

DATA STRUCTURES USING C++

2
EDITION



D.S. Malik

RUTRES

DATA STRUCTURES USING C++

SECOND EDITION

D.S. MALIK



 COURSE TECHNOLOGY
CENGAGE Learning

Australia • Brazil • Japan • Korea • Mexico • Singapore • Spain • United Kingdom • United States

Data Structures Using C++, Second Edition
D.S. Malik

Executive Editor: Marie Lee

Acquisitions Editor: Amy Jollymore

Senior Product Manager: Alyssa Pratt

Editorial Assistant: Zina Kresin

Marketing Manager: Bryant Chrzan

Content Project Manager: Heather Furrow

Art Director: Faith Brosnan

Image credit: © Fancy Photography/Veer
(Royalty Free)

Cover Designer: Roycroft Design

Compositor: Integra

© 2010 Course Technology, Cengage Learning

ALL RIGHTS RESERVED. No part of this work covered by the copyright herein may be reproduced, transmitted, stored or used in any form or by any means graphic, electronic, or mechanical, including but not limited to photocopying, recording, scanning, digitizing, taping, Web distribution, information networks, or information storage and retrieval systems, except as permitted under Section 107 or 108 of the 1976 United States Copyright Act, without the prior written permission of the publisher.

For product information and technology assistance, contact us at **Cengage Learning Customer & Sales Support, 1-800-354-9706**. For permission to use material from this text or product, submit all requests online at cengage.com/permissions. Further permissions questions can be emailed to permissionrequest@cengage.com.

ISBN-13: 978-0-324-78201-1

ISBN-10: 0-324-78201-2

Course Technology
20 Channel Center Street
Boston, MA 02210
USA

Cengage Learning is a leading provider of customized learning solutions with office locations around the globe, including Singapore, the United Kingdom, Australia, Mexico, Brazil, and Japan. Locate your local office at: international.cengage.com/region

Cengage Learning products are represented in Canada by Nelson Education, Ltd.

For your lifelong learning solutions, visit
www.cengage.com/coursestechnology

Purchase any of our products at your local college store or at our preferred online store www.ichapters.com

Some of the product names and company names used in this book have been used for identification purposes only and may be trademarks or registered trademarks of their respective manufacturers and sellers.

Any fictional data related to persons or companies or URLs used throughout this book is intended for instructional purposes only. At the time this book was printed, any such data was fictional and not belonging to any real persons or companies.

Course Technology, a part of Cengage Learning, reserves the right to revise this publication and make changes from time to time in its content without notice.

The programs in this book are for instructional purposes only.

They have been tested with care, but are not guaranteed for any particular intent beyond educational purposes. The author and the publisher do not offer any warranties or representations, nor do they accept any liabilities with respect to the programs.

Printed in the United States of America
1 2 3 4 5 6 7 15 14 13 12 11 10 09

Data Structures Using C++, Second Edition D.S. Malik

Executive Editor: Marie Lee **Acquisitions Editor:** Amy Jollymore **Senior Product Manager:** Alyssa Pratt
Editorial Assistant: Zina Kresin **Marketing Manager:** Bryant Chrzan **Content Project Manager:** Heather Furrow
Art Director: Faith Brosnan **Image credit:** a Fancy Photography/Veer

(Royalty Free) Cover Designer: Roycroft Design Compositor: Integra

Printed in the United States of America 1 2 3 4 5 6 7 15 14 13 12 11 10 09

a 2010 Course Technology, Cengage Learning

ALL RIGHTS RESERVED. No part of this work covered by the copyright herein may be reproduced, transmitted, stored or used in any form or by any means graphic, electronic, or mechanical, including but not limited to photocopying, recording, scanning, digitizing, taping, Web distribution, information networks, or information storage and retrieval systems, except as permitted under Section 107 or 108 of the 1976 United States Copyright Act, without the prior written permission of the publisher.

For product information and technology assistance, contact us at Cengage Learning Customer & Sales Support, 1-800-354-9706 For permission to use material from this text or product, submit all requests online at cengage.com/permissions Further permissions questions can be emailed to permissionrequest@cengage.com

ISBN-13: 978-0-324-78201-1 ISBN-10: 0-324-78201-2

Course Technology 20 Channel Center Street Boston, MA 02210 USA

Cengage Learning is a leading provider of customized learning solutions with office locations around the globe, including Singapore, the United Kingdom, Australia, Mexico, Brazil, and Japan. Locate your local office at: international.cengage.com/region

Cengage Learning products are represented in Canada by Nelson Education, Ltd.

For your lifelong learning solutions, visit www.cengage.com/coursetechnology

Purchase any of our products at your local college store or at our preferred online store www.ichapters.com Some of the product names and company names used in this book have been used for identification purposes only and may be trademarks or registered trademarks of their respective manufacturers and sellers. Any fictional data related to persons or companies or URLs used throughout this book is intended for instructional purposes only. At the time this book was printed, any such data was fictional and not belonging to any real persons or companies. Course Technology, a part of Cengage Learning, reserves the right to revise this publication and make changes from time to time in its content without notice. The programs in this book are for instructional purposes only.

They have been tested with care, but are not guaranteed for any particular intent beyond educational purposes. The author and the publisher do not offer any warranties or representations, nor do they accept any liabilities with respect to the programs.

TO

My Parents

TO

My Parents

This page intentionally left blank

This page intentionally left blank



PREFACE	xxiii
1. Software Engineering Principles and C++ Classes	1
2. Object-Oriented Design (OOD) and C++	59
3. Pointers and Array-Based Lists	131
4. Standard Template Library (STL) I	209
5. Linked Lists	265
6. Recursion	355
7. Stacks	395
8. Queues	451
9. Searching and Hashing Algorithms	497
10. Sorting Algorithms	533
11. Binary Trees and B-Trees	599
12. Graphs	685
13. Standard Template Library (STL) II	731
APPENDIX A Reserved Words	807
APPENDIX B Operator Precedence	809
APPENDIX C Character Sets	811
APPENDIX D Operator Overloading	815
APPENDIX E Header Files	817

PREFACE xxiii

1. Software Engineering Principles and C++ Classes 1

2. Object-Oriented Design (OOD) and C++ 59

3. Pointers and Array-Based Lists	131
4. Standard Template Library (STL) I	209
5. Linked Lists	265
6. Recursion	355
7. Stacks	395
8. Queues	451
9. Searching and Hashing Algorithms	497
10. Sorting Algorithms	533
11. Binary Trees and B-Trees	599
12. Graphs	685
13. Standard Template Library (STL) II	731
APPENDIX A Reserved Words	807
APPENDIX B Operator Precedence	809
APPENDIX C Character Sets	811
APPENDIX D Operator Overloading	815
APPENDIX E Header Files	817

APPENDIX F	Additional C++ Topics	825
APPENDIX G	C++ for Java Programmers	833
APPENDIX H	References	857
APPENDIX I	Answers to Odd-Numbered Exercises	859
INDEX		879

APPENDIX G C++ for Java Programmers 833

APPENDIX H References 857

APPENDIX I Answers to Odd-Numbered

Exercises 859

INDEX 879



TABLE OF CONTENTS

Preface

xxiii

1

SOFTWARE ENGINEERING PRINCIPLES AND C++ CLASSES

1

Software Life Cycle

2

Software Development Phase

3

Analysis

3

Design

3

Implementation

5

Testing and Debugging

7

Algorithm Analysis: The Big-O Notation

8

Classes

17

Constructors

21

Unified Modeling Language Diagrams

22

Variable (Object) Declaration

23

Accessing Class Members

24

Implementation of Member Functions

25

Reference Parameters and Class Objects (Variables)

30

Assignment Operator and Classes

31

Class Scope

32

Functions and Classes

32

Constructors and Default Parameters

32

Destructors

33

Structs

33

SOFTWARE ENGINEERING PRINCIPLES AND C++ CLASSES 1

Software Life Cycle 2

Software Development Phase 3 Analysis 3 Design 3 Implementation 5 Testing and Debugging 7

Algorithm Analysis: The Big-O Notation 8

Classes 17 Constructors 21 Unified Modeling Language Diagrams 22 Variable (Object) Declaration 23
Accessing Class Members 24 Implementation of Member Functions 25 Reference Parameters and Class
Objects (Variables) 30 Assignment Operator and Classes 31 Class Scope 32 Functions and Classes 32
Constructors and Default Parameters 32 Destructors 33 Structs 33

	Data Abstraction, Classes, and Abstract Data Types	33
	Programming Example: Fruit Juice Machine	38
	Identifying Classes, Objects, and Operations	48
	Quick Review	49
	Exercises	51
	Programming Exercises	57
2	OBJECT-ORIENTED DESIGN (OOD) AND C++	59
	Inheritance	60
	Redefining (Overriding) Member Functions of the Base Class	63
	Constructors of Derived and Base Classes	69
	Header File of a Derived Class	75
	Multiple Inclusions of a Header File	76
	Protected Members of a Class	78
	Inheritance as public , protected , or private	78
	Composition	79
	Polymorphism: Operator and Function Overloading	84
	Operator Overloading	85
	Why Operator Overloading Is Needed	85
	Operator Overloading	86
	Syntax for Operator Functions	86
	Overloading an Operator: Some Restrictions	87
	The Pointer this	87
	Friend Functions of Classes	91
	Operator Functions as Member Functions and Nonmember Functions	94
	Overloading Binary Operators	95
	Overloading the Stream Insertion (<<) and Extraction (>>) Operators	98
	Operator Overloading: Member Versus Nonmember	102
	Programming Example: Complex Numbers	103
	Function Overloading	108

Data Abstraction, Classes, and Abstract Data Types 33

Programming Example: Fruit Juice Machine 38

Identifying Classes, Objects, and Operations 48

Quick Review 49

Exercises 51

Programming Exercises 57

OBJECT-ORIENTED DESIGN (OOD) AND C++ 59

Inheritance 60 Redefining (Overriding) Member Functions of the Base Class 63 Constructors of Derived and Base Classes 69 Header File of a Derived Class 75 Multiple Inclusions of a Header File 76 Protected Members of a Class 78 Inheritance as public, protected, or private 78

Composition 79

Polymorphism: Operator and Function Overloading 84

Operator Overloading 85 Why Operator Overloading Is Needed 85 Operator Overloading 86 Syntax for Operator Functions 86 Overloading an Operator: Some Restrictions 87 The Pointer this 87 Friend Functions of Classes 91 Operator Functions as Member Functions and Nonmember

Functions 94 Overloading Binary Operators 95 Overloading the Stream Insertion (<<) and Extraction (>>)

Operators 98

Operator Overloading: Member Versus Nonmember 102

Programming Example: Complex Numbers 103

Function Overloading 108

Templates	108
Function Templates	109
Class Templates	111
Header File and Implementation File of a Class Template	112
Quick Review	113
Exercises	115
Programming Exercises	124

3

POINTERS AND ARRAY-BASED LISTS	131
The Pointer Data Type and Pointer Variables	132
Declaring Pointer Variables	132
Address of Operator (&)	133
Dereferencing Operator (*)	133
Pointers and Classes	137
Initializing Pointer Variables	138
Dynamic Variables	138
Operator new	138
Operator delete	139
Operations on Pointer Variables	145
Dynamic Arrays	147
Array Name: A Constant Pointer	148
Functions and Pointers	149
Pointers and Function Return Values	150
Dynamic Two-Dimensional Arrays	150
Shallow Vs. Deep Copy and Pointers	153
Classes and Pointers: Some Peculiarities	155
Destructor	155
Assignment Operator	157
Copy Constructor	159
Inheritance, Pointers, and Virtual Functions	162
Classes and Virtual Destructors	168
Abstract Classes and Pure Virtual Functions	169

Class Template 112

Quick Review 113

Exercises 115

Programming Exercises 124

POINTERS AND ARRAY-BASED LISTS 131

The Pointer Data Type and Pointer Variables 132 Declaring Pointer Variables 132 Address of Operator (&) 133 Dereferencing Operator (*) 133 Pointers and Classes 137 Initializing Pointer Variables 138 Dynamic Variables 138 Operator new 138 Operator delete 139 Operations on Pointer Variables 145 Dynamic Arrays 147 Array Name: A Constant Pointer 148 Functions and Pointers 149 Pointers and Function Return Values 150 Dynamic Two-Dimensional Arrays 150 Shallow Vs. Deep Copy and Pointers 153

Classes and Pointers: Some Peculiarities 155 Destructor 155 Assignment Operator 157 Copy Constructor 159

Inheritance, Pointers, and Virtual Functions 162 Classes and Virtual Destructors 168

Abstract Classes and Pure Virtual Functions 169

Table of Contents | ix