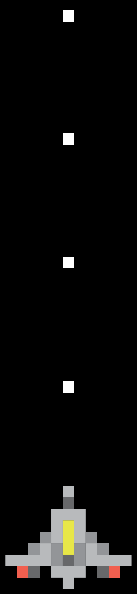
GLOBAL EDITION

Starting Out with C++

From Control Structures through Objects

NINTH EDITION

Tony Gaddis



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Contents at a Glance

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Preface

Welcome to *Starting Out with C++: From Control Structures through Objects, 9th edition*. This book is intended for use in a two-semester C++ programming sequence, or an accelerated one-semester course. Students new to programming, as well as 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.

Changes in the Ninth Edition

This book's pedagogy, organization, and clear writing style remain the same as in the previous edition. Many improvements and updates have been made, which are summarized here:

- The material on the Standard Template Library (STL) has been completely rewritten and expanded into its own chapter. Previously, Chapter 16 covered exceptions, templates, and gave brief coverage to the STL. In this edition, Chapter 16 covers exceptions and templates, and Chapter 17 is a new chapter dedicated to the STL. The new chapter covers the following topics:

    - The `array` and `vector` classes
    - The various types of iterators
    - Emplacement versus insertion
    - The `map`, `multimap`, and `unordered_map` Classes
    - The `set`, `multiset`, and `unordered_set` Classes
    - Sorting and searching algorithms
    - Permutation algorithms
    - Set algorithms
    - Using function pointers with STL algorithms
    - Function objects, or functors
    - Lambda expressions

- Chapter 2 now includes a discussion of alternative forms of variable initialization, including functional notation, and brace notation (also known as uniform initialization).

- Chapter 3 now mentions the `round` function, introduced in C++ 11.
- Chapter 7 now introduces array initialization much earlier.
- In Chapter 8, the bubble sort algorithm has been rewritten and improved.
- A new example of sorting and searching a `vector` of strings has been added to Chapter 8.
- In Chapter 9, the section on smart pointers now gives an overview of `shared_ptrs` and `weak_ptrs`, in addition to the existing coverage of `unique_ptrs`.
- In Chapter 10, a new *In the Spotlight* section on string tokenizing has been added.
- Chapter 10 now covers the `string`-to-number conversion functions that were introduced in C++ 11.
- The material on unions that previously appeared in Chapter 11 has been moved to Appendix K, available on the book's companion Website.
- Chapter 13 has new sections covering:
  - Member initialization lists.
  - In-place initialization.
  - Constructor delegation.
- Several new topics were added to Chapter 14, including:
  - Rvalue references and move semantics.
  - Checking for self-assignment when overloading the = operator.
  - Using member initialization lists in aggregate classes.
- Chapter 15 includes a new section on constructor inheritance.
- Several new programming problems have been added throughout the book.

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, some flexibility is provided. The diagram shown in Figure P-1 suggests possible sequences of instruction.

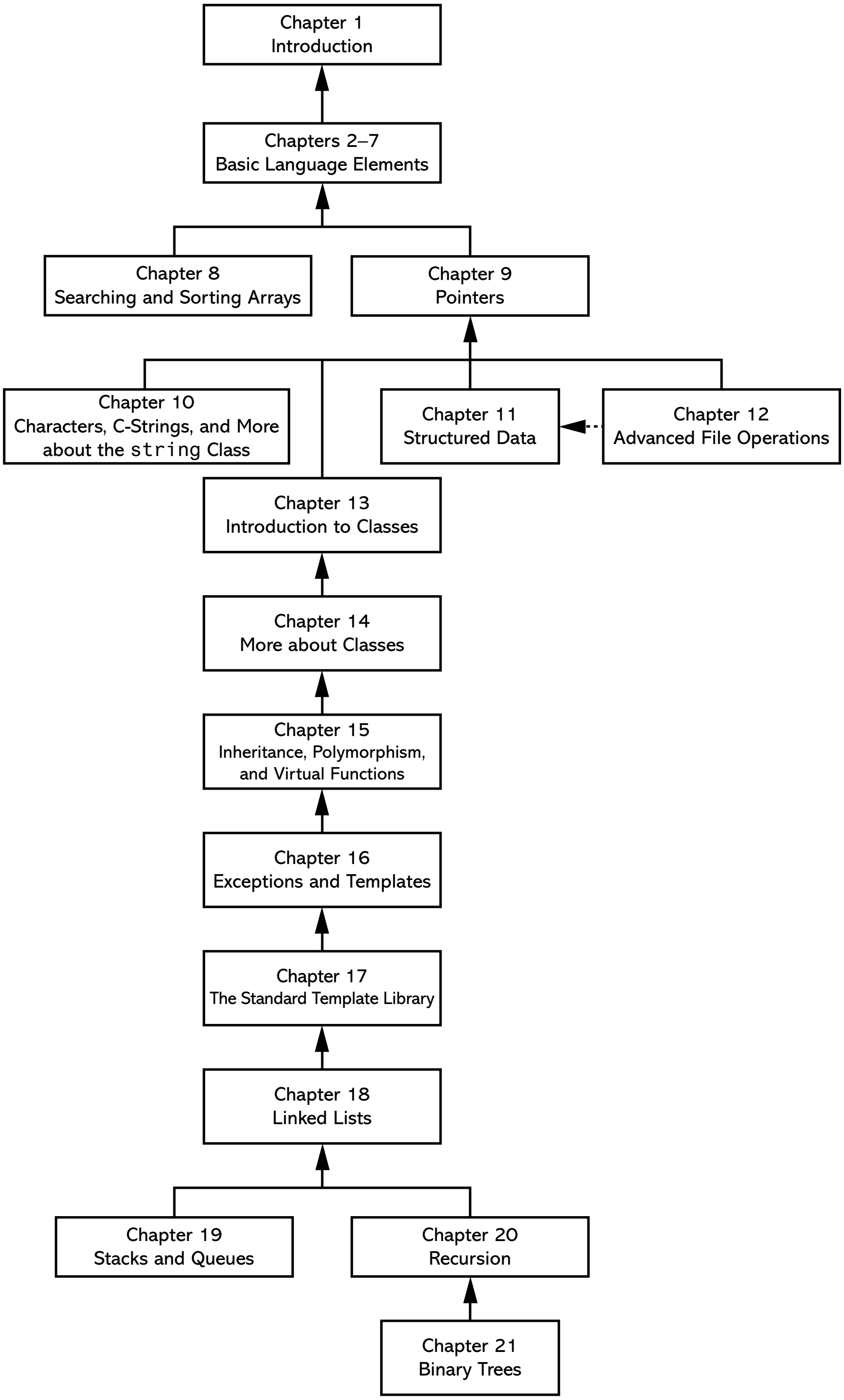
Chapter 1 covers fundamental hardware, software, and programming concepts. You may choose to skip this chapter if the class is already familiar with those topics. Chapters 2 through 7 cover basic C++ syntax, data types, expressions, selection structures, repetition structures, functions, and arrays. Each of these chapters builds on the previous chapter and should be covered in the order presented.

After Chapter 7 has been covered, you may proceed to Chapter 8, or jump to Chapter 9.

After Chapter 9 has been covered, Chapter 10, 11, 12, or 13 may be covered. (If you jump to Chapter 12 at this point, you will need to postpone Sections 12.8, 12.9, and 12.10 until Chapter 11 has been covered.) After Chapter 13, you may cover Chapters 14 through 18 in sequence. Next, you can proceed to either Chapter 19 or Chapter 20. Finally, Chapter 21 may be covered.

This text's approach starts with a firm foundation in structured, procedural programming before delving fully into object-oriented programming and advanced data structures.

Figure P-1 Chapter dependency chart



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 programming, problem solving, and software design. The components of programs, such as key words, variables, operators, and punctuation, are covered. The tools of the trade, such as pseudocode, flow charts, and hierarchy charts, are also presented.

Chapter 2: Introduction to C++

This chapter gets the student started in C++ by introducing data types, identifiers, variable declarations, constants, comments, program output, simple arithmetic operations, and C-strings. Programming style conventions are introduced and good programming style is modeled here, as it is throughout the text.

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 in greater detail, with emphasis on operator precedence. Debugging is introduced, with a section on hand tracing a program. Sections are also included on simple output formatting, on data type conversion and type casting, and on using library functions that work with numbers.

Chapter 4: Making Decisions

Here, the student learns about relational operators, relational expressions, and how to control the flow of a program with the `if`, `if/else`, and `if/else if` statements. The conditional operator and the `switch` statement are also covered. Crucial applications of these constructs are covered, such as menu-driven programs and the validation of input.

Chapter 5: Loops and Files

This chapter covers repetition control structures. The `while` loop, `do-while` loop, and `for` loop are taught, along with common uses for these devices. Counters, accumulators, running totals, sentinels, and other application-related topics are discussed. Sequential file I/O is also introduced. The student learns to read and write text files, and use loops to process the data in a file.

Chapter 6: Functions

In this chapter, the student learns how and why to modularize programs, using both `void` and value returning functions. Argument 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.

Chapter 7: Arrays and Vectors

In this chapter, the student learns to create and work with single and multi-dimensional arrays. Many examples of array processing are provided including examples illustrating how to find the sum, average, highest, and lowest values in an array, and how to sum the rows, columns, and all elements of a two-dimensional array. 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.

Chapter 8: Searching and Sorting Arrays

Here, the student learns the basics of sorting arrays and searching for data stored in them. The chapter covers the Bubble Sort, Selection Sort, Linear Search, and Binary Search algorithms. There is also a section on sorting and searching STL `vector` objects.

Chapter 9: Pointers

This chapter explains how to use pointers. Pointers are compared to and contrasted with reference variables. Other topics include pointer arithmetic, initialization of pointers, relational comparison of pointers, pointers and arrays, pointers and functions, dynamic memory allocation, and more.

Chapter 10: Characters, C-Strings, and More about the `string` Class

This chapter discusses various ways to process text at a detailed level. Library functions for testing and manipulating characters are introduced. C-strings are discussed, and the technique of storing C-strings in `char` arrays is covered. An extensive discussion of the `string` class methods is also given.

Chapter 11: Structured Data

The student is introduced to abstract data types and taught how to create them using structures, unions, and enumerated data types. Discussions and examples include using pointers to structures, passing structures to functions, and returning structures from functions.

Chapter 12: Advanced File Operations

This chapter covers sequential access, random access, text, and binary files. The 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.

Chapter 13: Introduction to Classes

The student now shifts focus to the object-oriented paradigm. This chapter covers the fundamental concepts of classes. Member variables and functions are discussed. The student learns about private and public access specifications, and reasons to use each. The topics of constructors, overloaded constructors, and destructors are also presented. The chapter presents a section modeling classes with UML, and how to find the classes in a particular problem.

Chapter 14: More about Classes

This chapter continues the study of classes. Static members, friends, memberwise assignment, and copy constructors are discussed. The chapter also includes in-depth sections on operator overloading, object conversion, and object aggregation. There is also a section on class collaborations and the use of CRC cards.

Chapter 15: Inheritance, Polymorphism, and Virtual Functions

The study of classes continues in this chapter with the subjects of inheritance, polymorphism, and virtual member functions. The topics covered include base and derived class constructors and destructors, virtual member functions, base class pointers, static and dynamic binding, multiple inheritance, and class hierarchies.

Chapter 16: Exceptions and Templates

The student learns to develop enhanced error trapping techniques using exceptions. Discussion then turns to function and class templates as a method for reusing code.

Chapter 17: The Standard Template Library

This chapter discusses the containers, iterators, and algorithms in the Standard Template Library (STL). The specific containers covered are the `array`, `vector`, `map`, `multimap`, `unordered_map`, `set`, `multiset`, and `unordered_set` classes. The student then learns about sorting, searching, permutation, and set algorithms. The chapter concludes with a discussion of function objects (functors) and lambda functions.

Chapter 18: 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.

Chapter 19: 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.

Chapter 20: Recursion

This chapter discusses recursion and its use in problem solving. A visual trace of recursive calls is provided, and recursive applications are discussed. Many recursive algorithms are presented, including recursive functions for finding factorials, finding a greatest common denominator (GCD), performing a binary search, and sorting (QuickSort). The classic Towers of Hanoi example is also presented. For students who need more challenge, there is a section on exhaustive algorithms.

Chapter 21: 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.

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 chart showing the C++ operators and their precedence

The following appendices are available online at www.pearsonglobaleditions.com/gaddis.

Appendix C: Introduction to Flowcharting

A brief introduction to flowcharting. This tutorial discusses sequence, decision, case, repetition, and module structures.

Appendix D: Using UML in Class Design

This appendix shows the student how to use the Unified Modeling Language to design classes. Notation for showing access specification, data types, parameters, return values, overloaded functions, composition, and inheritance are included.

Appendix E: Namespaces

This appendix explains namespaces and their purpose. Examples showing how to define a namespace and access its members are given.

Appendix F: Passing Command Line Arguments

Teaches the student how to write a C++ program that accepts arguments from the command line. This appendix will be useful to students working in a command line environment, such as Unix, Linux, or the Windows command prompt.

Appendix G: Binary Numbers and Bitwise Operations

A guide to the C++ bitwise operators, as well as a tutorial on the internal storage of integers

Appendix H: STL Algorithms

This appendix gives a summary of each of the function templates provided by the Standard Template Library (STL), and defined in the `<algorithm>` header file.

Appendix I: Multi-Source File Programs

Provides a tutorial on creating programs that consist of multiple source files. Function header files, class specification files, and class implementation files are discussed.

Appendix J: Stream Member Functions for Formatting

Covers stream member functions for formatting such as `setf`

Appendix K: Unions

This appendix introduces unions. It describes the purpose of unions and the difference between a union and a `struct`, demonstrates how to declare a union and define a union variable, and shows example programs that use unions.

Appendix L: Answers to Checkpoints

Students may test their own progress by comparing their answers to the Checkpoint exercises against this appendix. The answers to all Checkpoints are included.

Appendix M: Answers to Odd Numbered Review Questions

Another tool that students can use to gauge their progress

Features of the Text

Concept Statements Each major section of the text starts with a concept statement. This statement summarizes the ideas of the section.

Example Programs The text has hundreds of 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.

In the Spotlight Each of these sections provides a programming problem and a detailed, step-by-step analysis showing the student how to solve it.

VideoNotes A series of online videos, developed specifically for this book, is available for viewing at www.pearsonglobaleditions.com/gaddis. 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 can be downloaded from the book's Website at www.pearsonglobaleditions.com/gaddis. This allows students to 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 are notes that 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. 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*. Answers to the odd-numbered review questions and review exercises can be downloaded from the book's Website at www.pearsonglobaleditions.com/gaddis.

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.

Software Development Project: Serendipity Booksellers Available for download from the book's Website at www.pearsonglobaleditions.com/gaddis. This is an ongoing project that instructors can optionally assign to teams of students. It systematically develops a "real-world" software package: a point-of-sale program for the fictitious Serendipity Booksellers organization. The Serendipity assignment for each chapter adds more functionality to the software, using constructs and techniques covered in that chapter. When complete, the program will act as a cash register, manage an inventory database, and produce a variety of reports.

C++11 Throughout the text, new C++11 language features are introduced. Look for the C++11 icon to find these new features.

Supplements

Student Online Resources

Many student resources are available for this book from the publisher. The following items are available at www.pearsonglobaleditions.com/gaddis:

- The source code for each example program in the book
- Access to the book's VideoNotes
- A full set of appendices, including answers to the Checkpoint questions and answers to the odd-numbered review questions
- A collection of valuable Case Studies
- The complete Serendipity Booksellers Project

Online Practice and Assessment with MyProgrammingLab

MyProgrammingLab helps students fully grasp the logic, semantics, and syntax of programming. Through practice exercises and immediate, personalized feedback, MyProgrammingLab improves the programming competence of beginning students who often struggle with the basic concepts and paradigms of popular high-level programming languages.

A self-study and homework tool, a MyProgrammingLab course consists of hundreds of small practice exercises organized around the structure of this textbook. For students, the system automatically detects errors in the logic and syntax of their code submissions and offers targeted hints that enable students to figure out what went wrong—and why. For instructors, a comprehensive gradebook tracks correct and incorrect answers and stores the code inputted by students for review.

MyProgrammingLab is offered to users of this book in partnership with Turing's Craft, the makers of the CodeLab interactive programming exercise system. For a full demonstration, to see feedback from instructors and students, or to get started using MyProgrammingLab in your course, visit www.myprogramminglab.com.

Instructor Resources

The following supplements are available only to qualified instructors:

- Answers to all Review Questions in the text
- Solutions for all Programming Challenges in the text
- PowerPoint presentation slides for every chapter
- Computerized test bank
- Answers to all Student Lab Manual questions
- Solutions for all Student Lab Manual programs

Visit the Pearson Instructor Resource Center (www.pearsonglobaleditions.com/gaddis) for information on how to access instructor resources.

Textbook Web site

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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++: From Control Structures through Objects*
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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	**EARLIER 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.	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.
INTRODUCTION OF DATA STRUCTURES AND RECURSION	**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.	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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