

# Contents

<b>Preface</b>	<b>v</b>
<b>1 Basic Concepts of C++</b>	<b>1</b>
1.1 Objects, Values, Types, Variables . . . . .	1
1.1.1 Objects and Addresses . . . . .	1
1.1.2 Values and Types . . . . .	2
1.1.3 Referring to Objects and Values: Variables, Constants, Ex- pressions . . . . .	2
1.2 Defining and Manipulating Objects . . . . .	3
1.3 References . . . . .	4
1.4 Functions . . . . .	6
1.4.1 Defining a Function . . . . .	6
1.4.2 Calling a Function . . . . .	7
1.4.3 More on Parameter Passing . . . . .	10
1.5 Program Structure . . . . .	12
1.5.1 Translation Units, Definitions and Declarations . . . . .	12
1.5.2 The Compilation Process . . . . .	13
1.5.3 Program Organization . . . . .	15
1.5.4 Linking and Executing a Program . . . . .	17
1.6 Syntactic and Lexical Considerations . . . . .	19
1.6.1 Identifiers and Keywords . . . . .	19
1.6.2 Comments . . . . .	20
1.7 Scopes and Namespaces . . . . .	21
1.7.1 Scopes . . . . .	21
1.7.2 Namespaces . . . . .	22

<b>2</b>	<b>Built-in Types</b>	<b>25</b>
2.1	Arithmetic Types . . . . .	25
2.2	Conversions for Arithmetic Types . . . . .	27
2.3	Arithmetic Type Operations . . . . .	28
2.4	String Literals . . . . .	32
<b>3</b>	<b>Functions</b>	<b>37</b>
3.1	Function Declarations . . . . .	37
3.1.1	Function Types, Signatures . . . . .	37
3.1.2	Default Arguments . . . . .	38
3.1.3	Unspecified Number of Arguments . . . . .	38
3.1.4	Inline Functions . . . . .	39
3.2	Overloading . . . . .	41
3.3	Function Definitions . . . . .	42
3.3.1	Statements . . . . .	42
3.3.2	Control Flow Statements . . . . .	43
	The compound statement and the sequence operator . . . . .	43
	The if statement and the ? operator . . . . .	43
	The while statements . . . . .	44
	The for statement . . . . .	45
	The switch statement . . . . .	46
	The return, break and continue statements . . . . .	47
3.3.3	Local and Static Variables . . . . .	49
	Local object lifetime . . . . .	49
	Persistent local objects . . . . .	49
<b>4</b>	<b>User-Defined Types</b>	<b>51</b>
4.1	Abstract Data Types . . . . .	51
4.2	Classes . . . . .	53
4.2.1	Class Members, Access Specification . . . . .	53
4.2.2	Class Objects . . . . .	54
4.2.3	Data Member Declarations and Object Layout . . . . .	54
4.2.4	Class Scope . . . . .	55
4.2.5	Function Member Declaration . . . . .	55
4.2.6	Overloading Member Functions . . . . .	56
4.2.7	Initializing a Class Object . . . . .	56

The default constructor . . . . .	58
The copy constructor . . . . .	58
4.2.8 Function Member Definition . . . . .	59
4.2.9 Inline Function Members . . . . .	60
4.2.10 Member Functions with Default Parameters . . . . .	61
4.2.11 User-Defined Conversions . . . . .	61
4.2.12 Operator Overloading . . . . .	63
Overloading the assignment operator . . . . .	65
Overloading the increment and decrement operators . . . . .	66
Forbidding operators . . . . .	67
4.2.13 Finalizing an Object . . . . .	68
4.2.14 Member Objects . . . . .	69
4.2.15 Friends . . . . .	71
4.2.16 Nested Classes . . . . .	72
4.2.17 Static Members . . . . .	74
4.2.18 Implementation Aspects . . . . .	74
4.2.19 Example: the Rational Class . . . . .	76
4.3 Enumerations . . . . .	80
4.4 Typedef . . . . .	81
<b>5 Built-in Type Constructors</b> . . . . .	<b>83</b>
5.1 Constant Objects . . . . .	83
5.2 Pointers . . . . .	89
5.2.1 Pointers, Addresses, Dereferencing . . . . .	89
5.2.2 Handles . . . . .	90
5.2.3 Member Selection from Pointers . . . . .	91
5.2.4 Constant Pointers . . . . .	91
5.2.5 Pointers vs. References . . . . .	92
5.2.6 The <b>this</b> Pointer . . . . .	93
5.3 Arrays . . . . .	95
5.3.1 Initializing an Array . . . . .	96
5.3.2 Arrays vs. Pointers, Pointer Arithmetic . . . . .	97
5.3.3 Array Parameters . . . . .	99
5.3.4 Multidimensional Arrays . . . . .	101
5.4 Command Line Processing . . . . .	101

5.5	Pointers to Functions . . . . .	102
5.6	Pointers to Members . . . . .	102
5.7	Memory Management . . . . .	104
5.7.1	Static, Global, Automatic and Member Objects . . . . .	104
5.7.2	Free Objects . . . . .	104
5.7.3	Encapsulating Pointers . . . . .	107
5.8	More Operator Overloading . . . . .	110
5.8.1	Overloading <b>new</b> , <b>delete</b> . . . . .	110
5.8.2	Placement New . . . . .	113
5.8.3	Smart Pointers . . . . .	114
<b>6</b>	<b>User-Defined Type Constructors</b>	<b>117</b>
6.1	Function Templates . . . . .	117
6.1.1	Template Argument Deduction . . . . .	120
6.1.2	Overloading Function Templates . . . . .	120
6.1.3	Explicit Specializations of Function Templates . . . . .	121
6.1.4	A Generic Sort Function . . . . .	122
6.2	Class Templates . . . . .	123
6.2.1	Friends of Class Templates . . . . .	126
6.2.2	Nested Class Templates . . . . .	127
6.2.3	Function Objects . . . . .	128
6.2.4	Class Template Specialization . . . . .	131
6.2.5	Reference Counting Pointers . . . . .	132
6.2.6	Auto Pointers . . . . .	134
<b>7</b>	<b>Generic Programming Using the STL</b>	<b>137</b>
7.1	Generic Programming . . . . .	137
7.2	Iterators . . . . .	140
7.2.1	Types Associated with an Iterator . . . . .	143
7.2.2	Iterator Traits . . . . .	146
7.2.3	Dispatching on the Iterator Category . . . . .	148
7.3	Stream Iterators . . . . .	149
7.3.1	Input Stream Iterator . . . . .	149
7.3.2	Output Stream Iterator . . . . .	151
7.4	STL Containers . . . . .	152
7.4.1	Pair . . . . .	153

7.4.2	List . . . . .	153
7.4.3	Vector . . . . .	155
7.4.4	Map . . . . .	157
7.4.5	Set . . . . .	161
7.4.6	Other Containers . . . . .	163
7.4.7	Container Adaptors . . . . .	163
7.5	STL Algorithms . . . . .	164
7.5.1	Non-mutating Algorithms . . . . .	164
	Finding elements in a range . . . . .	165
	Finding subranges . . . . .	165
	Counting elements in a range . . . . .	166
	Processing a range . . . . .	166
	Comparing ranges . . . . .	167
	Minimum and maximum . . . . .	168
7.5.2	Basic Mutating Algorithms . . . . .	169
	Copying ranges . . . . .	169
	Swapping elements . . . . .	169
	Transforming a range . . . . .	169
	Replacing elements in a range . . . . .	170
	Filling a range . . . . .	170
	Removing elements . . . . .	170
	Permuting algorithms . . . . .	171
	Partitioning ranges . . . . .	172
	Random shuffling and sampling . . . . .	172
	Generalized numeric algorithms . . . . .	173
7.5.3	Sorting and Searching . . . . .	174
	Sorting ranges . . . . .	174
	Operations on sorted ranges . . . . .	175
	Set operations . . . . .	176
	Heap operations . . . . .	177
7.6	Iterator Adaptors . . . . .	179
7.6.1	Insert Iterators . . . . .	179
7.6.2	Reverse Iterators . . . . .	181

8.1	Derived Classes . . . . .	183
8.1.1	Construction and Destruction of Derived Class Objects . . . . .	185
8.1.2	Inheritance and Scope . . . . .	185
8.1.3	Inheritance and Conversions . . . . .	186
8.1.4	Inheritance and Arrays . . . . .	187
8.2	Virtual Member Functions . . . . .	187
8.2.1	Implementation of Virtual Member Functions . . . . .	189
8.2.2	Pure Virtual Function Members and Abstract Classes . . . . .	191
8.2.3	Virtual Destructors . . . . .	192
8.3	Derivation and Access Control . . . . .	193
8.3.1	Protected Members . . . . .	193
8.3.2	Protected and Private Derivation . . . . .	194
8.4	Multiple and Virtual Inheritance . . . . .	195
8.4.1	Multiple Inheritance . . . . .	195
8.4.2	Implementing Multiple Inheritance . . . . .	196
8.4.3	Virtual Inheritance . . . . .	197
8.5	Object-Oriented Programming . . . . .	199
8.5.1	Class Hierarchies . . . . .	199
8.5.2	Polymorphism . . . . .	199
8.6	Run-Time Type Identification . . . . .	201
<b>9</b>	<b>Exceptions</b>	<b>205</b>
9.1	Throwing and Catching Exceptions . . . . .	205
9.2	Run-Time Behaviour . . . . .	208
9.3	Exceptions, Constructors and Destructors . . . . .	210
9.3.1	Exceptions and Resource Management . . . . .	210
9.3.2	Constructors Throwing Exceptions . . . . .	211
9.3.3	Destructors Throwing Exceptions . . . . .	212
9.4	Exception Specifications . . . . .	213
9.5	Standard Exceptions . . . . .	214
<b>10</b>	<b>Iostreams</b>	<b>217</b>
10.1	Requirements . . . . .	217
10.2	Design . . . . .	218
10.3	Streambuf . . . . .	219
10.4	Stream Base Classes . . . . .	223

10.4.1	Ios_base . . . . .	223
10.4.2	Basic_ios<CharT,Traits> . . . . .	225
10.5	Stream Classes . . . . .	227
10.5.1	Basic_istream<CharT,Traits> . . . . .	227
10.5.2	Basic_ostream<CharT,Traits> . . . . .	230
10.5.3	Basic_iostream<CharT,Traits> . . . . .	231
10.6	Manipulators . . . . .	231
10.7	File Streams . . . . .	234
10.7.1	Basic_ifstream<CharT,Traits> . . . . .	235
10.7.2	Basic_ofstream<CharT,Traits> . . . . .	236
10.7.3	Basic_fstream<CharT,Traits> . . . . .	236
10.8	String Streams . . . . .	237
<b>11</b>	<b>Introduction to Program Design</b>	<b>241</b>
11.1	Motivation: Properties of Good Programs . . . . .	241
11.2	Abstractions . . . . .	246
11.3	Criteria For Good Abstractions . . . . .	252
11.4	The Design Process . . . . .	259
11.4.1	Finding Abstractions . . . . .	259
11.4.2	Designing Classes . . . . .	260
11.4.3	Refactoring . . . . .	260
11.4.4	Documentation . . . . .	260
11.4.5	Patterns . . . . .	261
<b>A</b>	<b>C++ Operators</b>	<b>265</b>
<b>B</b>	<b>The String Class</b>	<b>267</b>
	<b>Bibliography</b>	<b>273</b>
	<b>Index</b>	<b>275</b>