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C How to Program, Fifth Edition

C 大学教程

—(第五版) (英文版)—

Introducing
C++ and **OOB** and
Game Programming with the
Allegro C Library



C

HOW TO PROGRAM

FIFTH EDITION

国外计算机科学教材系列

C 大学教程

(第五版)

(英文版)

C How To Program

Fifth Edition

P. J. Deitel

Deitel & Associates, Inc.

[美]

著

H. M. Deitel

Deitel & Associates, Inc.

電子工業出版社

Publishing House of Electronics Industry

北京 · BEIJING

内 容 简 介

本书是全球畅销的C语言教程之一。全书系统介绍了4种流行的程序设计方法——面向过程、基于对象、面向对象以及泛型编程,内容全面、生动、易懂,由浅入深地介绍了结构化编程和软件工程的基本概念,从简单的概念到最终完整的语言描述,清晰、准确、透彻、详细地讲解C语言,尤其注重程序设计思想和方法的介绍。在内容方面,本书新增加了介绍C99标准、排序、基于Allegro C函数库的游戏编程以及有关C++面向对象程序设计的章节,并且在附录中增加了Sudoku游戏程序设计的讲解。“活代码”方法是本书的另一特色,它可以促进学生积极地参与到程序设计中来。书中列出的各种程序设计提示,是作者多年教学经验的总结。

本书不仅适合于初学者学习,作为高校计算机程序设计教学的教科书,也同样适用于有经验的程序员,作为软件开发人员的专业参考书。

Original edition, entitled C HOW TO PROGRAM, FIFTH EDITION, 0132404168 by DEITEL, PAUL J; DEITEL, HARVERY M, published by Pearson Education, Inc, publishing as Prentice Hall, Copyright © 2007 by Pearson Education, Inc.

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版权贸易合同登记号 图字:01-2010-0538

图书在版编目(CIP)数据

C大学教程:第5版=C:How to Program,5/e:英文/(美)戴特尔(Deitel, P. J.), (美)戴特尔(Deitel, H.M.)著.-北京:电子工业出版社,2010.5

(国外计算机科学教材系列)

ISBN 978-7-121-10620-0

I. ①C… II. ①戴… ②戴… III. ①C语言-程序设计-高等学校-教材-英文 IV. ①TP312

中国版本图书馆CIP数据核字(2010)第056099号

责任编辑:许菊芳

印 刷:北京市天竺颖华印刷厂

装 订:三河市鑫金马印装有限公司

出版发行:电子工业出版社

北京市海淀区万寿路173信箱 邮编:100036

开 本:787×1092 1/16 印张:56 字数:1434千字

印 次:2010年5月第1次印刷

定 价:95.00元(含光盘1张)

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Library of Congress Cataloging-in-Publication Data
On file

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Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

ISBN 0-13-240416-8

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Pearson Education Singapore, Pte. Ltd.
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To Marcia Horton,

*Thank you for being our mentor in publishing
and a special friend to us and to our families.*

Paul and Harvey Deitel

出版说明

21世纪初的5至10年是我国国民经济和社会发展的关键时期,也是信息产业快速发展的关键时期。在我国加入WTO后的今天,培养一支适应国际化竞争的一流IT人才队伍是我国高等教育的重要任务之一。信息科学和技术方面人才的优劣与多寡,是我国面对国际竞争时成败的关键因素。

当前,正值我国高等教育特别是信息科学领域的教育调整、变革的重大时期,为使我国教育体制与国际化接轨,有条件的高等院校正在为某些信息学科和技术课程使用国外优秀教材和优秀原版教材,以使我国在计算机教学上尽快赶上国际先进水平。

电子工业出版社秉承多年来引进国外优秀图书的经验,翻译出版了“国外计算机科学教材系列”丛书,这套教材覆盖学科范围广、领域宽、层次多,既有本科专业课程教材,也有研究生课程教材,以适应不同院系、不同专业、不同层次的师生对教材的需求,广大师生可自由选择 and 自由组合使用。这些教材涉及的学科方向包括网络与通信、操作系统、计算机组织与结构、算法与数据结构、数据库与信息处理、编程语言、图形图像与多媒体、软件工程等。同时,我们也适当引进了一些优秀英文原版教材,本着翻译版本和英文原版并重的原则,对重点图书既提供英文原版又提供相应的翻译版本。

在图书选题上,我们大都选择国外著名出版公司出版的高校教材,如Pearson Education培生教育出版集团、麦格劳—希尔教育出版集团、麻省理工学院出版社、剑桥大学出版社等。撰写教材的许多作者都是蜚声世界的教授、学者,如道格拉斯·科默(Douglas E. Comer)、威廉·斯托林斯(William Stallings)、哈维·戴特尔特(Harvey M. Deitel)、尤利斯·布莱克(Uyless Black)等。

为确保教材的选题质量和翻译质量,我们约请了清华大学、北京大学、北京航空航天大学、复旦大学、上海交通大学、南京大学、浙江大学、哈尔滨工业大学、华中科技大学、西安交通大学、国防科学技术大学、解放军理工大学等著名高校的教授和骨干教师参与了本系列教材的选题、翻译和审校工作。他们中既有讲授同类教材的骨干教师、博士,也有积累了几十年教学经验的老教授和博士生导师。

在该系列教材的选题、翻译和编辑加工过程中,为提高教材质量,我们做了大量细致的工作,包括对所选教材进行全面论证;选择编辑时力求达到专业对口;对排版、印制质量进行严格把关。对于英文教材中出现的错误,我们通过作者联络和网上下载勘误表等方式,逐一进行了修订。

此外,我们还将与国外著名出版公司合作,提供一些教材的教学支持资料,希望能为授课老师提供帮助。今后,我们将继续加强与各高校教师的密切联系,为广大师生引进更多的国外优秀教材和参考书,为我国计算机科学教学体系与国际教学体系的接轨做出努力。

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Preface

Welcome to ANSI/ISO Standard C, and to C++, too! This book presents leading-edge computing technologies for computer science students, software developers and IT professionals. At Deitel & Associates, we write computer science textbooks for college students and professional books for software developers. We also teach this material in industry seminars at organizations worldwide.

This book was a joy to create. To start, we put the previous edition under the microscope:

- The entire C portion of the previous edition was reviewed by a distinguished review team including the head and assistant head of the working group responsible for the C standard (ISO/IEC JTC1 SC22 WG14) and other experts from industry and academia. All of this material was carefully tuned.
- All of the chapters have been significantly updated and upgraded.
- We updated the history of computing in Chapter 1.
- We added a new chapter on game programming with the Allegro C library.
- We added a new chapter that takes a deeper look at sorting.
- We added a new chapter introducing the C99 standard. This was placed last among the C chapters to make it convenient to include or omit.
- We included a completely new section on object-oriented programming in C++ based on *C++ How to Program, 5/e*.
- We added an appendix on solving and programming the wildly popular game of Sudoku.

All of this has been carefully scrutinized by a substantial team of academics, industry developers and members of the working group responsible for the C standard.

We believe that this book and its support materials have everything instructors, students and professionals need for an informative, interesting, challenging and entertaining C educational experience. In this Preface, we overview various conventions used in the book, such as syntax coloring the code examples and code highlighting. We also discuss the book's comprehensive suite of ancillary materials that help instructors maximize their students' learning experience, including the Prentice Hall *Instructor's Resource Center* (which contains the Instructor's Manual, Test Item File and PowerPoint® Slide lecture notes), companion Web site, SafariX (Pearson Education's WebBook publications) and more.

C How to Program, 5/e presents hundreds of complete, working C and C++ programs and depicts their inputs and outputs. This is our signature "live-code" approach — we present concepts in the context of complete working programs.

As you read this book, if you have questions, send an e-mail to deitel@deitel.com; we will respond promptly. For updates on this book and the status of C and C++ software, and for the latest news on all Deitel publications and services, visit www.deitel.com regularly and be sure to sign up for the free *Deitel® Buzz Online* e-mail newsletter at www.deitel.com/newsletter/subscribe.html. Also be sure to visit our new C Resource Center at www.deitel.com/c/.

Before You Begin

Installing the Microsoft Visual C++ 2005 Express Edition Software

On November 7, 2005 Microsoft released its Visual Studio 2005 development tools, including the Visual C++ 2005 Express Edition. Per Microsoft's Web site, Microsoft Express Editions are "lightweight, easy-to-use and easy-to-learn tools for the hobbyist, novice and student developer." According to the Microsoft Express Editions FAQ page (msdn.microsoft.com/vstudio/express/support/faq/), "Effective April 19th, 2006, all Visual Studio 2005 Express Editions are free permanently. SQL Server 2005 Express Edition has always been and will continue to be a free download."

You may use this software to compile and execute the example C and C++ programs in this book. The Visual C++ 2005 Express Edition Software is available on the CD-ROM included with this book. You can also download Visual C++ 2005 Express Edition at:

msdn.microsoft.com/vstudio/express/visualc/

When you install this software, you should install the help documentation and SQL Server 2005 Express. Microsoft provides a dedicated forum for help using the Express Edition:

forums.microsoft.com/msdn/ShowForum.aspx?ForumID=24

C How to Program, 5/e Code Examples

The book's source code is available for download at www.deitel.com/books/chtp5. Once you download the complete `examples.zip` file, use a ZIP file tool such as WinZip (available from www.winzip.com) to extract the files to the C:\ folder on your computer. This will create an `examples` folder that contains subfolders for each chapter (e.g., `ch01`, `ch02`, etc.)

Additional Software Downloads

Chapter 15 uses the Allegro C Library. The Allegro library is available for free at

www.allegro.cc/files

Download the "Source" package for your platform, and an IDE (integrated development environment) that is compatible with it. Allegro can be used with most C IDEs, but in this text, we use Bloodshed Software's Dev-C++, which is available for free at

www.bloodshed.net/devcpp.html

Chapter 17 uses Bloodshed Software's Dev-C++ 4.9.9.2 IDE, which is available for free at

www.bloodshed.net/dev/devcpp.html

We provide updates on the status of the software used in this book at www.deitel.com and in our free e-mail newsletter www.deitel.com/newsletter/subscribe.html.

Additional C and C++ Compilers and IDEs

Our C Resource Center (www.deitel.com/C) and our C++ Resource Center (www.deitel.com/cplusplus) list many free compilers and IDEs and some for-sale products for Windows, Linux and Macintosh platforms. These Resource Centers also include free tutorials to help you get started with these tools.

Features of C How to Program, Fifth Edition

This new edition contains many new and enhanced features.

Interior Design

Working with the creative services team at Prentice Hall, we redesigned the interior styles for our *How to Program Series* books. In response to reader requests, we now place the key terms and the index's page reference for each defining occurrence in **bold blue** text for easier reference. We emphasize on-screen components in the **bold Helvetica** font (e.g., the **File** menu) and emphasize Visual Basic program text in the Lucida font (for example, `int x = 5`).

Syntax Shading

We syntax shade all the C# code, similar to the way most C# integrated-development environments and code editors syntax color code. This greatly improves code readability — an especially important goal, given that this book contains 16,400+ lines of code. Our syntax-shading conventions are as follows¹:

comments appear like this
keywords appear like this
errors and ASP.NET delimiters appear like this

1 由于印刷原因，本书代码段中已取消颜色区分。

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

Code Highlighting

Extensive code highlighting makes it easy for readers to spot each program's featured code segments — we place gray rectangles around the key code.

Game Programming with the Allegro C Game Programming Library

Chapter 15 introduces the Allegro game programming C library. This library — originally developed by Climax game programmer Shawn Hargreaves — was created to be a powerful tool for programming games in C while still remaining relatively simple compared to other, more complicated graphics libraries such as DirectX and OpenGL. In Chapter 15, we use Allegro's capabilities to create the simple game of Pong. Along the way, we demonstrate how to display graphics, play sounds, receive input from the keyboard and create timed events—features that students can use to create games of their own. We believe that Allegro is a valuable addition to *C How to Program, 5/e*, and we hope that students and instructors alike will find it interesting and entertaining. We include extensive web resources, one of which offers more than 1000 open-source Allegro games.

Sorting: A Deeper Look

Sorting places data in ascending or descending order based on one or more sort keys. We begin our presentation of sorting with the simple bubble sort algorithm in Chapter 6. In Chapter 16, we present a deeper look at sorting. We consider several algorithms and compare them with regard to their memory consumption and processor consumption. For this purpose, we introduce Big O notation, which indicates how hard an algorithm may have to work to solve a problem. Through examples and exercises, Chapter 16 discusses the selection sort, insertion sort, recursive merge sort, recursive selection sort, bucket sort and recursive Quicksort.

Introduction to C99

C99 is a revised standard for the C programming language that refines and expands the capabilities of C89 (which we refer to as Standard C in Chapters 1–15). C99 has not been widely adopted, and many C compilers do not fully support it. We use the Dev-C++ 4.9.9.2 IDE from Bloodshed Software to demonstrate various C99 features.

Some new features of C99 include: // single-line comments; declaring a variable anywhere in a block before the variable's use (including the initialization clause of a `for` statement); designated initializers that allow you to initialize array elements explicitly by subscript, and union or struct elements explicitly by name; the `_Bool` type, which can hold only the values 0 or 1; requiring functions to have an explicit return type (rather than implicitly assuming `int`); support for complex numbers and complex arithmetic; variable-length arrays whose length, or size, is determined at execution time (but once determined remains fixed); support for longer identifier names (extended identifiers); restricted pointers for exclusive access to a region in memory; reliable integer division; flexible array members in structs; the `long long int` type; generic math; inline functions; requiring an expression in a `return` statement of a function with a non-void return type; disallowing an expression in a `return` statement of a function with return type `void`; and function `sprintf` to prevent buffer overflow when printing to strings in memory. Our treatment introduces C99 and provides web resources for the reader who wishes to dig deeper.

Updated C++ Treatment

In *C++ How to Program, 5/e*, we changed to an early classes and objects pedagogy. In *C How to Program, 5/e*, we've completely replaced our C++ treatment with this new approach. We introduce the basic concepts and terminology of object technology in Chapter 18. Then, Chapter 19 uses a new `GradeBook` case study to introduce classes and objects. We then use those concepts in the subsequent C++ chapters that present object-oriented programming, operator overloading, C++-style input/output streams and templates. Many of the C++ chapters reinforce object-oriented concepts with the Unified Modeling Language (UML) — the preferred graphical modeling language for designers of object-oriented systems. All the UML diagrams in the book comply with the UML 2.0 specification. We use UML class diagrams to visually represent classes and their inheritance relationships.

Teaching Approach

C How to Program, 5/e contains a rich collection of examples. The book concentrates on the principles of good software engineering and stresses program clarity. We avoid arcane terminology and syntax specifications in favor of teaching by example. We are educators who teach leading-edge topics in industry classrooms worldwide. Dr. Harvey M. Deitel has 22 years of college teaching experience and 17 years of industry teaching experience. Paul Deitel has 15 years of industry teaching experience. The Deitels have taught courses at all levels to government, industry, military and academic clients of Deitel & Associates.

Live-Code Approach

C How to Program, 5/e is loaded with live-code examples—each new concept is presented in the context of a complete working C application that is immediately followed by one or more sample executions showing the program's inputs and outputs. This style exemplifies the way we teach and write about programming. We call this method of teaching and writing the “live-code” approach.

World Wide Web Access

All of the source-code examples for *C How to Program, 5/e*, (and for our other publications) are available for download from:

www.deitel.com/books/cht5
www.prenhall.com/deitel

Site registration is quick and easy. Download all the examples, then run each program as you read the corresponding discussions. Making changes to the examples and immediately seeing the effects of those changes is a great way to enhance your C learning experience.

Objectives

Each chapter begins with a statement of objectives. This lets students know what to expect and gives them an opportunity, after reading the chapter, to determine if they have met these objectives.

Quotations

The learning objectives are followed by quotations. Some are humorous, philosophical or offer interesting insights. We hope that you will enjoy relating the quotations to the chapter material. Many of the quotations are worth a second look after reading the chapter.

Outline

The chapter outline helps students approach the material in a top-down fashion, so they can anticipate what is to come, and set a comfortable and effective learning pace.

Sections

Each chapter is organized into small sections that address key C or C++ topics.

Thousands of Lines of Syntax-Highlighted Code in Hundreds of Example Programs (with Outputs)

We present C and C++ features in the context of complete, working programs using our live-code approach. Each program is followed by screenshots of the outputs produced when the program is run, so you can confirm that the programs run as expected. Our programs demonstrate the diverse features of C and C++. The code is syntax highlighted, with keywords, comments and other program text emphasized with variations of bold, blue and italic text. This makes reading the code easier, especially in the larger programs.

Illustrations/Figures

An abundance of charts, tables, line drawings, programs and program outputs is included. We model the flow of control in control statements with UML activity diagrams. UML class diagrams model the fields, constructors and methods of classes.

Programming Tips

We include programming tips to help students focus on important aspects of program development. We highlight these tips in the form of *Good Programming Practices*, *Common Programming Errors*, *Error-Prevention Tips*, *Performance Tips*, *Portability Tips* and *Software Engineering Observations*. These tips and practices represent the best we have gleaned from a combined six decades of programming and teaching experience. One of our students — a mathematics major — told us that she feels this approach is like the highlighting of axioms, theorems and corollaries in mathematics books; it provides a basis on which to build good software.



Good Programming Practice

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



Common Programming Error

Students learning a language tend to make certain kinds of errors frequently. Pointing out these Common Programming Errors reduces the likelihood that readers will make the same mistakes.



Error-Prevention Tip

When we first designed this tip type, we thought the tips would contain suggestions for exposing bugs and removing them from programs. In fact, many of the tips describe aspects of C that prevent bugs from getting into programs in the first place, thus simplifying the testing and debugging processes.



Performance Tip

Students like to “turbo charge” their programs. We include Performance Tips that highlight opportunities for improving program performance — making programs run faster or minimizing the amount of memory that they occupy.



Portability Tip

We include Portability Tips to help you write portable code and to explain how C achieves its high degree of portability.



Software Engineering Observation

The object-oriented programming paradigm necessitates a complete rethinking of the way we build software systems. C is an effective language for achieving good software engineering. The Software Engineering Observations highlight architectural and design issues that affect the construction of software systems, especially large-scale systems.

Summary Bullets

Each chapter ends with additional pedagogical devices. We present a thorough, bullet-liststyle summary of the chapter, section by section. This helps the students review and reinforce key concepts.

Terminology

We include an alphabetized list of the important terms defined in each chapter—again, for further reinforcement. Each term also appears in the index, and the defining occurrence of each term is highlighted in the index with a **bold, blue** page number so the student can locate the definitions of terms quickly.

Self-Review Exercises and Answers

Extensive self-review exercises and answers are included for self-study. This gives you a chance to build confidence with the material and prepare for the regular exercises. We encourage students to do all the self-review exercises and check their answers.

Exercises

Each chapter concludes with a substantial set of exercises including simple recall of important terminology and concepts; writing individual program statements; writing small portions of functions and C++ classes; writing complete functions, C++ classes and programs; and writing major term projects. The large number of exercises enables instructors to tailor their courses to the unique needs of their students and to vary course assignments each semester. Instructors can use these exercises to form homework assignments, short quizzes and major examinations. [NOTE: Please do not write to us requesting access to the Prentice Hall Instructor's Resource Center. Access is limited strictly to college instructors teaching from the book. Instructors may obtain access only through their Prentice Hall representatives.]