

Contents

Preface	xxiii
Chapter 1 Getting Started	1
1.1 Writing a Simple C++ Program	2
1.1.1 Compiling and Executing Our Program	3
1.2 A First Look at Input/Output	5
1.3 A Word about Comments	9
1.4 Flow of Control	11
1.4.1 The while Statement	11
1.4.2 The for Statement	13
1.4.3 Reading an Unknown Number of Inputs	14
1.4.4 The if Statement	17
1.5 Introducing Classes	19
1.5.1 The sales_item Class	20
1.5.2 A First Look at Member Functions	23
1.6 The Bookstore Program	24
Chapter Summary	26
Defined Terms	26
Part I The Basics	29
Chapter 2 Variables and Basic Types	31
2.1 Primitive Built-in Types	32
2.1.1 Arithmetic Types	32
2.1.2 Type Conversions	35
2.1.3 Literals	38
2.2 Variables	41
2.2.1 Variable Definitions	41
2.2.2 Variable Declarations and Definitions	44
2.2.3 Identifiers	46
2.2.4 Scope of a Name	48
2.3 Compound Types	50
2.3.1 References	50
2.3.2 Pointers	52

2.3.3	Understanding Compound Type Declarations	57
2.4	<code>const</code> Qualifier	59
2.4.1	References to <code>const</code>	61
2.4.2	Pointers and <code>const</code>	62
2.4.3	Top-Level <code>const</code>	63
2.4.4	<code>constexpr</code> and Constant Expressions	65
2.5	Dealing with Types	67
2.5.1	Type Aliases	67
2.5.2	The <code>auto</code> Type Specifier	68
2.5.3	The <code>decltype</code> Type Specifier	70
2.6	Defining Our Own Data Structures	72
2.6.1	Defining the <code>Sales_data</code> Type	72
2.6.2	Using the <code>Sales_data</code> Class	74
2.6.3	Writing Our Own Header Files	76
	Chapter Summary	78
	Defined Terms	78
Chapter 3	Strings, Vectors, and Arrays	81
3.1	Namespace using Declarations	82
3.2	Library <code>string</code> Type	84
3.2.1	Defining and Initializing <code>strings</code>	84
3.2.2	Operations on <code>strings</code>	85
3.2.3	Dealing with the Characters in a <code>string</code>	90
3.3	Library <code>vector</code> Type	96
3.3.1	Defining and Initializing <code>vectors</code>	97
3.3.2	Adding Elements to a <code>vector</code>	100
3.3.3	Other <code>vector</code> Operations	102
3.4	Introducing Iterators	106
3.4.1	Using Iterators	106
3.4.2	Iterator Arithmetic	111
3.5	Arrays	113
3.5.1	Defining and Initializing Built-in Arrays	113
3.5.2	Accessing the Elements of an Array	116
3.5.3	Pointers and Arrays	117
3.5.4	C-Style Character Strings	122
3.5.5	Interfacing to Older Code	124
3.6	Multidimensional Arrays	125
	Chapter Summary	131
	Defined Terms	131
Chapter 4	Expressions	133
4.1	Fundamentals	134
4.1.1	Basic Concepts	134
4.1.2	Precedence and Associativity	136
4.1.3	Order of Evaluation	137
4.2	Arithmetic Operators	139
4.3	Logical and Relational Operators	141

4.4	Assignment Operators	144
4.5	Increment and Decrement Operators	147
4.6	The Member Access Operators	150
4.7	The Conditional Operator	151
4.8	The Bitwise Operators	152
4.9	The sizeof Operator	156
4.10	Comma Operator	157
4.11	Type Conversions	159
4.11.1	The Arithmetic Conversions	159
4.11.2	Other Implicit Conversions	161
4.11.3	Explicit Conversions	162
4.12	Operator Precedence Table	166
	Chapter Summary	168
	Defined Terms	168
Chapter 5	Statements	171
5.1	Simple Statements	172
5.2	Statement Scope	174
5.3	Conditional Statements	174
5.3.1	The if Statement	175
5.3.2	The switch Statement	178
5.4	Iterative Statements	183
5.4.1	The while Statement	183
5.4.2	Traditional for Statement	185
5.4.3	Range for Statement	187
5.4.4	The do while Statement	189
5.5	Jump Statements	190
5.5.1	The break Statement	190
5.5.2	The continue Statement	191
5.5.3	The goto Statement	192
5.6	try Blocks and Exception Handling	193
5.6.1	A throw Expression	193
5.6.2	The try Block	194
5.6.3	Standard Exceptions	197
	Chapter Summary	199
	Defined Terms	199
Chapter 6	Functions	201
6.1	Function Basics	202
6.1.1	Local Objects	204
6.1.2	Function Declarations	206
6.1.3	Separate Compilation	207
6.2	Argument Passing	208
6.2.1	Passing Arguments by Value	209
6.2.2	Passing Arguments by Reference	210
6.2.3	const Parameters and Arguments	212
6.2.4	Array Parameters	214

6.2.5	main: Handling Command-Line Options	218
6.2.6	Functions with Varying Parameters	220
6.3	Return Types and the return Statement	222
6.3.1	Functions with No Return Value	223
6.3.2	Functions That Return a Value	223
6.3.3	Returning a Pointer to an Array	228
6.4	Overloaded Functions	230
6.4.1	Overloading and Scope	234
6.5	Features for Specialized Uses	236
6.5.1	Default Arguments	236
6.5.2	Inline and constexpr Functions	238
6.5.3	Aids for Debugging	240
6.6	Function Matching	242
6.6.1	Argument Type Conversions	245
6.7	Pointers to Functions	247
	Chapter Summary	251
	Defined Terms	251
Chapter 7	Classes	253
7.1	Defining Abstract Data Types	254
7.1.1	Designing the Sales_data Class	254
7.1.2	Defining the Revised Sales_data Class	256
7.1.3	Defining Nonmember Class-Related Functions	260
7.1.4	Constructors	262
7.1.5	Copy, Assignment, and Destruction	267
7.2	Access Control and Encapsulation	268
7.2.1	Friends	269
7.3	Additional Class Features	271
7.3.1	Class Members Revisited	271
7.3.2	Functions That Return *this	275
7.3.3	Class Types	277
7.3.4	Friendship Revisited	279
7.4	Class Scope	282
7.4.1	Name Lookup and Class Scope	283
7.5	Constructors Revisited	288
7.5.1	Constructor Initializer List	288
7.5.2	Delegating Constructors	291
7.5.3	The Role of the Default Constructor	293
7.5.4	Implicit Class-Type Conversions	294
7.5.5	Aggregate Classes	298
7.5.6	Literal Classes	299
7.6	static Class Members	300
	Chapter Summary	305
	Defined Terms	305

Part II The C++ Library	307
Chapter 8 The IO Library	309
8.1 The IO Classes	310
8.1.1 No Copy or Assign for IO Objects	311
8.1.2 Condition States	312
8.1.3 Managing the Output Buffer	314
8.2 File Input and Output	316
8.2.1 Using File Stream Objects	317
8.2.2 File Modes	319
8.3 string Streams	321
8.3.1 Using an <code>istream</code>	321
8.3.2 Using <code>ostream</code> s	323
Chapter Summary	324
Defined Terms	324
Chapter 9 Sequential Containers	325
9.1 Overview of the Sequential Containers	326
9.2 Container Library Overview	328
9.2.1 Iterators	331
9.2.2 Container Type Members	332
9.2.3 <code>begin</code> and <code>end</code> Members	333
9.2.4 Defining and Initializing a Container	334
9.2.5 Assignment and <code>swap</code>	337
9.2.6 Container Size Operations	340
9.2.7 Relational Operators	340
9.3 Sequential Container Operations	341
9.3.1 Adding Elements to a Sequential Container	341
9.3.2 Accessing Elements	346
9.3.3 Erasing Elements	348
9.3.4 Specialized <code>forward_list</code> Operations	350
9.3.5 Resizing a Container	352
9.3.6 Container Operations May Invalidate Iterators	353
9.4 How a <code>vector</code> Grows	355
9.5 Additional <code>string</code> Operations	360
9.5.1 Other Ways to Construct <code>strings</code>	360
9.5.2 Other Ways to Change a <code>string</code>	361
9.5.3 <code>string</code> Search Operations	364
9.5.4 The <code>compare</code> Functions	366
9.5.5 Numeric Conversions	367
9.6 Container Adaptors	368
Chapter Summary	372
Defined Terms	372

Chapter 10 Generic Algorithms	375
10.1 Overview	376
10.2 A First Look at the Algorithms	378
10.2.1 Read-Only Algorithms	379
10.2.2 Algorithms That Write Container Elements	380
10.2.3 Algorithms That Reorder Container Elements	383
10.3 Customizing Operations	385
10.3.1 Passing a Function to an Algorithm	386
10.3.2 Lambda Expressions	387
10.3.3 Lambda Captures and Returns	392
10.3.4 Binding Arguments	397
10.4 Revisiting Iterators	401
10.4.1 Insert Iterators	401
10.4.2 <code>iostream</code> Iterators	403
10.4.3 Reverse Iterators	407
10.5 Structure of Generic Algorithms	410
10.5.1 The Five Iterator Categories	410
10.5.2 Algorithm Parameter Patterns	412
10.5.3 Algorithm Naming Conventions	413
10.6 Container-Specific Algorithms	415
Chapter Summary	417
Defined Terms	417
Chapter 11 Associative Containers	419
11.1 Using an Associative Container	420
11.2 Overview of the Associative Containers	423
11.2.1 Defining an Associative Container	423
11.2.2 Requirements on Key Type	424
11.2.3 The <code>pair</code> Type	426
11.3 Operations on Associative Containers	428
11.3.1 Associative Container Iterators	429
11.3.2 Adding Elements	431
11.3.3 Erasing Elements	434
11.3.4 Subscripting a <code>map</code>	435
11.3.5 Accessing Elements	436
11.3.6 A Word Transformation Map	440
11.4 The Unordered Containers	443
Chapter Summary	447
Defined Terms	447
Chapter 12 Dynamic Memory	449
12.1 Dynamic Memory and Smart Pointers	450
12.1.1 The <code>shared_ptr</code> Class	450
12.1.2 Managing Memory Directly	458
12.1.3 Using <code>shared_ptr</code> s with <code>new</code>	464
12.1.4 Smart Pointers and Exceptions	467
12.1.5 <code>unique_ptr</code>	470

12.1.6	<code>weak_ptr</code>	473
12.2	Dynamic Arrays	476
12.2.1	<code>new</code> and Arrays	477
12.2.2	The <code>allocator</code> Class	481
12.3	Using the Library: A Text-Query Program	484
12.3.1	Design of the Query Program	485
12.3.2	Defining the Query Program Classes	487
	Chapter Summary	491
	Defined Terms	491

Part III Tools for Class Authors 493

Chapter 13	Copy Control	495
13.1	Copy, Assign, and Destroy	496
13.1.1	The Copy Constructor	496
13.1.2	The Copy-Assignment Operator	500
13.1.3	The Destructor	501
13.1.4	The Rule of Three/Five	503
13.1.5	Using <code>= default</code>	506
13.1.6	Preventing Copies	507
13.2	Copy Control and Resource Management	510
13.2.1	Classes That Act Like Values	511
13.2.2	Defining Classes That Act Like Pointers	513
13.3	Swap	516
13.4	A Copy-Control Example	519
13.5	Classes That Manage Dynamic Memory	524
13.6	Moving Objects	531
13.6.1	Rvalue References	532
13.6.2	Move Constructor and Move Assignment	534
13.6.3	Rvalue References and Member Functions	544
	Chapter Summary	549
	Defined Terms	549
Chapter 14	Overloaded Operations and Conversions	551
14.1	Basic Concepts	552
14.2	Input and Output Operators	556
14.2.1	Overloading the Output Operator <code><<</code>	557
14.2.2	Overloading the Input Operator <code>>></code>	558
14.3	Arithmetic and Relational Operators	560
14.3.1	Equality Operators	561
14.3.2	Relational Operators	562
14.4	Assignment Operators	563
14.5	Subscript Operator	564
14.6	Increment and Decrement Operators	566
14.7	Member Access Operators	569
14.8	Function-Call Operator	571

14.8.1	Lambdas Are Function Objects	572
14.8.2	Library-Defined Function Objects	574
14.8.3	Callable Objects and <code>function</code>	576
14.9	Overloading, Conversions, and Operators	579
14.9.1	Conversion Operators	580
14.9.2	Avoiding Ambiguous Conversions	583
14.9.3	Function Matching and Overloaded Operators	587
Chapter Summary	590
Defined Terms	590
Chapter 15	Object-Oriented Programming	591
15.1	OOP: An Overview	592
15.2	Defining Base and Derived Classes	594
15.2.1	Defining a Base Class	594
15.2.2	Defining a Derived Class	596
15.2.3	Conversions and Inheritance	601
15.3	Virtual Functions	603
15.4	Abstract Base Classes	608
15.5	Access Control and Inheritance	611
15.6	Class Scope under Inheritance	617
15.7	Constructors and Copy Control	622
15.7.1	Virtual Destructors	622
15.7.2	Synthesized Copy Control and Inheritance	623
15.7.3	Derived-Class Copy-Control Members	625
15.7.4	Inherited Constructors	628
15.8	Containers and Inheritance	630
15.8.1	Writing a <code>Basket</code> Class	631
15.9	Text Queries Revisited	634
15.9.1	An Object-Oriented Solution	636
15.9.2	The <code>Query_base</code> and <code>Query</code> Classes	639
15.9.3	The Derived Classes	642
15.9.4	The <code>eval</code> Functions	645
Chapter Summary	649
Defined Terms	649
Chapter 16	Templates and Generic Programming	651
16.1	Defining a Template	652
16.1.1	Function Templates	652
16.1.2	Class Templates	658
16.1.3	Template Parameters	668
16.1.4	Member Templates	672
16.1.5	Controlling Instantiations	675
16.1.6	Efficiency and Flexibility	676
16.2	Template Argument Deduction	678
16.2.1	Conversions and Template Type Parameters	679
16.2.2	Function-Template Explicit Arguments	681
16.2.3	Trailing Return Types and Type Transformation	683

16.2.4	Function Pointers and Argument Deduction	686
16.2.5	Template Argument Deduction and References	687
16.2.6	Understanding <code>std::move</code>	690
16.2.7	Forwarding	692
16.3	Overloading and Templates	694
16.4	Variadic Templates	699
16.4.1	Writing a Variadic Function Template	701
16.4.2	Pack Expansion	702
16.4.3	Forwarding Parameter Packs	704
16.5	Template Specializations	706
	Chapter Summary	713
	Defined Terms	713

Part IV Advanced Topics 715

Chapter 17	Specialized Library Facilities	717
17.1	The tuple Type	718
17.1.1	Defining and Initializing tuples	718
17.1.2	Using a tuple to Return Multiple Values	721
17.2	The bitset Type	723
17.2.1	Defining and Initializing bitsets	723
17.2.2	Operations on bitsets	725
17.3	Regular Expressions	728
17.3.1	Using the Regular Expression Library	729
17.3.2	The Match and Regex Iterator Types	734
17.3.3	Using Subexpressions	738
17.3.4	Using <code>regex_replace</code>	741
17.4	Random Numbers	745
17.4.1	Random-Number Engines and Distribution	745
17.4.2	Other Kinds of Distributions	749
17.5	The IO Library Revisited	752
17.5.1	Formatted Input and Output	753
17.5.2	Unformatted Input/Output Operations	761
17.5.3	Random Access to a Stream	763
	Chapter Summary	769
	Defined Terms	769
Chapter 18	Tools for Large Programs	771
18.1	Exception Handling	772
18.1.1	Throwing an Exception	772
18.1.2	Catching an Exception	775
18.1.3	Function try Blocks and Constructors	777
18.1.4	The <code>noexcept</code> Exception Specification	779
18.1.5	Exception Class Hierarchies	782
18.2	Namespaces	785
18.2.1	Namespace Definitions	785

18.2.2	Using Namespace Members	792
18.2.3	Classes, Namespaces, and Scope	796
18.2.4	Overloading and Namespaces	800
18.3	Multiple and Virtual Inheritance	802
18.3.1	Multiple Inheritance	803
18.3.2	Conversions and Multiple Base Classes	805
18.3.3	Class Scope under Multiple Inheritance	807
18.3.4	Virtual Inheritance	810
18.3.5	Constructors and Virtual Inheritance	813
Chapter Summary		816
Defined Terms		816
Chapter 19	Specialized Tools and Techniques	819
19.1	Controlling Memory Allocation	820
19.1.1	Overloading new and delete	820
19.1.2	Placement new Expressions	823
19.2	Run-Time Type Identification	825
19.2.1	The dynamic_cast Operator	825
19.2.2	The typeid Operator	826
19.2.3	Using RTTI	828
19.2.4	The type_info Class	831
19.3	Enumerations	832
19.4	Pointer to Class Member	835
19.4.1	Pointers to Data Members	836
19.4.2	Pointers to Member Functions	838
19.4.3	Using Member Functions as Callable Objects	841
19.5	Nested Classes	843
19.6	union: A Space-Saving Class	847
19.7	Local Classes	852
19.8	Inherently Nonportable Features	854
19.8.1	Bit-fields	854
19.8.2	volatile Qualifier	856
19.8.3	Linkage Directives: extern "C"	857
Chapter Summary		862
Defined Terms		862
Appendix A	The Library	865
A.1	Library Names and Headers	866
A.2	A Brief Tour of the Algorithms	870
A.2.1	Algorithms to Find an Object	871
A.2.2	Other Read-Only Algorithms	872
A.2.3	Binary Search Algorithms	873
A.2.4	Algorithms That Write Container Elements	873
A.2.5	Partitioning and Sorting Algorithms	875
A.2.6	General Reordering Operations	877
A.2.7	Permutation Algorithms	879
A.2.8	Set Algorithms for Sorted Sequences	880

A.2.9	Minimum and Maximum Values	880
A.2.10	Numeric Algorithms	881
A.3	Random Numbers	882
A.3.1	Random Number Distributions	883
A.3.2	Random Number Engines	884
Index		887