for a Country ... 573
Exercise 36.5-10 Searching in Each Column of a Two-Dimensional Array ... 575
36.6 Exercises of a General Nature with Arrays ... 578
Exercise 36.6-1 On Which Days was There a Possibility of Snow? ... 578
Exercise 36.6-2 Was There Any Possibility of Snow? ... 579
Exercise 36.6-3 In Which Cities was There a Possibility of Snow? ... 581
Exercise 36.6-4 Display from Highest to Lowest Grades by Student, and in Alphabetical Order ... 584
Exercise 36.6-5 Archery at the Summer Olympics ... 586
36.7 Review Questions: True/False ... 588
36.8 Review Exercises ... 589

Review Questions in "Arrays" ... ***601***

Section 7 Subprograms ... **603**

Chapter 37 Introduction to Subprograms ... ***605***
37.1 What is Procedural Programming? ... 605
37.2 What is Modular Programming? ... 605
37.3 What Exactly is a Subprogram? ... 606
37.4 Review Questions: True/False ... 607

Chapter 38 User-Defined Functions ... ***609***
38.1 Writing your Own Functions in C++ ... 609
38.2 How Do You Call a Function? ... 609
38.3 Formal and Actual Arguments ... 612
38.4 How Does a Function Execute? ... 613
Exercise 38.4-1 Back to Basics – Calculating the Sum of Two Numbers ... 614
Exercise 38.4-2 Calculating the Sum of Two Numbers Using Fewer Lines of Code! ... 615
38.5 Review Questions: True/False ... 616
38.6 Review Exercises ... 617

Chapter 39 User-Defined void Functions (Procedures) *621*
39.1 Writing your Own void Functions (Procedures) in C++ 621
39.2 How Do You Call a void Function? 622
39.3 Formal and Actual Arguments 623
39.4 How Does a void Function Execute? 624
Exercise 39.4-1 Back to Basics – Displaying the Absolute Value of a Number 625
Exercise 39.4-2 A Simple Currency Converter 627
39.5 Review Questions: True/False 628
39.6 Review Exercises 628

Chapter 40 Tips and Tricks with Subprograms *633*
40.1 Can Two Subprograms use Variables of the Same Name? 633
40.2 Can a Subprogram Call Another Subprogram? 635
Exercise 40.2-1 A Currency Converter – Using Functions with void Functions 635
40.3 Passing Arguments by Value and by Reference 637
Exercise 40.3-1 Finding the Logic Error 640
40.4 Passing and/or Returning an Array 641
40.5 Default Argument Values (Optional Arguments) 644
40.6 The Scope of a Variable 645
40.7 Converting Parts of Code into Subprograms 646
40.8 Overloading Functions 652
40.9 Review Questions: True/False 655
40.10 Review Exercises 656

Chapter 41 More Exercises with Subprograms *663*
41.1 Simple Exercises with Subprograms 663
Exercise 41.1-1 Finding the Average Values of Positive Integers 663
Exercise 41.1-2 Finding the Sum of Odd Positive Integers 664
Exercise 41.1-3 Roll, Roll, Roll the… Dice! 665
Exercise 41.1-4 How Many Times Does Each Number of the Dice Appear? 666
41.2 Exercises of a General Nature with Subprograms 669
Exercise 41.2-1 Validating Data Input 669
Exercise 41.2-2 Sorting an Array 670
Exercise 41.2-3 Progressive Rates and Electricity Consumption 672
41.3 Review Exercises 674

Review Questions in "Subprograms" *687*

Index **689**

Some Final Words from the Authors **695**

More of our Books **695**