LOCATION OF VIDEONOTES IN THE TEXT

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LOCATION OF VIDEONOTES IN THE TEXT *(continued)*

Seventh Edition

Starting Out with C++ Early Objects

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Contents at a Glance

Contents

Preface

Welcome to *Starting Out with C++: Early Objects,* 7th Edition. This book is intended for use in a two-term or three-term C++ programming sequence, or an accelerated one-term course. Students new to programming, as well those with prior course work in other languages, will find this text beneficial. The fundamentals of programming are covered for the novice, while the details, pitfalls, and nuances of the C++ language are explored in-depth for both the beginner and more experienced student. The book is written with clear, easy-to-understand language and it covers all the necessary topics for an introductory programming course. This text is rich in example programs that are concise, practical, and real world oriented, ensuring that the student not only learns how to implement the features and constructs of C++, but why and when to use them.

What's New in the Seventh Edition

This book's pedagogy, organization, and clear writing style remain the same as in the previous edition. However, many improvements have been made to make it even more student-friendly and to keep it state of the art for introductory programming using the C++ programming language.

- **Updated Material**
  Material has been updated throughout the book to reflect changes in technology, operating systems, and software development environments, as well as to improve clarity and incorporate best practices in object-oriented programming.
- **New Material**
  New material has been added on a number of topics including embedding operating system calls in program code, using object composition and aggregation, and creating text-based graphics.
- **Completely Revised Chapter 7**
  Chapter 7, *Introduction to Classes and Objects*, has been reorganized and almost entirely rewritten to start right in with classes and objects, instead of introducing structures first.

- **Greater Focus on Object-Oriented Programming**
  Many examples throughout the text have been rewritten to incorporate appropriate use of classes and objects.
- **Reusability**
  Material has been added illustrating how to create general classes that can be appropriately reused in multiple applications.
- **Improved Diagrams**
  Many diagrams have been improved and new diagrams added to better illustrate important concepts.
- **Online VideoNotes**
  An extensive set of online videos have been developed to accompany this text. Throughout the book, *VideoNotes* icons alert the student to videos covering specific topics they are studying. Additionally, one Programming Challenge at the end of each chapter now has an accompanying video explaining how to develop the problem's solution. The videos are available at `http://www.pearsonhighered.com/gaddis/`
- **New *Tying It All Together* Sections**
  A new *Tying It All Together* section has been added at the end of every chapter that shows the student how to do something clever and fun with the material covered in that chapter.
- **New Programming Challenges**
  New Programming Challenges have been added to every chapter, including a number of Challenges that ask students to develop object-oriented solutions and to create solutions that reuse, modify, and build on previously written code.
- **New Compiler and IDE Bundled with the Book**
  The MinGW C++ Compiler and wxDev-C++ Software Development Environment now come bundled, for free, with the book.
- **New Appendices**
  An Appendix has been added on using the MinGW C++ Compiler and wxDev-C++ IDE that accompany the book. Additional new appendices cover the Microsoft Visual C++ 2008 Express Edition IDE and Multiple and Virtual Inheritance.

Organization of the Text

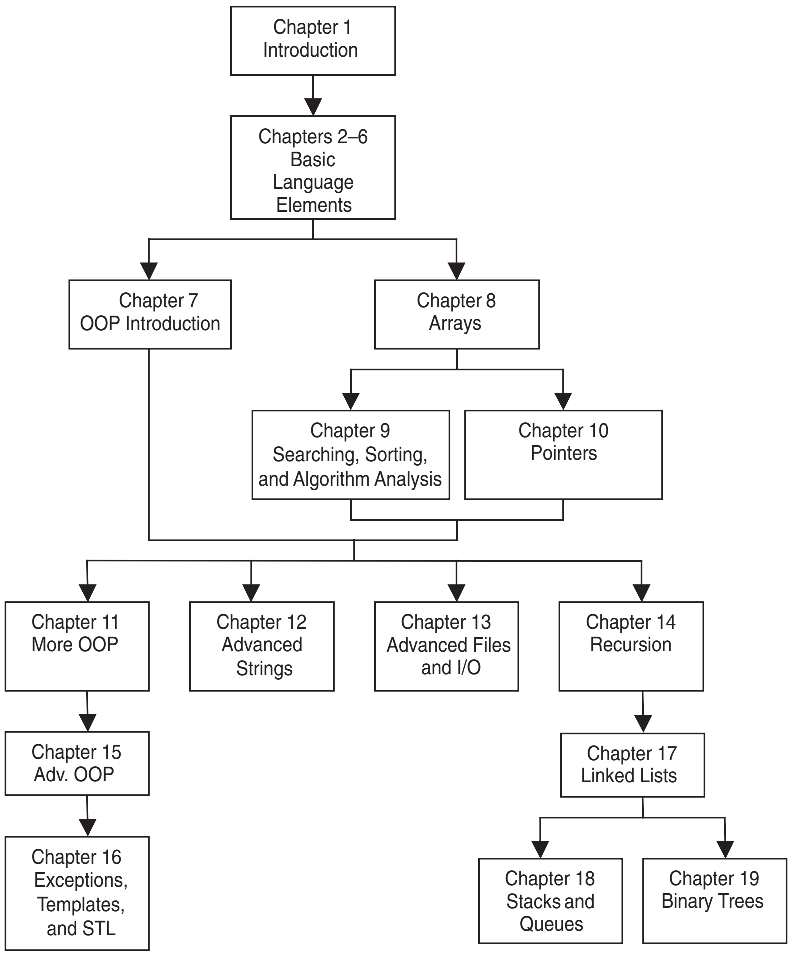
This text teaches C++ in a step-by-step fashion. Each chapter covers a major set of topics and builds knowledge as the student progresses through the book. Although the chapters can be easily taught in their existing sequence, flexibility is provided. The following dependency diagram (Figure P-1) suggests possible sequences of instruction.

Chapter 1 covers fundamental hardware, software, and programming concepts. The instructor may choose to skip this chapter if the class has already mastered those topics. Chapters 2 through 6 cover basic C++ syntax, data types, expressions, selection structures, repetition structures, and functions. Each of these chapters builds on the previous chapter and should be covered in the order presented.

Chapter 7 introduces object-oriented programming. It can be covered any time after Chapter 6, but before Chapter 11. Instructors who prefer to introduce arrays before classes can cover Chapter 8 before Chapter 7. In this case it is only necessary to postpone section 8.12 (Arrays of Class Objects) until Chapter 7 has been covered.

As Figure P-1 illustrates, in the second half of the book Chapters 11, 12, 13, and 14 can be covered in any order. Chapters 11, 15, and 16, however, should be done in sequence. Instructors who wish to introduce data structures at an earlier point in the course, without having first covered advanced C++ and OOP features, can cover Chapter 17 (Linked Lists), followed by Chapters 18 and 19 (Stacks & Queues and Binary Trees), any time after Chapter 14 (Recursion). In this case it is necessary to simply omit the sections in Chapters 17–19 that deal with templates and the Standard Template Library.

Figure P-1


Chapter 1 Introduction
Chapters 2–6 Basic Language Elements
Chapter 7 OOP Introduction
Chapter 8 Arrays
Chapter 9 Searching, Sorting, and Algorithm Analysis
Chapter 10 Pointers
Chapter 11 More OOP
Chapter 12 Advanced Strings
Chapter 13 Advanced Files and I/O
Chapter 14 Recursion
Chapter 15 Adv. OOP
Chapter 17 Linked Lists
Chapter 16 Exceptions, Templates, and STL
Chapter 18 Stacks and Queues
Chapter 19 Binary Trees

Brief Overview of Each Chapter

Chapter 1: Introduction to Computers and Programming

This chapter provides an introduction to the field of computer science and covers the fundamentals of hardware, software, operating systems, programming, problem solving, and software engineering. The components of programs, such as key words, variables, operators, and punctuation are covered. The tools of the trade, such as hierarchy charts and pseudocode, are also presented. The new *Tying It All Together* section shows students how to use the `cout` statement to create a personalized output message. Two new Programming Challenges help students see how the same basic input, processing, and output structure can be used to create multiple programs.

Chapter 2: Introduction to C++

This chapter gets the student started in C++ by introducing the basic parts of a C++ program, data types, variable definitions, assignment statements, constants, comments, program output, and simple arithmetic operations. The C++ string class is presented and string objects are used from this point on in the book as the primary method of handling strings. Programming style conventions are introduced and good programming style is modeled here, as it is throughout the text. An optional section explains the difference between ANSI standard and prestandard C++ programs. The new *Tying It All Together* section lets the student play with simple text-based graphics.

Chapter 3: Expressions and Interactivity

In this chapter the student learns to write programs that input and handle numeric, character, and string data. The use of arithmetic operators and the creation of mathematical expressions are covered, with emphasis on operator precedence. Debugging is introduced, with a section on hand tracing a program. Sections are also included on using random numbers, on reading and writing sequential files, on simple output formatting, on data type conversion and type casting, and on using library functions that work with numbers. For those who wish to cover them, there is also a section on C-strings. The new *Tying It All Together* section shows students how to create a simple interactive word game.

Chapter 4: Making Decisions

Here the student learns about relational expressions and how to control the flow of a program with the `if`, `if/else`, and `if/else if` statements. Logical operators, the conditional operator, and the `switch` statement are also covered. Applications of these constructs, such as menu-driven programs, are illustrated. This chapter also continues the theme of debugging with a section on validating output results. The new *Tying It All Together* section uses random numbers and branching statements to create a fortune telling game.

Chapter 5: Looping

This chapter covers C++'s repetitive control mechanisms. The `while` loop, `do-while` loop, and `for` loop are taught, along with a variety of methods to control them. These include using counters, user input, end sentinels, and end-of-file testing. Applications utilizing loops, such as keeping a running total and performing data validation, are covered. The emphasis on testing and debugging continues, with a section on creating good test data. The new *Tying It All Together* section introduces students to Windows commands to create colorful output and uses a loop to create a multi-colored display.

Chapter 6: Functions

In this chapter the student learns how and why to modularize programs, using both `void` and value-returning functions. Parameter passing is covered, with emphasis on when arguments should be passed by value versus when they need to be passed by reference. Scope of variables is covered and sections are provided on local versus global variables and on static local variables. Overloaded functions are also introduced and demonstrated. The new *Tying It All Together* section includes a modular, menu-driven program that emphasizes the versatility of functions, illustrating how their behavior can be controlled by the arguments sent to them.

Chapter 7: Introduction to Classes and Objects

In this chapter the text begins to focus on the object-oriented paradigm. Students learn how to define classes and to create and use objects. Careful attention is paid to illustrating which functions belong in a class versus which functions belong in a client program that uses the class. Good object-oriented practices are discussed and modeled, such as protecting member data through carefully constructed accessor and mutator functions and hiding class implementation details from client programs. Once students are comfortable working with classes and objects, the chapter provides a brief introduction to the topic of object-oriented analysis and design. The chapter also introduces structures and uses them in this chapter's *Tying It All Together* section, where students learn to use screen control techniques to create an animation that simulates the motion of a yoyo.

Chapter 8: Arrays

In this chapter the student learns to create and work with single and multidimensional arrays. Many examples of array processing are provided, including functions to compute the sum, average, highest and lowest values in an array. Students also learn to create tables using two-dimensional arrays, and to analyze the array data by row or by column. Programming techniques using parallel arrays are also demonstrated, and the student is shown how to use a data file as an input source to populate an array. STL vectors are introduced and compared to arrays. Sections on arrays of objects and structures are located at the end of the chapter, so they can be covered now or saved for later if the instructor wishes to cover this chapter before Chapter 7. The new *Tying It All Together* section uses arrays to create a game of *Rock*, *Paper*, *Scissors* between a human player and the computer.

Chapter 9: Searching, Sorting, and Algorithm Analysis

Here the student learns the basics of searching for information stored in arrays and of sorting arrays, including arrays of objects. The chapter covers the Linear Search, Binary Search, Bubble Sort, and Selection Sort algorithms, and has an optional section on sorting and searching STL vectors. A brief introduction to algorithm analysis is included and students are shown how to determine which of two algorithms is more efficient. The new *Tying It All Together* section uses both a table lookup and a searching algorithm to encode and decode secret messages.

Chapter 10: Pointers

This chapter explains how to use pointers. The topics include pointer arithmetic, initialization of pointers, comparison of pointers, pointers and arrays, pointers and functions, dynamic memory allocation, and more. The new *Tying It All Together* section demonstrates the use of pointers to access library data structures and functions that return calendar and wall clock time.

Chapter 11: More about Classes and Object-Oriented Programming

This chapter continues the study of classes and object-oriented programming. It covers object aggregation and composition, as well as inheritance, and illustrates the difference between is-a and has-a relations. Constant member functions, static members, friends, memberwise assignment, copy constructors, object type conversion operators, convert constructors, and a newly rewritten section on operator overloading are also included. The new *Tying It All Together* section brings together the concepts of inheritance and convert constructors to build a program that formats the contents of an array to form an HTML table for display on a Web site.

Chapter 12: More about Characters, Strings, and the `string` Class

This chapter covers standard library functions for working with characters and C-strings, covering topics such as passing C-strings to functions and using the C++ `sstream` classes to convert between numeric and string forms of numbers. Additional material about the C++ string class and its member functions and operators is presented and a new, improved program illustrates how to write your own string class. The new *Tying It All Together* section shows students how to access string-based program environments to obtain information about the computer and the network on which the program is running.

Chapter 13: Advanced File and I/O Operations

This chapter covers sequential access, random access, text, and binary files. Various modes for opening files are discussed, as well as the many methods for reading and writing file contents. Advanced output formatting is also covered. The new *Tying It All Together* program applies many of the techniques covered in the chapter to merge two text files into an HTML document for display on the Web, with different colors used to illustrate which file each piece of data came from.

Chapter 14: Recursion

In this chapter recursion is defined and demonstrated. A visual trace of recursive calls is provided, and recursive applications are discussed. Many recursive algorithms are presented, including recursive functions for computing factorials, finding a greatest common denominator (GCD), performing a binary search, sorting QuickSort, and solving the famous Towers of Hanoi problem. For students who need more challenge, there is a section on exhaustive and enumeration algorithms. The new *Tying It All Together* section uses recursion to evaluate prefix expressions.

Chapter 15: Polymorphism and Virtual Functions

The study of classes and object-oriented programming continues in this chapter with the introduction of more advanced concepts such as polymorphism and virtual functions. Information is also presented on abstract base classes, pure virtual functions, type compatibility within an inheritance hierarchy, and virtual inheritance. The material on multiple inheritance previously in the chapter has been rewritten and moved to an appendix. The new *Tying It All Together* section illustrates the use of inheritance and polymorphism to display and animate graphical images.

Chapter 16: Exceptions, Templates, and the Standard Template Library (STL)

Here the student learns to develop enhanced error trapping techniques using exceptions. Discussion then turns to function and class templates as a method for writing generic code. Finally, the student is introduced to the containers, iterators, and algorithms offered by the Standard Template Library (STL). The new *Tying It All Together* section uses various containers in the Standard Template Library to create an educational children's game.

Chapter 17: Linked Lists

This chapter introduces concepts and techniques needed to work with lists. A linked list ADT is developed and the student is taught to code operations such as creating a linked list, appending a node, traversing the list, searching for a node, inserting a node, deleting a node, and destroying a list. A linked list class template is also demonstrated. The new *Tying It All Together* section brings together many of the most important concepts of OOP by using objects, inheritance, and polymorphism to animate a collection of images.

Chapter 18: Stacks and Queues

In this chapter the student learns to create and use static and dynamic stacks and queues. The operations of stacks and queues are defined, and templates for each ADT are demonstrated. The static array-based stack uses exception-handling to handle stack overflow and underflow, providing a realistic and natural example of defining, throwing, and catching exceptions. The new *Tying It All Together* section discusses strategies for evaluating postfix expressions and for converting them to infix.

Chapter 19: Binary Trees

This chapter covers the binary tree ADT and demonstrates many binary tree operations. The student learns to traverse a tree, insert an element, delete an element, replace an element, test for an element, and destroy a tree. The new *Tying It All Together* section introduces a tree structure versatile enough to create genealogy trees.

Appendices

Appendix A: The ASCII Character Set A list of the ASCII and extended ASCII characters and their codes.

Appendix B: Operator Precedence and Associativity A list of the C++ operators with their precedence and associativity.

The following appendices are on the accompanying student CD

Appendix C: A Brief Introduction to Object-Oriented Programming An introduction to the concepts and terminology of object-oriented programming.

Appendix D: Using UML in Class Design A brief introduction to the Unified Modeling Language (UML) class diagrams with examples of their use.

Appendix E: Namespaces An explanation of namespaces and their purpose, with examples provided on how to define a namespace and access its members.

Appendix F: Passing Command Line Arguments An introduction to writing C++ programs that accept command-line arguments. This appendix will be useful to students working in a command-line environment, such as UNIX or Linux.

Appendix G: Header File and Library Function Reference A reference for the C++ library functions and header files used in the book.

Appendix H: Binary Numbers and Bitwise Operations A guide to the binary number system and the C++ bitwise operators, as well as a tutorial on the internal storage of integers.

Appendix I: C++ Casts and Run-Time Type Identification An introduction to the different ways of doing type casting in C++ and to run-time type identification.

Appendix J: Multi-Source File Programs A tutorial on how to create, compile, and link programs with multiple source files. Includes the use of function header files, class specification files, and class implementation files.

Appendix K: Multiple and Virtual Inheritance A self-contained discussion of the C++ concepts of multiple and virtual inheritance for anyone already familiar with single inheritance.

Appendix L: Introduction to the MinGW C++ Compiler and the wxDev-C++ IDE A tutorial on how to start a wxDev-C++ project, compile and run a program, save source files, and more.

Appendix M: Introduction to Microsoft Visual C++ 2008 Express Edition A tutorial on how to start a project using Microsoft Visual C++ 2008, compile and run a program, save source files, and more.

Appendix N: .NET and Managed C++ A short introduction to Microsoft .NET and managed C++.

Appendix O: Introduction to Flowcharting A tutorial that introduces flowcharting and its symbols. Includes handling sequence, selection, case, repetition, and calls to other modules. Sample flowcharts for several of the book's example programs are presented.

Appendix P: Answers to Checkpoints A tool students can use to assess their understanding by comparing their answers to the Checkpoint exercises found throughout the book. The answers to all Checkpoint exercises are included.

Appendix Q: Answers to Odd-Numbered Review Questions Another tool students can use to gauge their understanding and progress.

Features of the Text

Concept Statements	Each major section of the text starts with a concept statement. This statement summarizes the key idea of the section.
Example Programs	The text has over 350 complete example programs, each designed to highlight the topic currently being studied. In most cases, these are practical, real-world examples. Source code for these programs is provided so that students can run the programs themselves.
Program Output	After each example program there is a sample of its screen output. This immediately shows the student how the program should function.
Tying It All Together	This special section, found at the end of every chapter, shows the student how to do something clever and fun with the material covered in that chapter.
VideoNotes	A series of online videos, developed specifically for this book, are available for viewing at `http://www.pearsonhighered.com/gaddis/`. *VideoNotes* icons appear throughout the text, alerting the student to videos about specific topics.
Checkpoints	Checkpoints are questions placed throughout each chapter as a self-test study aid. Answers for all Checkpoint questions are provided on the student CD so students can check how well they have learned a new topic.
Notes	Notes appear at appropriate places throughout the text. They are short explanations of interesting or often misunderstood points relevant to the topic at hand.
Warnings	Warnings caution the student about certain C++ features, programming techniques, or practices that can lead to malfunctioning programs or lost data.
Case Studies	Case studies that simulate real-world applications appear in many chapters throughout the text, with complete code provided for each one. Additional case studies are provided on the student CD. These case studies are designed to highlight the major topics of the chapter in which they appear.
Review Questions and Exercises	Each chapter presents a thorough and diverse set of review questions, such as fill-in-the-blank and short answer, that check the student's mastery of the basic material presented in the chapter. These are followed by exercises requiring problem solving and analysis, such as the *Algorithm Workbench*, *Predict the Output*, and *Find the Errors* sections. Each chapter ends with a *Soft Skills* exercise that focuses on communication and group process skills. Answers to the odd numbered review questions and review exercises are provided on the student CD.
Programming Challenges	Each chapter offers a pool of programming exercises designed to solidify the student's knowledge of the topics currently being studied. In most cases the assignments present real-world problems to be solved. When applicable, these exercises include input validation rules.

Group Projects	There are several group programming projects throughout the text, intended to be constructed by a team of students. One student might build the program's user interface, while another student writes the mathematical code, and another designs and implements a class the program uses. This process is similar to the way many professional programs are written and encourages team work within the classroom.
C++ Quick Reference Guide	For easy access, a quick reference guide to the C++ language is printed on the inside front and back covers.

Supplements

Student CD

This CD includes:

- MinGW C++ Compiler
- wxDev-C++ IDE
- Answers to all Checkpoint questions (Appendix P)
- Answers to all odd-numbered Review Questions and Exercises (Appendix Q)
- Complete source code for every program included in the book
- Additional case studies, complete with source code
- Serendipity Booksellers ongoing software development project
- A full set of appendices (including several tutorials) that accompany the book

If a CD did not come with your book or you can't locate your CD, you can access most of these items at `http://www.pearsonhighered.com/cssupport`

Other CDs Upon Request Professors should contact their campus Pearson Education/ Addison-Wesley representative for the specific ISBN to order this book packaged with Microsoft Visual C++.

MyCodeMate—Your Own T.A. Just a Click Away

Addison-Wesley's *MyCodeMate* is a book-specific Web resource that provides tutorial help and evaluation of student programs. Example programs throughout the book and selected Programming Challenges from every chapter have been integrated into *MyCodeMate*. Using this tool, a student is able to write and compile programs from any computer with Internet access and receive guidance and feedback on how to proceed and on how to address compiler error messages. Instructors can track each student's progress on Programming Challenges from the text or can develop projects of their own. **A complimentary subscription to *MyCodeMate* is offered when the access code is ordered in a package with a new copy of this text.** Subscriptions can also be purchased online. For more information visit www.mycodemate.com, or contact your campus Pearson Education/Addison-Wesley representative.

Instructor Resources

The following supplements are available to qualified instructors only.

- Answers to all Review Questions in the text
- Solutions for all Programming Challenges in the text
- PowerPoint presentation slides for every chapter

- A computerized test bank
- A collection of lab materials
- Source code files

Visit the Pearson Education Instructor Resource Center (`http://www.pearsonhighered.com/irc`) or send an email to computing@aw.com for information on how to access them.

Textbook Web Site

A Web site for the *Starting Out with* C++ series of books is located at the following URL:

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The *Starting Out with* C++ Series includes three books, one of which is sure to fit your course:

- *Starting Out with C++: Control Structures through Objects;*
- *Starting Out with C++: Early Objects;*
- *Starting Out with C++: Brief Version.*

The following chart will help you determine which book is right for your course.

▪ FROM CONTROL STRUCTURES THROUGH OBJECTS ▪ BRIEF VERSION	▪ EARLY OBJECTS
LATE INTRODUCTION OF OBJECTS Classes are introduced in Chapter 13 of the standard text and Chapter 11 of the brief text, after control structures, functions, arrays, and pointers. Advanced OOP topics, such as inheritance and polymorphism, are covered in the following two chapters.	**EARLIER INTRODUCTION OF OBJECTS** Classes are introduced in Chapter 7, after control structures and functions, but before arrays and pointers. Their use is then integrated into the remainder of the text. Advanced OOP topics, such as inheritance and polymorphism, are covered in Chapters 11 and 15.
USE OF C-STRINGS Null-terminated C-strings are used throughout, with the C++ `string` class covered briefly.	**USE OF `string` OBJECTS** Standard library `string` class objects are used throughout, with C-strings covered briefly.
INTRODUCTION OF DATA STRUCTURES AND RECURSION Linked lists, stacks and queues, and binary trees are introduced in the final chapters of the standard text. Recursion is covered after stacks and queues, but before binary trees. These topics are not covered in the brief text, though it does have appendices dealing with linked lists and recursion.	**INTRODUCTION OF DATA STRUCTURES AND RECURSION** Linked lists, stacks and queues, and binary trees are introduced in the final chapters of the text, after the chapter on recursion.

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