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C++大学教程

(第九版)(英文版)

[美] Paul Deitel
Harvey Deitel 著

C++ How to Program

Ninth Edition

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内 容 简 介

本书是一本 C++编程方面的优秀教材，全面介绍了面向对象编程的原理与方法，详细分析了与 C++编程有关的技术。本书的主要内容包括类与对象、控制语句、函数与递归、数组、指针、运算符重载、继承、多态、输入/输出流、异常处理、文件处理、模板、搜索与排序等。全书以“活代码”的方式详细分析了每个知识要点，提供了丰富的自测练习和项目练习，是初学者和中高级程序员学习 C++编程的理想用书。

本书可作为高等院校相关专业的 C++语言课程的双语教材，也是软件设计人员学习 C++编程的理想读物。

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HOW TO PROGRAM

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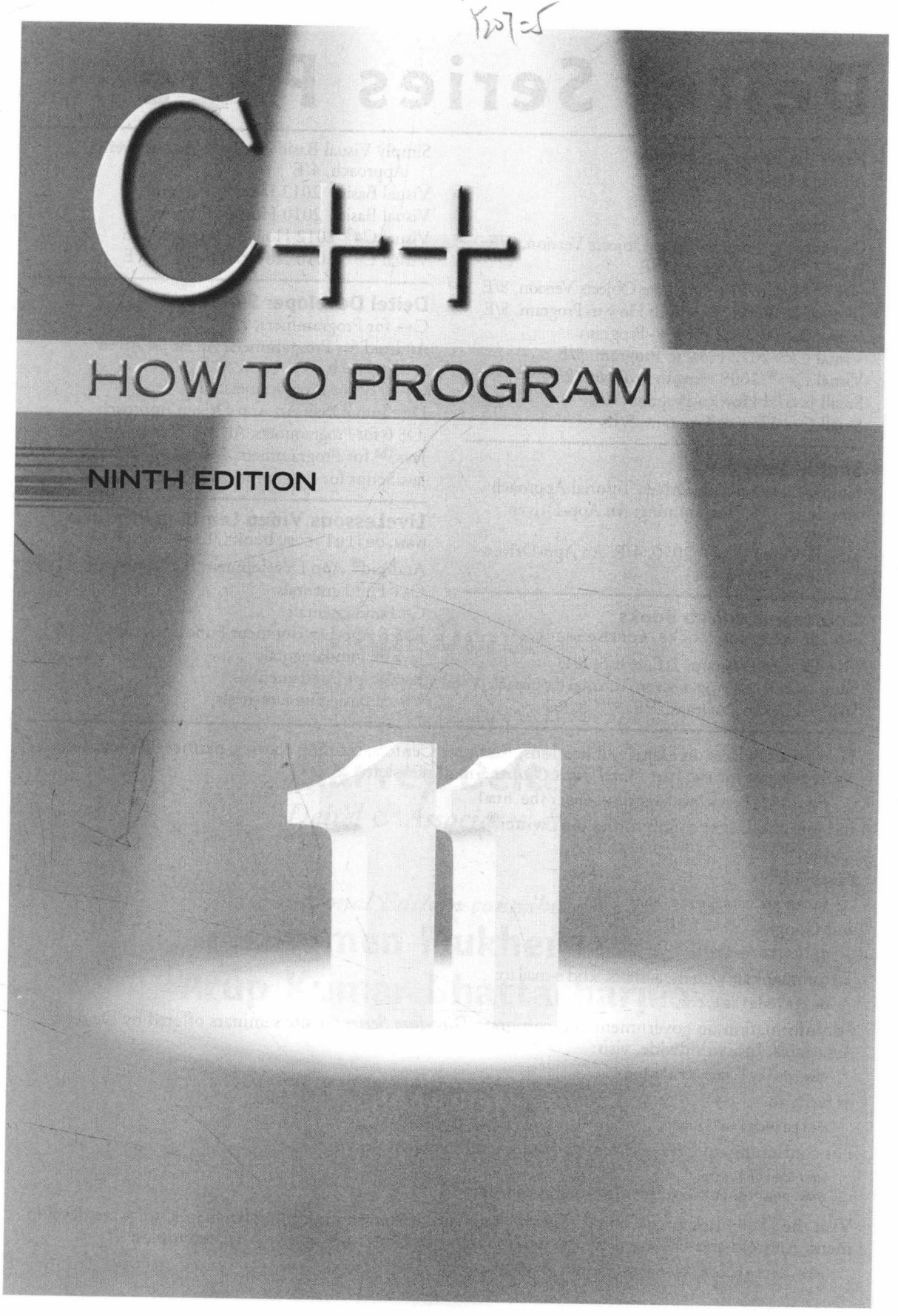

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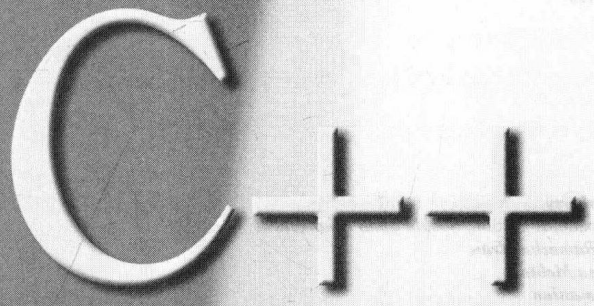



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In memory of Dennis Ritchie,
creator of the C programming language—
one of the key languages that inspired C++.

Paul and Harvey Deitel

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Preface

"The chief merit of language is clearness ..."
—Galen

Welcome to the C++ computer programming language and *C++ How to Program, Ninth Edition*. This book presents leading-edge computing technologies. It's appropriate for introductory course sequences based on the curriculum recommendations of two key professional organizations—the ACM and the IEEE. If you haven't already done so, please read the back cover and inside back cover—these capture the essence of the book concisely. In this Preface we provide more detail for students, instructors and professionals.

At the heart of the book is the Deitel signature *live-code approach*—we present concepts in the context of complete working programs followed by sample executions, rather than in code snippets. Read the online Before You Begin section(`www.deitel.com/books/cpphtp9/cpphtp9_BYB.pdf`) to learn how to set up your Linux-based, Windows-based or Apple OS X-based computer to run the hundreds of code examples. All the source code is available at `www.deitel.com/books/cpphtp9` and `www.pearsoninternational-editions.com/deitel`. Use the source code we provide to *run each program* as you study it.

We believe that this book and its support materials will give you an informative, challenging and entertaining introduction to C++. As you read the book, if you have questions, we're easy to reach at `deitel@deitel.com`—we'll respond promptly. For book updates, visit `www.deitel.com/books/cpphtp9`, join our social media communities on Facebook(`www.deitel.com/DeitelFan`), Twitter(`@deitel`), Google+ (`gplus.to/deitel`) and LinkedIn(`bit.ly/DeitelLinkedIn`), and subscribe to the *Deitel Buzz® Online* newsletter (`www.deitel.com/newsletter/subscribe.html`).

C++11 Standard

The new C++11 standard, published in 2011, motivated us to write *C++ How to Program, 9/e*. Throughout the book, each new C++11 feature is marked with the "11" icon you see here in the margin. These are some of the key C++11 features of this new edition:

- ***Conforms to the new C++11 standard.*** Extensive coverage of the new C++11 features (Fig. 1).
- ***Code thoroughly tested on three popular industrial-strength C++11 compilers.*** We tested the code examples on GNU C++ 4.7, Microsoft® Visual C++® 2012 and Apple® LLVM in Xcode® 4.5.
- ***Smart pointers.*** Smart pointers help you avoid dynamic memory management errors by providing additional functionality beyond that of built-in pointers. We discuss `unique_ptr` in Chapter 17, and `shared_ptr` and `weak_ptr` in Chapter 24.
- ***Earlier coverage of Standard Library containers, iterators and algorithms, enhanced with C++11 capabilities.*** We moved the treatment of Standard Library containers, iterators and algorithms from Chapter 22 in the previous edition to Chapters 15 and 16 and enhanced it with additional C++11 features. The vast majority of your data structure needs can be fulfilled by *reusing* these Standard Library capabilities. We'll show you how to build your own *custom* data structures in Chapter 19.

C++11 features in *C++ How to Program, 9/e*		
`all_of` algorithm	Inheriting base-class constructors	Non-deterministic random number generation
`any_of` algorithm	`insert` container member functions return iterators	`none_of` algorithm
`array` container	`is_heap` algorithm	Numeric conversion functions
`auto` for type inference	`is_heap_until` algorithm	`nullptr`
`begin`/`end` functions	Keywords new in C++11	`override` keyword
`cbegin`/`cend` container member functions	Lambda expressions	Range-based `for` statement
Compiler fix for >> in template types	List initialization of key–value `pairs`	Regular expressions
`copy_if` algorithm	List initialization of `pair` objects	Rvalue references
`copy_n` algorithm	List initialization of return values	Scoped `enum`s
`crbegin`/`crend` container member functions	List initializing a dynamically allocated array	`shared_ptr` smart pointer
`decltype`	List initializing a `vector`	`shrink_to_fit` `vector`/`deque` member function
Default type arguments in function templates	List initializers in constructor calls	Specifying the type of an enum's constants
`defaulted` member functions	`long long int` type	`static_assert` objects for file names
Delegating constructors	`min` and `max` algorithms with `initializer_list` parameters	`string` objects for file names
`deleted` member functions	`minmax` algorithm	`swap` non-member function
`explicit` conversion operators	`minmax_element` algorithm	Trailing return types for functions
`final` classes	`move` algorithm	`tuple` variadic template
`final` member functions	Move assignment operators	`unique_ptr` smart pointer
`find_if_not` algorithm	`move_backward` algorithm	Unsigned `long long int`
`forward_list` container	Move constructors	`weak_ptr` smart pointer
Immutable keys in associative containers	`noexcept`	
In-class initializers		

Fig. 1 | A sampling of C++11 features in *C++ How to Program, 9/e*.

- ***Online Chapter 24, C++11: Additional Features.*** In this chapter, we present additional C++11 topics. The new C++11 standard has been available since 2011, but not all C++ compilers have fully implemented the features. If all three of our key compilers already implemented a particular C++11 feature at the time we wrote this book, we generally integrated a discussion of that feature into the text with a live-code example. If any of these compilers had *not* implemented that feature, we included a bold italic heading followed by a brief discussion of the feature. Many of those discussions are expanded in online Chapter 24 as the features are implemented. This chapter includes discussions of regular expressions, `shared_ptr` and `weak_ptr` smart pointers, move semantics and more.
- ***Random Number generation, simulation and game playing.*** To help make programs more secure, we've added a treatment of C++11's new non-deterministic random-number generation capabilities.

Object-Oriented Programming

- ***Early-objects approach.*** The book introduces the basic concepts and terminology of object technology in Chapter 1. You'll develop your first customized classes and objects in Chapter 3. Presenting objects and classes early gets you "thinking about objects" immediately and mastering these concepts more thoroughly.[①]
- ***C++ Standard Library string.*** C++ offers *two* types of strings—`string` class objects (which we begin using in Chapter 3) and C strings. We've replaced most occurrences of C strings with instances of C++

① For courses that require a late-objects approach, consider *C++ How to Program, Late Objects Version*, which begins with six chapters on programming fundamentals (including two on control statements) and continues with seven chapters that gradually introduce object-oriented programming concepts.

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class `string` to make programs more robust and eliminate many of the security problems of C strings. We continue to discuss C strings later in the book to prepare you for working with the legacy code that you'll encounter in industry. In new development, you should favor `string` objects.

- ***C++ Standard Library array.*** Our primary treatment of arrays now uses the Standard Library's `array` class template instead of built-in, C-style, pointer-based arrays. We still cover built-in arrays because they remain useful in C++ and so that you'll be able to read legacy code. C++ offers *three* types of arrays—`array`s and `vector`s (which we start using in Chapter 7) and C-style, pointer-based arrays which we discuss in Chapter 8. As appropriate, we use class template `array` instead of C arrays throughout the book. In new development, you should favor class template `array` objects.
- ***Crafting valuable classes.*** A key goal of this book is to prepare you to build valuable classes. In the Chapter 10 case study, you'll build your own custom `Array` class, then in the Chapter 18 exercises you'll convert it to a class template. You'll truly appreciate the class concept. Chapter 10 begins with a test-drive of class template `string` so you can see an elegant use of operator overloading before you implement your own customized class with overloaded operators.
- ***Case studies in object-oriented programming.*** We provide case studies that span multiple sections and chapters and cover the software development lifecycle. These include the `GradeBook` class in Chapters 3–7, the `Time` class in Chapter 9 and the `Employee` class in Chapters 11–12. Chapter 12 contains a detailed diagram and explanation of how C++ can implement polymorphism, `virtual` functions and dynamic binding "under the hood."
- ***Optional case study: Using the UML to develop an object-oriented design and C++ implementation of an ATM.*** The UML(Unified Modeling Language) is the industry-standard graphical language for modeling object-oriented systems. We introduce the UML in the early chapters. Online Chapters 25 and 26 include an *optional* case study on object-oriented design using the UML. We design and implement the software for a simple automated teller machine(ATM). We analyze a typical requirements document that specifies the system to be built. We determine the classes needed to implement that system, the attributes the classes need to have, the behaviors the classes need to exhibit and we specify how the classes must interact with one another to meet the system requirements. From the design we produce a complete C++ implementation. Students often report that the case study helps them "tie it all together" and truly understand object orientation.
- ***Exception handling.*** We integrate basic exception handling *early* in the book. Instructors can easily pull more detailed material forward from Chapter 17, Exception Handling: A Deeper Look.
- ***Custom template-based data structures.*** We provide a rich multi-chapter treatment of data structures—see the Data Structures module in the chapter dependency chart (Fig. 5).
- ***Three programming paradigms.*** We discuss *structured programming*, *object-oriented programming* and *generic programming*.

Pedagogic Features

- ***Rich coverage of C++ fundamentals.*** We include a clear two-chapter treatment of control statements and algorithm development.
- ***Chapter 2 provides a simple introduction to C++ programming.***

- ***Examples.*** We include a broad range of example programs selected from computer science, business, simulation, game playing and other topics (Fig. 2).
- ***Audience.*** The examples are accessible to computer science, information technology, software engineering and business students in novice-level and intermediate-level C++ courses. The book is also used by professional programmers.

Examples	
`Array` class case study	Craps dice game simulation
`Author` class	Credit inquiry program
Bank account program	`Date` class
Bar chart printing program	Downcasting and runtime type information
`BasePlusCommissionEmployee` class	`Employee` class
Binary tree creation and traversal	`explicit` constructor
`BinarySearch` test program	`fibonacci` function
Card shuffling and dealing	`fill` algorithms
`ClientData` class	Function-template specializations of function template `printArray`
`CommissionEmployee` class	`generate` algorithms
Comparing `strings`	`GradeBook` Class
Compilation and linking process	Initializing an array in a declaration
Compound interest calculations with `for`	Input from an `istringstream` object
Converting `string` objects to C strings	Iterative factorial solution
Counter-controlled repetition	`SalesPerson` class
Lambda expressions	Searching and sorting algorithms of the Standard Library
Linked list manipulation	Sequential files
`map` class template	`set` class template
Mathematical algorithms of the Standard Library	`shared_ptr` program
`maximum` function template	`stack` adapter class
Merge sort program	`Stack` class
`multiset` class template	Stack unwinding
`new` throwing `bad_alloc` on failure	Standard Library `string` class program
`PhoneNumber` class	Stream manipulator `showbase`
Poll analysis program	`string` assignment and concatenation
Polymorphism demonstration	`string` member function `substr`
Preincrementing and postincrementing	Summing integers with the `for` statement
`priority_queue` adapter class	`Time` class
`queue` adapter class	`unique_ptr` object managing dynamically allocated memory
Random-access files	Validating user input with regular expressions
Random number generation	`vector` class template
Recursive function `factorial`	
Rolling a six-sided die 6,000,000 times	
`SalariedEmployee` class	

Fig. 2 | A sampling of the book's examples.

- ***Self-Review Exercises and Answers.*** Extensive self-review exercises *and* answers are included for self-study.
- ***Interesting, entertaining and challenging exercises.*** Each chapter concludes with a substantial set of exercises, including simple recall of important terminology and concepts, identifying the errors in code samples, writing individual program statements, writing small portions of C++ classes and member and non-member functions, writing complete programs and implementing major projects. Fig. 3 lists a sampling of the book's exercises, including our *Making a Difference* exercises, which encourage you to use computers and the Internet to research and solve significant social problems. We hope you'll approach these exercises with *your own* values, politics and beliefs.
- ***Illustrations and figures.*** Abundant tables, line drawings, UML diagrams, programs and program outputs are included. A sampling of the book's drawings and diagrams is shown in Fig. 4.

Exercises		
Airline Reservations System	Bubble Sort	Calculating Salaries
Advanced String-Manipulation Exercises	Build Your Own Compiler	CarbonFootprint Abstract Class: Polymorphism
Card Shuffling and Dealing	Build Your Own Computer	Pythagorean Triples
Computer-Assisted Instruction	Eight Queens	Salary Calculator
Computer-Assisted Instruction: Difficulty Levels	Emergency Response	Sieve of Eratosthenes
Computer-Assisted Instruction: Monitoring Student Performance	Enforcing Privacy with Cryptography	Simple Decryption
Computer-Assisted Instruction: Reducing Student Fatigue	Facebook User Base Growth	Simple Encryption
Computer-Assisted Instruction: Varying the Types of Problems	Fibonacci Series	SMS Language
Cooking with Healthier Ingredients	Gas Mileage	Spam Scanner
Craps Game Modification	Global Warming Facts Quiz	Spelling Checker
Credit Limits	Guess the Number Game	Target-Heart-Rate Calculator
Crossword Puzzle Generator	Hangman Game	Tax Plan Alternatives; The "Fair Tax"
Cryptograms	Health Records Knight's Tour	Telephone number word generator
De Morgan's Laws	Limericks	"The Twelve Days of Christmas" Song
Dice Rolling	Maze Traversal: Generating Mazes Randomly	Tortoise and the Hare Simulation
	Morse Code	Towers of Hanoi
	Payroll System Modification	World Population Growth
	Peter Minuit Problem	
	Phishing Scanner	
	Pig Latin	
	Polymorphic Banking Program Using Account Hierarchy	

Fig. 3 | A sampling of the book's exercises.

Drawings and diagrams		
Main text drawings and diagrams		
Data hierarchy	`while` repetition statement UML activity diagram	Pass-by-value and pass-by-reference analysis of a program
Compilation and linking process for multiple source file programs	`for` repetition statement UML activity diagram	Inheritance hierarchy diagrams
Order in which a second-degree polynomial is evaluated	`do...while` repetition statement UML activity diagram	Function-call stack and activation records
`GradeBook` class diagrams	`switch` multiple-selection statement activity diagram	Recursive calls to function `fibonacci`
`if` single-selection statement activity diagram	C++'s single-entry/single-exit sequence, selection and repetition statements	Pointer arithmetic diagrams
`if...else` double-selection statement activity diagram	Graphical representation of a list	`CommunityMember` Inheritance hierarchy
`public`, `protected` and `private` inheritance	Operation `insertAtFront` represented graphically	`Shape` inheritance hierarchy
`Employee` hierarchy UML class diagram	Operation `insertAtBack` represented graphically	Operation `removeFromBack` represented graphically
How `virtual` function calls work	Operation `removeFromFront` represented graphically	Circular, singly linked list
Stream-I/O template hierarchy		Doubly linked list
Two self-referential class objects linked together		Circular, doubly linked list
		Graphical representation of a binary tree
ATM Case Study drawings and diagrams		
Use case diagram for the ATM system from the User's perspective	Classes in the ATM system with attributes and operations	Class diagram showing composition relationships of a class `Car`
Class diagram showing an association among classes	Communication diagram of the ATM executing a balance inquiry	Class diagram for the ATM system model including class `Deposit`
Class diagram showing composition relationships	Communication diagram for executing a balance inquiry	Activity diagram for a `Deposit`

Drawings and diagrams		
Class diagram for the ATM system model	Sequence diagram that models a `Withdrawal` executing	transaction Sequence diagram that models a `Deposit` executing
Classes with attributes	Use case diagram for a modified version of our ATM system that also allows users to transfer money between accounts	
State diagram for the ATM		
Activity diagram for a `Balance-Inquiry` transaction		
Activity diagram for a `Withdrawal` transaction		

Fig. 4 | A sampling of the book's drawings and diagrams.

Other Features

- ***Pointers.*** We provide thorough coverage of the built-in pointer capabilities and the intimate relationship among built-in pointers, C strings and built-in arrays.
- ***Visual presentation of searching and sorting, with a simple explanation of Big O.***
- ***Printed book contains core content; additional content is online.*** A few online chapters and appendices are included.
- ***Debugger appendices.*** We provide three debugger appendices on the book's Companion Website—Appendix H, Using the Visual Studio Debugger, Appendix I, Using the GNU C++ Debugger and Appendix J, Using the Xcode Debugger.

Secure C++ Programming

It's difficult to build industrial-strength systems that stand up to attacks from viruses, worms, and other forms of "malware." Today, via the Internet, such attacks can be instantaneous and global in scope. Building security into software from the beginning of the development cycle can greatly reduce vulnerabilities.

The CERT® Coordination Center(`www.cert.org`)was created to analyze and respond promptly to attacks. CERT—the Computer Emergency Response Team—is a government-funded organization within the Carnegie Mellon University Software Engineering Institute. CERT publishes and promotes secure coding standards for various popular programming languages to help software developers implement industrial strength systems that avoid the programming practices that leave systems open to attacks.

We'd like to thank Robert C. Seacord, Secure Coding Manager at CERT and an adjunct professor in the Carnegie Mellon University School of Computer Science. Mr. Seacord was a technical reviewer for our book, *C How to Program, 7/e*, where he scrutinized our C programs from a security standpoint, recommending that we adhere to the *CERT C Secure Coding Standard.*

We've done the same for *C++ How to Program, 9/e*, adhering to the *CERT C++ Secure Coding Standard*, which you can find at:

```
www.securecoding.cert.org
```

We were pleased to discover that we've already been recommending many of these coding practices in our books. We upgraded our code and discussions to conform to these prac tices, as appropriate for an introductory/intermediate-level textbook. If you'll be building industrial-strength C++ systems, consider reading *Secure Coding in C and C++, Second Edition* (Robert Seacord, Addison-Wesley Professional).

Online Content[①]

The book's Companion Website, which is accessible at

```
www.pearsoninternationaleditions.com/deitel
```

contains the following chapters and appendices in searchable PDF format:

- Chapter 24, C++11: Additional Features.
- Chapter 25, ATM Case Study, Part 1: Object-Oriented Design with the UML.
- Chapter 26, ATM Case Study, Part 2: Implementing an Object-Oriented Design.
- Appendix F, C Legacy Code Topics.
- Appendix G, UML 2: Additional Diagram Types.
- Appendix H, Using the Visual Studio Debugger.
- Appendix I, Using the GNU C++ Debugger.
- Appendix J, Using the Xcode Debugger.
- Appendix K, Test Driving a C++ Program on Mac OS X. (The test drives for Windows and Linux are in Chapter 1.)

The Companion Website also includes:

- Building Your Own Compiler exercise descriptions from Chapter 19 (posted at the Companion Website and at `www.deitel.com/books/cpphtp9`).
- Chapter 1 test-drive for Mac OS X.

Dependency Chart

The chart in Fig. 5 shows the dependencies among the chapters to help instructors plan their syllabi. *C++ How to Program, 9/e* is appropriate for CS1 and many CS2 courses. The chart shows the book's modular organization.

Teaching Approach

C++ How to Program, 9/e, contains a rich collection of examples. We stress program clarity and concentrate on building well-engineered software.

Live-code approach. The book is loaded with "live-code" examples—most new concepts are presented in *complete working C++ applications*, followed by one or more executions showing program inputs and outputs. In the few cases where we use a code snippet, to ensure that it's correct we tested it in a complete working program, then copied and pasted it into the book.

Syntax coloring. For readability, we syntax color all the C++ code, similar to the way most C++ integrated-development environments and code editors syntax color code. Our coloring conventions are as follows:

```
comments appear like this
keywords appear like this
constants and literal values appear like this
all other code appears in black
```

Code highlighting. We place light-blue shaded rectangles around key code segments.

Using fonts for emphasis. We emphasize on-screen components in the bold Helvetica font (e.g., the File menu) and C++ program text in the `Lucida` font (for example, `int x = 5;`).

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① 相关资源可登录华信教育资源网(www.hxedu.com.cn)下载。

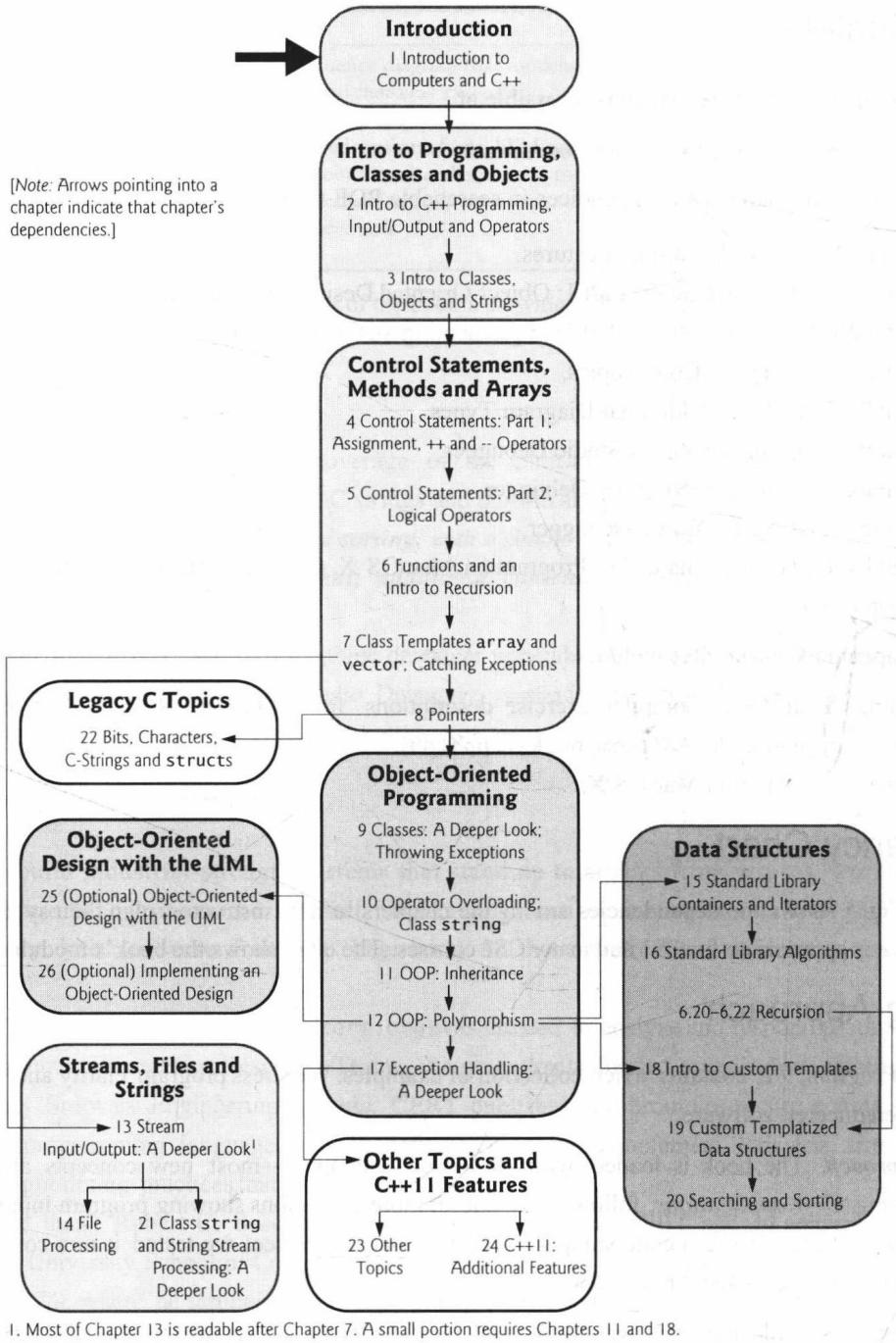

Fig. 5 | Chapter Dependency Chart.

Objectives. The opening quotes are followed by a list of chapter objectives.

Programming tips. We include programming tips to help you focus on key aspects of pro gram development. These tips and practices represent the best we've gleaned from a com bined seven decades of teaching and industry experience.



Good Programming Practices

The Good Programming Practices *call attention to techniques that will help you pro duce programs that are clearer, more understandable and more maintainable.*

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