

Ivor Horton's Beginning Visual C++® 2013

**Ivor Horton** 

INTRODUCTIO	DN xxxiii
CHAPTER 1	Programming with Visual C++
CHAPTER 2	Data, Variables, and Calculations
CHAPTER 3	Decisions and Loops
CHAPTER 4	Arrays, Strings, and Pointers 129
CHAPTER 5	Introducing Structure into Your Programs
CHAPTER 6	More about Program Structure
CHAPTER 7	Defining Your Own Data Types
CHAPTER 8	More on Classes
CHAPTER 9	Class Inheritance and Virtual Functions
CHAPTER 10	The Standard Template Library
CHAPTER 11	Windows Programming Concepts
CHAPTER 12	Windows Programming with the Microsoft Foundation Classes (MFC)
CHAPTER 13	Working with Menus and Toolbars
CHAPTER 14	Drawing in a Window
CHAPTER 15	Improving the View
CHAPTER 16	Working with Dialogs and Controls
CHAPTER 17	Storing and Printing Documents
CHAPTER 18	Programming for Windows 8
INDEX	

## IVOR HORTON'S BEGINNING Visual C++® 2013

# IVOR HORTON'S BEGINNING Visual C++® 2013

Ivor Horton



### Ivor Horton's Beginning Visual C++® 2013

Published by John Wiley & Sons, Inc. 10475 Crosspoint Boulevard Indianapolis, IN 46256 www.wiley.com

Copyright © 2014 by Ivor Horton

Published by John Wiley & Sons, Inc., Indianapolis, Indiana

Published simultaneously in Canada

ISBN: 978-1-118-84571-4 ISBN: 978-1-118-84568-4 (ebk) ISBN: 978-1-118-84577-6 (ebk)

Manufactured in the United States of America

 $10\ 9\ 8\ 7\ 6\ 5\ 4\ 3\ 2\ 1$ 

No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, scanning or otherwise, except as permitted under Sections 107 or 108 of the 1976 United States Copyright Act, without either the prior written permission of the Publisher, or authorization through payment of the appropriate per-copy fee to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, (978) 750-8400, fax (978) 646-8600. Requests to the Publisher for permission should be addressed to the Permissions Department, John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, (201) 748-6011, fax (201) 748-6008, or online at http://www.wiley.com/go/permissions.

Limit of Liability/Disclaimer of Warranty: The publisher and the author make no representations or warranties with respect to the accuracy or completeness of the contents of this work and specifically disclaim all warranties, including without limitation warranties of fitness for a particular purpose. No warranty may be created or extended by sales or promotional materials. The advice and strategies contained herein may not be suitable for every situation. This work is sold with the understanding that the publisher is not engaged in rendering legal, accounting, or other professional services. If professional assistance is required, the services of a competent professional person should be sought. Neither the publisher nor the author shall be liable for damages arising herefrom. The fact that an organization or Web site is referred to in this work as a citation and/or a potential source of further information does not mean that the author or the publisher endorses the information the organization or Web site may provide or recommendations it may make. Further, readers should be aware that Internet Web sites listed in this work may have changed or disappeared between when this work was written and when it is read.

For general information on our other products and services please contact our Customer Care Department within the United States at (877) 762-2974, outside the United States at (317) 572-3993 or fax (317) 572-4002.

Wiley publishes in a variety of print and electronic formats and by print-on-demand. Some material included with standard print versions of this book may not be included in e-books or in print-on-demand. If this book refers to media such as a CD or DVD that is not included in the version you purchased, you may download this material at http://booksupport.wiley.com. For more information about Wiley products, visit www.wiley.com.

#### Library of Congress Control Number: 2014930412

**Trademarks:** Wiley, the Wrox logo, Programmer to Programmer, and related trade dress are trademarks or registered trademarks of John Wiley & Sons, Inc. and/or its affiliates, in the United States and other countries, and may not be used without written permission. Visual C++ is a registered trademark of Microsoft Corporation. All other trademarks are the property of their respective owners. John Wiley & Sons, Inc., is not associated with any product or vendor mentioned in this book.

This book is for my dear wife, Eve.

## ABOUT THE AUTHOR

**IVOR HORTON** graduated as a mathematician and was lured into information technology by promises of great rewards for very little work. In spite of the reality usually being a great deal of work for relatively modest rewards, he has continued to work with computers to the present day. He has been engaged at various times in programming, systems design, consultancy, and the management and implementation of projects of considerable complexity.

Horton has many years of experience in the design and implementation of computer systems applied to engineering design and manufacturing operations in a variety of industries. He has considerable experience in developing occasionally useful applications in a wide variety of programming languages, and in teaching primarily scientists and engineers to do likewise. He has been writing books on programming for several years, and his currently published works include tutorials on C, C++, and Java. At the present time, when he is not writing programming books or providing advice to others, he spends his time fishing, traveling, and enjoying life in general.

### ABOUT THE TECHNICAL EDITORS

**GIOVANNI DICANIO** is a Microsoft Visual C++ MVP, computer programmer, and Pluralsight author. His computer programming experience dates back to the glorious Commodore 64 and Commodore Amiga 500 golden days. He started with C=64 BASIC, then moved to assembly, Pascal, C, C++, Java, and C#. Giovanni wrote computer programming articles on C++, MFC, OpenGL, and other programming subjects in Italian computer magazines. He contributed code to some open-source projects as well, including a mathematical expression parser written in C++ for one of the first versions of QCAD. Giovanni's programming experience includes Windows programming using C++, Win32, COM, and ATL. His favorite programming languages are C and C++.

He has recently started cultivating an interest for mobile platforms and embedded systems.

He can be contacted via e-mail at giovanni.dicanio@gmail.com.

MARC GREGOIRE is a software engineer from Belgium. He graduated from the University of Leuven, Belgium, with a degree in "Burgerlijk ingenieur in de computer wetenschappen" (equivalent to Master of Science in engineering in computer science). The year after, he received the cum laude degree of master in artificial intelligence at the same university. After his studies, Marc started working for a software consultancy company called Ordina Belgium. As a consultant, he worked for Siemens and Nokia Siemens Networks on critical 2G and 3G software running on Solaris for telecom operators. This required working in international teams stretching from South America and the United States to EMEA and Asia. Now, Marc is working for Nikon Metrology on 3D laser scanning software.

His main expertise is C/C++, and specifically Microsoft VC++ and the MFC framework. He has experience in developing C++ programs running 24x7 on Windows and Linux platforms; for example, KNX/EIB home automation software. Next to C/C++, Marc also likes C# and uses PHP for creating web pages.

Since April 2007, he received the yearly Microsoft MVP (Most Valuable Professional) award for his Visual C++ expertise.

Marc is the founder of the Belgian C++ Users Group (www.becpp.org), author of *Professional* C++, Wrox, 2011 (ISBN 978-047-0-93244-9) and a member on the CodeGuru forum (as Marc G). He maintains a blog on www.nuonsoft.com/blog/.

### CREDITS

Executive Editor Robert Elliott

**Project Editors** Sydney Jones Argenta Edward Connor

**Technical Editors** Giovani Dicanio Marc Gregoire

**Production Editor** Christine Mugnolo

**Copy Editor** Charlotte Kughen

Manager of Content Development and Assembly Mary Beth Wakefield

Director of Community Marketing David Mayhew

Marketing Manager Ashley Zurcher Business Manager Amy Knies

Vice President and Executive Group Publisher Richard Swadley

Associate Publisher Jim Minatel

**Project Coordinator, Cover** Todd Klemme

**Proofreader** Sarah Kaikini, Word One New York

**Indexer** Johnna VanHoose Dinse

Cover Designer Wiley

**Cover Image** ©iStockphoto.com/xyno

## ACKNOWLEDGMENTS

**THE AUTHOR** is only one member of the large team of people necessary to get a book into print. I'd like to thank the John Wiley & Sons and Wrox Press editorial and production teams for their help and support throughout.

I would particularly like to thank my technical editors, Marc Gregoire and Giovanni Dicanio, for doing such a fantastic job of reviewing the text and checking out all the code fragments and examples. Their many constructive comments and suggestions have undoubtedly made the book a much better tutorial.

# CONTENTS

HAPTER 1: PROGRAMMING WITH VISUAL C++	
Learning with Visual C++	
Writing C++ Applications	
Learning Desktop Applications Programming	
Learning C++	
C++ Concepts	
Functions	
Data and Variables	
Classes and Objects	
Templates	
Program Files	
Console Applications	
Windows Programming Concepts	
The Integrated Development Environment	
The Editor	
The Compiler	
The Linker	
The Libraries	
The Standard C++ Library	
Microsoft Libraries	
Using the IDE	
Toolbar Options	
Dockable Toolbars	1
Documentation	1
Projects and Solutions	1
Defining a Project	
Debug and Release Versions of Your Program	1
Executing the Program	1
Dealing with Errors	1
Setting Options in Visual C++	1
Creating and Executing Windows Applications	2
Creating an MFC Application	2
Building and Executing the MFC Application	2
Summary	

HAPTER 2: DATA, VARIABLES, AND CALCULATIONS	25
The Structure of a C++ Program	26
Program Comments	31
The #include Directive — Header Files	31
Namespaces and the Using Declaration	32
The main() Function	33
Program Statements	33
Whitespace	35
Statement Blocks	36
Automatically Generated Console Programs	36
Precompiled Header Files	37
Main Function Names	37
Defining Variables	38
Naming Variables	38
Keywords	39
Declaring Variables	39
Initial Values for Variables	40
Fundamental Data Types	40
Integer Variables	41
Character Data Types	42
Integer Type Modifiers	43
The Boolean Type	43
Floating-point Types	44
Fundamental Types in C++	45
Literals	45
Defining Type Aliases	46
Basic Input/Output Operations	47
Input from the Keyboard	47
Output to the Command Line	48
Formatting the Output	49
Escape Sequences	50
Calculating in C++	52
The Assignment Statement	52
Arithmetic Operations	52
The const Modifier	55
Constant Expressions	55
Program Input	56
Calculating the Result	56
Displaying the Result	57
Calculating a Remainder	58
Modifying a Variable	58

The Increment and Decrement Operators	59
The Sequence of Calculation	61
Operator Precedence	61
Type Conversion and Casting	63
Type Conversion in Assignments	64
Explicit Type Conversion	64
Old-style Casts	65
The auto Keyword	65
Discovering Types	66
The Bitwise Operators	67
The Bitwise AND	67
The Bitwise OR	68
The Bitwise Exclusive OR	69
The Bitwise NOT	70
The Bitwise Shift Operators	70
Introducing Lvalues and Rvalues	72
Understanding Storage Duration and Scope	72
Automatic Variables	73
Positioning Variable Declarations	75
Global Variables	75
Static Variables	78
Variables with Specific Sets of Values	79
Old Enumerations	79
Type-safe Enumerations	81
Namespaces	83
Declaring a Namespace	84
Multiple Namespaces	86
Summary	86
CHAPTER 3: DECISIONS AND LOOPS	91
Comparing Values	91
The if Statement	93
Nested if Statements	94
The Extended if Statement	96
Nested if-else Statements	98
Logical Operators and Expressions	100
Logical AND	101
Logical OR	101
Logical NOT	102
The Conditional Operator	103
The switch Statement	105

Unconditional Branching	109
Repeating a Block of Statements	109
What Is a Loop?	110
Variations on the for Loop	112
Using the continue Statement	116
Floating-Point Loop Counters	120
The while Loop	120
The do-while Loop	122
The Range-Based for Loop	123
Nested Loops	124
Summary	127
CHAPTER 4: ARRAYS, STRINGS, AND POINTERS	129
Handling Multiple Data Values of the Same Type	129
Arrays	130
Declaring Arrays	131
Initializing Arrays	134
Using the Range-based for Loop	135
Multidimensional Arrays	136
Initializing Multidimensional Arrays	137
Working with C-Style Strings	140
String Input	141
String Literals	143
Using the Range-based for Loop with Strings	144
Indirect Data Access	146
What Is a Pointer?	146
Declaring Pointers	146
The Address-of Operator	147
Using Pointers	147
The Indirection Operator	147
Why Use Pointers?	148
Initializing Pointers	148
Pointers to char	150
The sizeof Operator	154
Constant Pointers and Pointers to Constants	155
Pointers and Arrays	157
Pointer Arithmetic	157
Using Pointers with Multidimensional Arrays	162
Pointer Notation with Multidimensional Arrays	162
Dynamic Memory Allocation	163
The Free Store, Alias the Heap	163

The new and delete Operators	164
Allocating Memory Dynamically for Arrays	165
Dynamic Allocation of Multidimensional Arrays	167
Using References	168
What Is a Reference?	168
Declaring and Initializing Lvalue References	169
Using References in a Range-based for Loop	169
Creating Rvalue References	170
Library Functions for Strings	171
Finding the Length of a Null-terminated String	171
Joining Null-terminated Strings	172
Copying Null-terminated Strings	173
Comparing Null-terminated Strings	173
Searching Null-terminated Strings	174
Summary	176
CHAPTER 5: INTRODUCING STRUCTURE INTO YOUR PROGRAMS	179
Understanding Functions	179
Why Do You Need Functions?	181
Structure of a Function	181
The Function Header	181
The Function Body	183
The return Statement	183
Alternative Function Syntax	184
Using a Function	184
Function Prototypes	184
Passing Arguments to a Function	188
The Pass-by-Value Mechanism	189
Pointers as Arguments to a Function	190
Passing Arrays to a Function	192
Passing Multidimensional Arrays to a Function	194
References as Arguments to a Function	196
Use of the const Modifier	198
Rvalue Reference Parameters	200
Arguments to main()	202
Accepting a Variable Number of Function Arguments	204
Returning Values from a Function	206
Returning a Pointer	206
A Cast-Iron Rule for Returning Addresses	208
Returning a Reference	209
A Cast-Iron Rule: Returning References	212

Static Variables in a Function	212 <b>214</b>
Recursive Function Calls	214 217
Using Recursion Summary	217
Summary	217
CHAPTER 6: MORE ABOUT PROGRAM STRUCTURE	221
Pointers to Functions	221
Declaring Pointers to Functions	222
A Pointer to a Function as an Argument	225
Arrays of Pointers to Functions	227
Initializing Function Parameters	228
Exceptions	229
Throwing Exceptions	231
Catching Exceptions	232
Rethrowing Exceptions	234
Exception Handling in the MFC	234
Handling Memory Allocation Errors	235
Function Overloading	237
What Is Function Overloading?	237
Reference Types and Overload Selection	240
When to Overload Functions	241
Function Templates	241
Using a Function Template	241
Using the decltype Operator	244
An Example Using Functions	246
Implementing a Calculator	247
Analyzing the Problem	247
Eliminating Blanks from a String	250
How the Function Functions	250
Evaluating an Expression	250
How the Function Functions	252
Getting the Value of a Term	253
How the Function Functions	254
Analyzing a Number	254
How the Function Functions	256
Putting the Program Together	258
How the Function Functions	259
Extending the Program	259
How the Function Functions	261
Extracting a Substring	261

How the Function Functions	263
Running the Modified Program	263
Summary	264
CHAPTER 7: DEFINING YOUR OWN DATA TYPES	267
The struct in C++	267
What Is a struct?	268
Defining a struct	268
Initializing a struct	269
Accessing the Members of a struct	269
IntelliSense Assistance with Structures	272
The RECT Structure	274
Using Pointers with a struct	274
Accessing Structure Members through a Pointer	275
The Indirect Member Selection Operator	276
Types, Objects, Classes, and Instances	276
First Class	277
Operations on Classes	278
Terminology	278
Understanding Classes	279
Defining a Class	279
Access Control in a Class	280
Declaring Objects of a Class	280
Accessing the Data Members of a Class	280
Memberwise Initialization of an Object	283
Initializing Class Members	283
Member Functions of a Class	283
Defining a Member Function Outside a Class	286
Inline Functions	286
Class Constructors	287
What Is a Constructor?	287
The Default Constructor	289
Default Parameter Values	292
Using a Constructor Initialization List	294
Making a Constructor Explicit	295
Delegating Constructors	296
Private Members of a Class	297
Accessing private Class Members	299
The friend Functions of a Class	300
Placing friend Function Definitions Inside the Class	302

The Default Copy Constructor	303
The Pointer this	304
Const Objects	306
const Member Functions of a Class	307
Member Function Definitions Outside the Class	308
Arrays of Objects	309
Static Members of a Class	310
Static Data Members	311
Static Function Members of a Class	313
Pointers and References to Objects	314
Pointers to Objects	314
References to Class Objects	317
Implementing a Copy Constructor	317
Summary	318
CHAPTER 8: MORE ON CLASSES	323
Class Destructors	324
What Is a Destructor?	324
The Default Destructor	324
Destructors and Dynamic Memory Allocation	326
Implementing a Copy Constructor	329
Operator Overloading	331
Implementing an Overloaded Operator	332
Implementing Full Support for Comparison Operators	335
Overloading the Assignment Operator	340
Fixing the Problem	340
Overloading the Addition Operator	344
Overloading the Increment and Decrement Operators	348
Overloading the Function Call Operator	350
The Object Copying Problem	351
Avoiding Unnecessary Copy Operations	351
Applying Rvalue Reference Parameters	354
Named Objects Are Lvalues	356
Default Class Members	361
Class Templates	362
Defining a Class Template	363
Template Member Functions	365
Creating Objects from a Class Template	366
Class Templates with Multiple Parameters	370
Templates for Function Objects	372
Perfect Forwarding	373

Using References with Virtual Functions	460
Pure Virtual Functions	461
Abstract Classes	462
Indirect Base Classes	464
Virtual Destructors	467
Casting Between Class Types	470
Defining Conversion Operators	470
Explicit Conversion Operators	471
Nested Classes	471
Summary	475
CHAPTER 10: THE STANDARD TEMPLATE LIBRARY	479
What Is the Standard Template Library?	479
Containers	480
Allocators	482
Comparators	482
Container Adapters	483
lterators	483
Iterator Categories	483
SCARY Iterators	485
Functions Returning Iterators	485
Smart Pointers	485
Using unique_ptr Objects	486
Using shared_ptr Objects	487
Accessing the Raw Pointer in a Smart Pointer	488
Casting Smart Pointers	488
Algorithms	488
Function Objects in the STL	489
Function Adapters	490
The Range of STL Containers	490
Sequence Containers	490
Creating Vector Containers	492
The Capacity and Size of a Vector Container	495
Accessing the Elements in a Vector	499
Inserting and Deleting Elements in a Vector	500
Insert Operations	500
Emplace Operations	501
Erase Operations	502
Swap and Assign Operations	502
Storing Class Objects in a Vector	503
Sorting Vector Elements	508
Storing Pointers in a Vector	509

Double-ended Queue Containers515Using List Containers518Adding Elements to a List518Accessing Elements in a List520Sorting List Elements520Other Operations on Lists522Using Other Sequence Containers529Queue Containers529Queue Containers530Priority Queue Containers537The tuple Class Template539Associative Containers543Using Map Containers544Accessing Objects544Accessing Objects544Outher Map Operations546Using Input Stream Iterators555Using Input Stream Iterators556Using Output Stream Iterators556Using Output Stream Iterators566More on Function Objects566More on Algorithms564Type Traits and Static Assertions567The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expressions577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programming Basics580Elements of a Window583Windows API584Windows API584Windows API584Windows API584Windows API584Windows API584Windows API584Windows API584Windows API584Windows API584	Array Containers	511
Adding Elements to a List518Accessing Elements in a List520Sorting List Elements520Other Operations on Lists522Using forward_list Containers528Using Other Sequence Containers529Queue Containers530Priority Queue Containers537The tuple Class Template539Associative Containers543Using Map Containers543Using Map Containers543Using Map Containers543Storing Objects544Accessing Objects546Other Map Operations546Using Input Stream Iterators556Using Input Stream Iterators556Using Output Stream Iterators560More on Function Objects562More on Algorithms564Type Traits and Static Assertions567The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expressions577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programs and the Operating System583Windows API583Windows API583Windows Data Types584	Double-ended Queue Containers	515
Accessing Elements in a List520Sorting List Elements520Other Operations on Lists522Using forward_list Containers529Queue Containers529Queue Containers530Priority Queue Containers531Stack Containers533The tuple Class Template537Associative Containers543Using Map Containers543Storing Objects544Accessing Objects544Accessing Objects546Other Map Operations546Using a Multimap Container555More on Iterators556Using Input Stream Iterators556Using Input Stream Iterators560More on Function Objects562More on Algorithms564Type Traits and Static Assertions566Lambda Expressions570The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expressions577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programs and the Operating System582Event-Driven Programs583Windows API583Windows Data Types584	Using List Containers	518
Sorting List Elements520Other Operations on Lists522Using forward_list Containers528Using Other Sequence Containers530Priority Queue Containers532Stack Containers537The tuple Class Template539Associative Containers543Using Map Containers543Storing Objects544Accessing Objects544Accessing Objects546Other Map Operations546Using a Multimap Container555More on Iterators556Using Input Stream Iterators556Using Input Stream Iterators556Using Output Stream Iterators564Type Traits and Static Assertions566Lambda Expressions567The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programming Basics580Elements of a Window580Windows API583Windows API583Windows Data Types584	Adding Elements to a List	518
Other Operations on Lists522Using forward_list Containers528Using Other Sequence Containers529Queue Containers530Priority Queue Containers532Stack Containers537The tuple Class Template539Associative Containers543Using Map Containers543Storing Objects544Accessing Objects546Other Map Operations546Using a Multimap Container555More on Iterators556Using Input Stream Iterators556Using Output Stream Iterators556More on Function Objects562More on Algorithms564Type Traits and Static Assertions567The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expressions574Summary577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programming Basics580Elements of a Window583Windows API583Windows API583Windows Data Types584	Accessing Elements in a List	520
Using forward_list Containers528Using Other Sequence Containers529Queue Containers530Priority Queue Containers532Stack Containers532Stack Containers533Associative Containers533Associative Containers543Using Map Containers543Storing Objects544Accessing Objects544Other Map Operations546Using a Multimap Container555More on Iterators556Using Input Stream Iterators556Using Input Stream Iterators556Using Output Stream Iterators562More on Algorithms564Type Traits and Static Assertions566Lambda Expressions567The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expression574Summary577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programs and the Operating System582Event-Driven Programs583Windows API583Windows API583Windows Data Types584	Sorting List Elements	520
Using Other Sequence Containers529Queue Containers530Priority Queue Containers532Stack Containers537The tuple Class Template539Associative Containers543Using Map Containers543Storing Objects544Accessing Objects544Accessing Objects546Other Map Operations546Using a Multimap Container555More on Iterators556Using Input Stream Iterators556Using Output Stream Iterators556More on Function Objects562More on Function Objects564Type Traits and Static Assertions566Lambda Expressions567The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expression574Summary577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programs and the Operating System582Event-Driven Programs583Windows API583Windows Data Types584	Other Operations on Lists	522
Queue Containers530Priority Queue Containers532Stack Containers537The tuple Class Template539Associative Containers543Using Map Containers543Storing Objects544Accessing Objects544Accessing Objects546Other Map Operations546Using a Multimap Container555More on Iterators556Using Input Stream Iterators556Using Output Stream Iterators556Using Output Stream Iterators560More on Function Objects562More on Algorithms564Type Traits and Static Assertions566Lambda Expressions567The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expressions577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programs and the Operating System582Event-Driven Programs583Windows API583Windows Data Types584	Using forward_list Containers	528
Priority Queue Containers532Stack Containers537The tuple Class Template539Associative Containers543Using Map Containers543Storing Objects544Accessing Objects546Other Map Operations546Using a Multimap Container555More on Iterators556Using Input Stream Iterators556Using Output Stream Iterators556Using Output Stream Iterators556More on Algorithms562More on Algorithms564Type Traits and Static Assertions566Lambda Expressions567The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expressions577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programming Basics580Elements of a Window580Windows Programs and the Operating System582Event-Driven Programs583Windows API583Windows Data Types584	Using Other Sequence Containers	529
Stack Containers537The tuple Class Template539Associative Containers543Using Map Containers543Storing Objects544Accessing Objects544Accessing Objects546Other Map Operations546Using a Multimap Container555More on Iterators556Using Input Stream Iterators556Using Output Stream Iterators559Using Output Stream Iterators562More on Function Objects562More on Algorithms564Type Traits and Static Assertions566Lambda Expressions567The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expression574Summary577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programming Basics580Elements of a Window580Windows Programs and the Operating System582Event-Driven Programs583Windows API583Windows Data Types584	Queue Containers	530
The tuple Class Template539Associative Containers543Using Map Containers543Storing Objects544Accessing Objects544Accessing Objects546Other Map Operations546Using a Multimap Container555More on Iterators556Using Input Stream Iterators556Using Output Stream Iterators556Using Output Stream Iterators560More on Function Objects562More on Algorithms564Type Traits and Static Assertions566Lambda Expressions567The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expressions577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programming Basics580Elements of a Window580Windows Programs and the Operating System582Event-Driven Programs583Windows API583Windows Data Types584	Priority Queue Containers	532
Associative Containers543Using Map Containers543Storing Objects544Accessing Objects544Accessing Objects546Other Map Operations546Using a Multimap Container555More on Iterators556Using Input Stream Iterators556Using Output Stream Iterators559Using Output Stream Iterators560More on Function Objects562More on Algorithms564Type Traits and Static Assertions566Lambda Expressions567The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expressions577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programming Basics580Elements of a Window580Windows Mersages583The Windows API583Windows Data Types584	Stack Containers	537
Using Map Containers543Storing Objects544Accessing Objects546Other Map Operations546Using a Multimap Container555More on Iterators556Using Input Stream Iterators556Using Output Stream Iterators559Using Output Stream Iterators560More on Function Objects562More on Algorithms564Type Traits and Static Assertions566Lambda Expressions567The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expression574Summary577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programming Basics580Event-Driven Programs583Windows Messages583The Windows API583Windows Data Types584	The tuple Class Template	539
Storing Objects544Accessing Objects546Other Map Operations546Using a Multimap Container555More on Iterators556Using Input Stream Iterators556Using Output Stream Iterators559Using Output Stream Iterators560More on Function Objects562More on Algorithms564Type Traits and Static Assertions566Lambda Expressions567The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expression574Summary5777CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programming Basics580Event-Driven Programs583Windows Messages583The Windows API583Windows Data Types584	Associative Containers	543
Accessing Objects546Other Map Operations546Using a Multimap Container555More on Iterators556Using Input Stream Iterators556Using Output Stream Iterators559Using Output Stream Iterators560More on Function Objects562More on Algorithms564Type Traits and Static Assertions566Lambda Expressions567The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expression574Summary577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programming Basics580Elements of a Window580Windows Programs and the Operating System582Event-Driven Programs583Windows Messages583The Windows API583Windows Data Types584	Using Map Containers	543
Other Map Operations546Using a Multimap Container555More on Iterators556Using Input Stream Iterators556Using Output Stream Iterators559Using Output Stream Iterators560More on Function Objects562More on Algorithms564Type Traits and Static Assertions566Lambda Expressions567The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expression574Summary577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programs and the Operating System582Event-Driven Programs583Windows Messages583The Windows API583Windows Data Types584	Storing Objects	544
Using a Multimap Container 555 More on Iterators 556 Using Input Stream Iterators 559 Using Output Stream Iterators 560 More on Function Objects 562 More on Algorithms 564 Type Traits and Static Assertions 566 Lambda Expressions 567 The Capture Clause 568 Capturing Specific Variables 569 Templates and Lambda Expressions 570 Naming a Lambda Expression 574 Summary 577 CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS 579 Windows Programming Basics 580 Elements of a Window 580 Windows Programs and the Operating System 582 Event-Driven Programs 583 Windows Messages 583 The Windows API 583 Windows Data Types 584	Accessing Objects	546
More on Iterators556Using Input Stream Iterators556Using Output Stream Iterators559Using Output Stream Iterators560More on Function Objects562More on Algorithms564Type Traits and Static Assertions566Lambda Expressions567The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expression574Summary577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programs and the Operating System582Event-Driven Programs583Windows Messages583The Windows API583Windows Data Types584	Other Map Operations	546
Using Input Stream Iterators556Using Inserter Iterators559Using Output Stream Iterators560More on Function Objects562More on Algorithms564Type Traits and Static Assertions566Lambda Expressions567The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expression574Summary577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programming Basics580Elements of a Window580Windows Programs and the Operating System582Event-Driven Programs583Windows API583Windows Data Types584	Using a Multimap Container	555
Using Inserter Iterators559Using Output Stream Iterators560More on Function Objects562More on Algorithms564Type Traits and Static Assertions566Lambda Expressions567The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expression574Summary577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programming Basics580Elements of a Window582Event-Driven Programs583Windows Messages583The Windows API583Windows Data Types584	More on Iterators	556
Using Output Stream Iterators560More on Function Objects562More on Algorithms564Type Traits and Static Assertions566Lambda Expressions567The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expression574Summary577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programming Basics580Elements of a Window580Windows Programs and the Operating System582Event-Driven Programs583Windows Messages583The Windows API583Windows Data Types584	Using Input Stream Iterators	556
More on Function Objects562More on Algorithms564Type Traits and Static Assertions566Lambda Expressions567The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expression574Summary577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTSWindows Programming Basics580Elements of a Window580Windows Programs and the Operating System583Windows Messages583The Windows API583Windows Data Types584	Using Inserter Iterators	559
More on Algorithms564Type Traits and Static Assertions566Lambda Expressions567The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expression574Summary577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programming Basics580Elements of a Window580Windows Programs and the Operating System582Event-Driven Programs583Windows Messages583The Windows API583Windows Data Types584	Using Output Stream Iterators	560
Type Traits and Static Assertions566Lambda Expressions567The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expression574Summary577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programming Basics580Elements of a Window580Windows Programs and the Operating System582Event-Driven Programs583Windows Messages583The Windows API583Windows Data Types584	More on Function Objects	562
Lambda Expressions567The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expression574Summary577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programming Basics580Elements of a Window580Windows Programs and the Operating System582Event-Driven Programs583Windows Messages583The Windows API583Windows Data Types584	More on Algorithms	564
The Capture Clause568Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expression574Summary577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programming Basics580Elements of a Window580Windows Programs and the Operating System582Event-Driven Programs583Windows Messages583The Windows API583Windows Data Types584	Type Traits and Static Assertions	566
Capturing Specific Variables569Templates and Lambda Expressions570Naming a Lambda Expression574Summary577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programming Basics580Elements of a Window580Windows Programs and the Operating System582Event-Driven Programs583Windows Messages583The Windows API583Windows Data Types584	Lambda Expressions	567
Templates and Lambda Expressions570Naming a Lambda Expression574Summary577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programming Basics580Elements of a Window580Windows Programs and the Operating System582Event-Driven Programs583Windows Messages583The Windows API583Windows Data Types584	The Capture Clause	568
Naming a Lambda Expression574Summary577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programming Basics580Elements of a Window580Windows Programs and the Operating System582Event-Driven Programs583Windows Messages583The Windows API583Windows Data Types584	Capturing Specific Variables	569
Summary577CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programming Basics580Elements of a Window580Windows Programs and the Operating System582Event-Driven Programs583Windows Messages583The Windows API583Windows Data Types584	Templates and Lambda Expressions	570
CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS579Windows Programming Basics580Elements of a Window580Windows Programs and the Operating System582Event-Driven Programs583Windows Messages583The Windows API583Windows Data Types584	Naming a Lambda Expression	574
Windows Programming Basics580Elements of a Window580Windows Programs and the Operating System582Event-Driven Programs583Windows Messages583The Windows API583Windows Data Types584	Summary	577
Elements of a Window580Windows Programs and the Operating System582Event-Driven Programs583Windows Messages583The Windows API583Windows Data Types584	CHAPTER 11: WINDOWS PROGRAMMING CONCEPTS	579
Elements of a Window580Windows Programs and the Operating System582Event-Driven Programs583Windows Messages583The Windows API583Windows Data Types584	Windows Programming Basics	580
Windows Programs and the Operating System582Event-Driven Programs583Windows Messages583The Windows API583Windows Data Types584		
Event-Driven Programs583Windows Messages583The Windows API583Windows Data Types584		
Windows Messages583The Windows API583Windows Data Types584		
The Windows API583Windows Data Types584	5	
Windows Data Types 584	5	
Notation in Windows Programs	Notation in Windows Programs	585

The Structure of a Windows Program	586
The WinMain() Function	587
Specifying a Program Window	589
Creating a Program Window	591
Initializing the Program Window	593
Dealing with Windows Messages	594
A Complete WinMain() Function	598
How It Works	599
Processing Windows Messages	599
The WindowProc() Function	600
Decoding a Windows Message	600
Ending the Program	603
A Complete WindowProc() Function	603
How It Works	604
The Microsoft Foundation Classes	605
MFC Notation	605
How an MFC Program Is Structured	606
Summary	610
CHAPTER 12: WINDOWS PROGRAMMING WITH	
THE MICROSOFT FOUNDATION CLASSES (MFC)	613
i	
The MFC Document/View Concept	614
What Is a Document?	614
Document Interfaces	614
What Is a View?	614
Linking a Document and Its Views	615
Document Templates	616
Document Template Classes	
	616
Your Application and MFC	616 617
Creating MFC Applications	616 617 <b>618</b>
Creating MFC Applications Creating an SDI Application	616 617 <b>618</b> 619
Creating MFC Applications Creating an SDI Application MFC Application Wizard Output	616 617 <b>618</b> 619 623
Creating MFC Applications Creating an SDI Application MFC Application Wizard Output Viewing Project Files	616 617 <b>618</b> 619 623 625
Creating MFC Applications Creating an SDI Application MFC Application Wizard Output Viewing Project Files Viewing Classes	616 617 618 619 623 625 625
Creating MFC Applications Creating an SDI Application MFC Application Wizard Output Viewing Project Files Viewing Classes The Class Definitions	616 617 <b>618</b> 619 623 625 625 625
Creating MFC Applications Creating an SDI Application MFC Application Wizard Output Viewing Project Files Viewing Classes The Class Definitions Creating an Executable Module	616 617 618 619 623 625 625 625 626 631
Creating MFC Applications Creating an SDI Application MFC Application Wizard Output Viewing Project Files Viewing Classes The Class Definitions Creating an Executable Module Running the Program	616 617 618 619 623 625 625 625 626 631 631
Creating MFC Applications Creating an SDI Application MFC Application Wizard Output Viewing Project Files Viewing Classes The Class Definitions Creating an Executable Module Running the Program How the Program Works	616 617 618 619 623 625 625 625 626 631 631 632
Creating MFC Applications Creating an SDI Application MFC Application Wizard Output Viewing Project Files Viewing Classes The Class Definitions Creating an Executable Module Running the Program How the Program Works Creating an MDI Application	616 617 618 619 623 625 625 625 626 631 631 632 633
Creating MFC Applications Creating an SDI Application MFC Application Wizard Output Viewing Project Files Viewing Classes The Class Definitions Creating an Executable Module Running the Program How the Program Works	616 617 618 619 623 625 625 625 626 631 631 632

#### CONTENTS

CHAPTER 13: WORKING WITH MENUS AND TOOLBARS	637
Communicating with Windows	637
Understanding Message Maps	638
Message Handler Definitions	639
Message Categories	640
Handling Messages in Your Program	641
How Command Messages Are Processed	642
Extending the Sketcher Program	642
Elements of a Menu	643
Creating and Editing Menu Resources	643
Adding a Menu Item to the Menu Bar	644
Adding Items to the Element Menu	645
Modifying Existing Menu Items	645
Completing the Menu	646
Adding Menu Message Handlers	646
Choosing a Class to Handle Menu Messages	648
Creating Menu Message Handlers	648
Implementing Menu Message Handlers	650
Adding Members to Store Color and Element Mode	650
Defining Element and Color Types	652
Initializing the Color and Element Type Members	653
Implementing Menu Command Message Handlers	653
Running the Extended Example	654
Adding Menu Update Message Handlers	654
Coding a Command Update Handler	655
Exercising the Update Handlers	656
Adding Toolbar Buttons	656
Editing Toolbar Button Properties	658
Exercising the Toolbar Buttons	659
Adding Tooltips	659
Summary	660
CHAPTER 14: DRAWING IN A WINDOW	663
Basics of Drawing in a Window	663
The Window Client Area	664
The Windows Graphical Device Interface	664
Working with a Device Context	665
Mapping Modes	665
The MFC Drawing Mechanism	667
The View Class in Your Application	667

The OnDraw() Member Function	668
The CDC Class	669
Displaying Graphics	669
Drawing in Color	673
Drawing Graphics in Practice	678
Programming for the Mouse	680
Messages from the Mouse	681
WM_LBUTTONDOWN	682
WM_MOUSEMOVE	682
WM_LBUTTONUP	682
Mouse Message Handlers	682
Drawing Using the Mouse	684
Getting the Client Area Redrawn	686
Defining Element Classes	687
The CElement Class	691
The CLine Class	692
The CRectangle Class	695
The CCircle Class	697
The CCurve Class	700
Completing the Mouse Message Handlers	702
Drawing a Sketch	709
Running the Example	710
Capturing Mouse Messages	711
Summary	713
CHAPTER 15: IMPROVING THE VIEW	717
Sketcher Limitations	717
Improving the View	718
Updating Multiple Views	718
Scrolling Views	720
Logical Coordinates and Client Coordinates	722
Dealing with Client Coordinates	723
Using MM_LOENGLISH Mapping Mode	725
Deleting and Moving Elements	726
Implementing a Context Menu	726
Associating a Menu with a Class	728
Checking Context Menu Items	729
Identifying an Element Under the Cursor	730
Exercising the Context Menus	732
Highlighting Elements	732
Drawing Highlighted Elements	735