

Fourth AP Edition

# Java Methods

Object-Oriented Programming  
and  
Data Structures

Maria Litvin

Phillips Academy, Andover, Massachusetts

Gary Litvin

Skylight Software, Inc.

Skylight Publishing  
Andover, Massachusetts

Skylight Publishing  
9 Bartlet Street, Suite 70  
Andover, MA 01810

web: [www.skylit.com](http://www.skylit.com)  
e-mail: [sales@skylit.com](mailto:sales@skylit.com)  
[support@skylit.com](mailto:support@skylit.com)

**Copyright © 2022 by Maria Litvin, Gary Litvin, and  
Skylight Publishing**

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the authors and Skylight Publishing.

Library of Congress Control Number: 2021944689

ISBN 978-0-9972528-2-8

\* AP and Advanced Placement are registered trademarks of The College Board, which was not involved in the production of and does not endorse this book.

The names of commercially available software and products mentioned in this book are used for identification purposes only and may be trademarks or registered trademarks owned by corporations and other commercial entities. Skylight Publishing and the authors have no affiliation with and disclaim any sponsorship or endorsement by any of these product manufacturers or trademark owners.

Oracle, Java, and Java logos are trademarks or registered trademarks of Oracle Corporation and/or its affiliates in the U.S. and other countries.

SCRABBLE® is the registered trademark of HASBRO in the United States and Canada and of J.W. Spear and Sons, PLC, a subsidiary of Mattel, Inc., outside the United States and Canada.

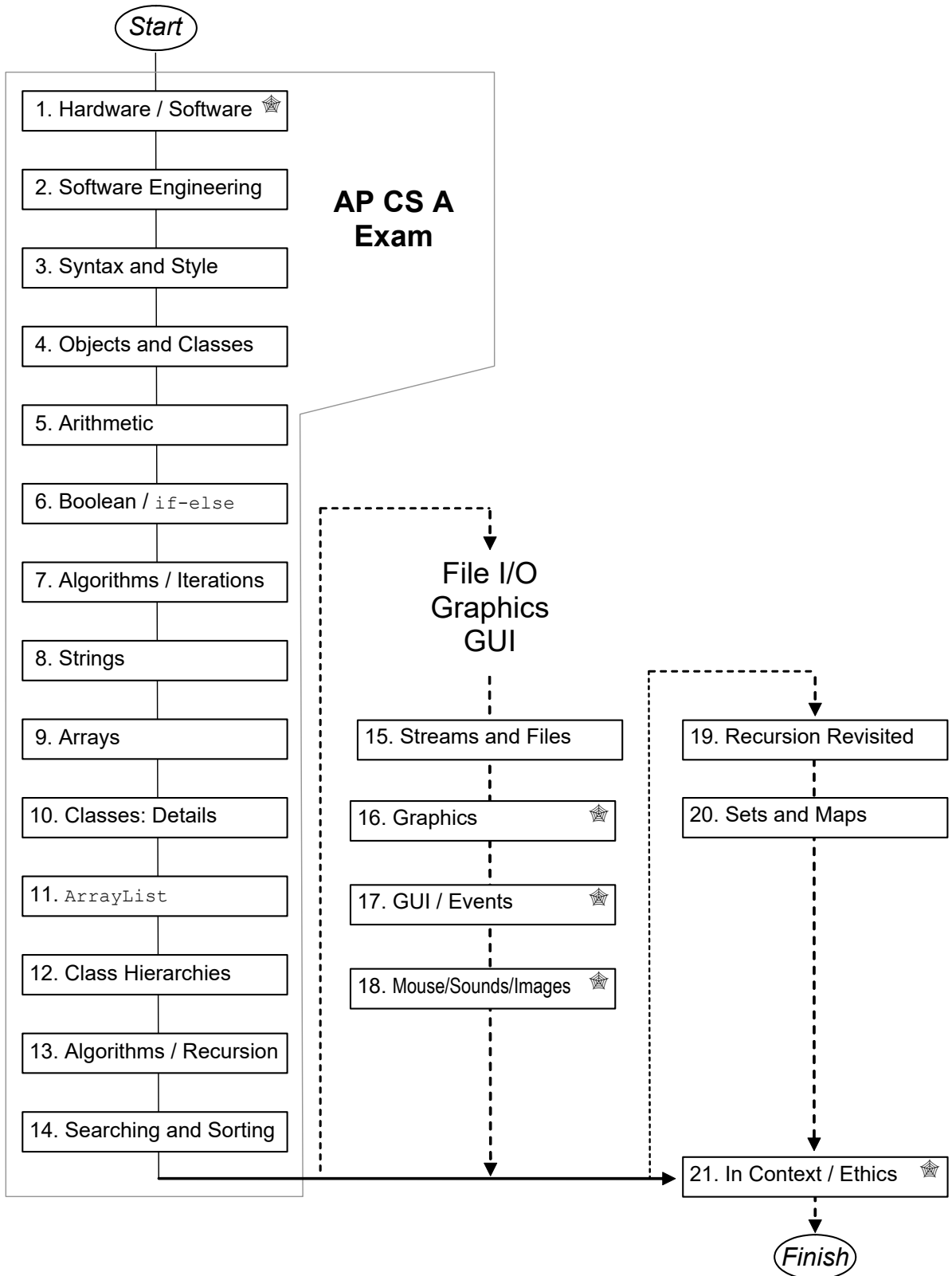
1 2 3 4 5 6 7 8 9 10      26 25 24 23 22 21

Printed in the United States of America

## Brief Contents

---

Preface	<i>xiii</i>
How to Use This Book	<i>xvii</i>
Chapter 1	Hardware, Software, and the Internet 1
Chapter 2	An Introduction to Software Engineering 11
Chapter 3	Java Syntax and Style 43
Chapter 4	Objects and Classes 65
Chapter 5	Data Types, Variables, and Arithmetic 95
Chapter 6	Boolean Expressions and <code>if-else</code> Statements 133
Chapter 7	Algorithms and Iterations 177
Chapter 8	Strings 207
Chapter 9	Arrays 235
Chapter 10	Implementing and Using Classes 271
Chapter 11	<code>java.util.ArrayList</code> 319
Chapter 12	Class Hierarchies 341
Chapter 13	Algorithms and Recursion 365
Chapter 14	Searching and Sorting 383
Chapter 15	Streams and Files 413
Chapter 16	Graphics 429
Chapter 17	GUI Components and Events 435
Chapter 18	Mouse, Keyboard, Sounds, and Images 443
Chapter 19	Recursion Revisited 447
Chapter 20	Sets and Maps 475
Chapter 21	Computing in Context 495
Appendices	🏠
Solutions to Selected Exercises	🏠
Index	499



# Contents

---

**Preface** *xiii*

**How to Use This Book** *xvii*

---

**Chapter 1. Hardware, Software, and the Internet** **1**

- 1.1 Prologue 2
- 1.2 Hardware Overview
  - 1.2.1 The CPU
  - 1.2.2 Memory
  - 1.2.3 Secondary Storage Devices
  - 1.2.4 Input and Output Devices
- 1.3 Software Overview
- 1.4 What Do Software Engineers Do?
- 1.5 Representation of Information in Computer Memory
  - 1.5.1 Numbers
  - 1.5.2 Characters
- 1.6 The Internet
- 1.7 Summary
- Exercises 5

 [www.skylit.com/javamethods4/  
JM-Chapter01-www.pdf](http://www.skylit.com/javamethods4/JM-Chapter01-www.pdf)

---

**Chapter 2. An Introduction to Software Engineering** **11**

- 2.1 Prologue 12
- 2.2 Compilers and Interpreters 14
- 2.3 Software Components and Packages 21
- 2.4 *Lab*: Three Ways to Say Hello 22
- 2.5 Object-Oriented Programming 29
- 2.6 *Lab*: More Ways to Say Hello 32
- 2.7 Summary 37
- Exercises 38

**Chapter 3. Java Syntax and Style** **43**

---

- 3.1 Prologue 44
- 3.2 An Example of a Class 45
- 3.3 Using Comments 48
- 3.4 Reserved Words and Programmer-Defined Names 50
- 3.5 Syntax vs. Style 53
- 3.6 Statements, Blocks, Indentation 57
- 3.7 *Lab*: Correcting Syntax Errors 58
- 3.8 Summary 60  
Exercises 61

**Chapter 4. Objects and Classes** **65**

---

- 4.1 Prologue 66
- 4.2 *Case Study*: A Drawing Program 67
- 4.3 Classes 70
- 4.4 Fields, Constructors, and Methods 75
- 4.5 Inheritance 81
- 4.6 *Case Study and Lab*: Balloons of All Kinds 85
- 4.7 Summary 88  
Exercises 90

**Chapter 5. Data Types, Variables, and Arithmetic** **95**

---

- 5.1 Prologue 96
- 5.2 Declaring Fields and Local Variables 98
- 5.3 Primitive Data Types 102
- 5.4 Strings 104
- 5.5 Constants 104
- 5.6 Scope of Variables 107
- 5.7 Arithmetic Expressions 109
- 5.8 Compound Assignment and Increment Operators 112
- 5.9 Avoiding Division by Zero Errors 114
- 5.10 Converting Numbers and Objects into Strings 115
- 5.11 *Lab*: Pie Chart 119
- 5.12 The `Math` Class 121
- 5.13 Calling a Method from `main` 122
- 5.14 Summary 123  
Exercises 125

---

**Chapter 6. Boolean Expressions and `if-else` Statements** **133**

---

- 6.1 Prologue 134
- 6.2 `if-else` Statements 136
- 6.3 `boolean` Data Type 137
- 6.4 Relational Operators 138
- 6.5 Logical Operators 140
- 6.6 Order of Operators 142
- 6.7 Short-Circuit Evaluation 143
- 6.8 `if-else-if` and Nested `if-else` 144
- 6.9 *Case Study and Lab: Rolling Dice* 149
- 6.10 The `switch` Statement 158
- 6.11 Enumerated Data Types 161
- 6.12 *Case Study and Lab: Rolling Dice Concluded* 163
- 6.13 Summary 167
  - Exercises 169

---

**Chapter 7. Algorithms and Iterations** **177**

---

- 7.1 Prologue 178
- 7.2 Properties of Algorithms 179
- 7.3 The `while` and `for` Loops 184
- 7.4 The `do-while` Loop 188
- 7.5 `return` and `break` in Loops 189
- 7.6 Nested Loops 191
- 7.7 *Case Study: Euclid's GCF Algorithm* 194
- 7.8 *Lab: Perfect Numbers* 196
- 7.9 Summary 197
  - Exercises 199

---

**Chapter 8. Strings** **207**

---

- 8.1 Prologue 208
- 8.2 Literal Strings 208
- 8.3 `String` Constructors and Immutability 209
- 8.4 `String` Methods 212
- 8.5 Formatting Numbers into Strings 219
- 8.6 Extracting Numbers from Strings 222
- 8.7 `Character` Methods 223
- 8.8 *Lab: Lipograms* 224
- 8.9 The `StringBuffer` Class 226
- 8.10 Summary 228
  - Exercises 229

**Chapter 9. Arrays** **235**

---

- 9.1 Prologue 236
- 9.2 One-Dimensional Arrays 237
- 9.3 *Lab*: Fortune Teller 241
- 9.4 Two-Dimensional Arrays 242
- 9.5 *Case Study and Lab*: Chomp 244
- 9.6 Iterations and the “For Each” Loop 249
- 9.7 Inserting and Removing Elements 252
- 9.8 *Case Study and Lab*: the Sieve of Eratosthenes 254
- 9.9 Summary 256  
Exercises 258

**Chapter 10. Implementing and Using Classes** **271**

---

- 10.1 Prologue 272
- 10.2 Public and Private Features of a Class 276
- 10.3 Constructors 278
- 10.4 References to Objects 282
- 10.5 Defining Methods 283
- 10.6 Calling Methods and Accessing Fields 286
- 10.7 Passing Parameters to Constructors and Methods 289
- 10.8 `return` Statement 292
- 10.9 *Case Study and Lab*: Snack Bar 295
- 10.10 Overloaded Methods 300
- 10.11 Static Fields and Methods 303
- 10.12 *Case Study*: Snack Bar Concluded 308
- 10.13 Summary 310  
Exercises 312

**Chapter 11. `java.util.ArrayList`** **319**

---

- 11.1 Prologue 320
- 11.2 `ArrayList`’s Structure 320
- 11.3 `ArrayList`’s Constructors and Methods 323
- 11.4 *Lab*: Exploding Dots 326
- 11.5 *Lab*: Shuffler 328
- 11.6 `ArrayList`’s Pitfalls 329
- 11.7 *Lab*: Creating an Index for a Document 332
- 11.8 Summary 336  
Exercises 337



---

<b>Chapter 12. Class Hierarchies</b>	<b>341</b>
12.1 Prologue	342
12.2 Class Hierarchies	344
12.3 Abstract Classes	345
12.4 Invoking Superclass's Constructors	347
12.5 Calling Superclass's Methods	350
12.6 Polymorphism	352
12.7 Interfaces	353
12.8 Summary	356
Exercises	358
<b>Chapter 13. Algorithms and Recursion</b>	<b>365</b>
13.1 Prologue	366
13.2 Recursive Methods	367
13.3 Tracing Recursive Methods	370
13.4 <i>Case Study</i> : File Manager	371
13.5 Summary	375
Exercises	375
<b>Chapter 14. Searching and Sorting</b>	<b>383</b>
14.1 Prologue	384
14.2 equals, compareTo, and compare	385
14.3 Sequential and Binary Search	391
14.4 <i>Lab</i> : Keeping Things in Order	395
14.5 Selection Sort	396
14.6 Insertion Sort	397
14.7 Mergesort	399
14.8 Quicksort	402
14.9 <i>Lab</i> : Benchmarks	404
14.10 java.util.Arrays and java.util.Collections	406
14.11 Summary	408
Exercises	410


**Chapter 15. Streams and Files** **413**

---

- 15.1 Prologue 414
- 15.2 Pathnames and the `java.io.File` Class 416
- 15.3 Reading from a Text File 418
- 15.4 Writing to a Text File 421
- 15.5 *Lab: Choosing Words* 423
- 15.6 Summary 424
- Exercises 425


**Chapter 16. Graphics** **429**

---

- 16.1 Prologue 430
- 16.2 `paint`, `paintComponent`, and `repaint`
- 16.3 Coordinates  [www.skylit.com/javamethods4/  
JM-Chapter16-www.pdf](http://www.skylit.com/javamethods4/JM-Chapter16-www.pdf)
- 16.4 Colors
- 16.5 Drawing Shapes
- 16.6 Fonts and Text
- 16.7 *Case Study and Lab: Pieces of the Puzzle*
- 16.8 Summary
- Exercises 432

**Chapter 17. GUI Components and Events** **435**

---


- 17.1 Prologue 436
- 17.2 Pluggable Look and Feel
- 17.3 Basic *Swing* Components and Their Events  [www.skylit.com/javamethods4/  
JM-Chapter17-www.pdf](http://www.skylit.com/javamethods4/JM-Chapter17-www.pdf)
- 17.4 Layouts
- 17.5 Menus
- 17.6 *Case Study and Lab: the Ramblecs Game*
- 17.7 Summary
- Exercises 438

---

**Chapter 18. Mouse, Keyboard, Sounds, and Images** **443**

---

18.1	Prologue	444
18.2	Mouse Events Handling	
18.3	Keyboard Events Handling	
18.4	<i>Lab</i> : Rambles Concluded	
18.5	Playing Audio Clips	
18.6	Working with Images	
18.7	<i>Lab</i> : Slide Show	
18.8	Summary	
	Exercises	445

 [www.skylit.com/javamethods/  
JM-Chapter18-www.pdf](http://www.skylit.com/javamethods/JM-Chapter18-www.pdf)

---

**Chapter 19. Recursion Revisited** **447**

---

19.1	Prologue	448
19.2	Three Examples	448
19.3	When Not to Use Recursion	455
19.4	Understanding and Debugging Recursive Methods	459
19.5	<i>Lab</i> : the Tower of Hanoi	462
19.6	<i>Case Study and Lab</i> : the Game of Hex	463
19.7	Summary	468
	Exercises	468


---

**Chapter 20. Sets and Maps** **475**


---

20.1	Prologue	476
20.2	Lookup Tables	477
20.3	<i>Lab</i> : Cryptogram Solver	479
20.4	Hash Tables	482
20.5	<code>java.util</code> 's <code>HashSet</code> and <code>HashMap</code>	484
20.6	<i>Lab</i> : Search Engine	487
20.7	Summary	489
	Exercises	490

**Chapter 21. Computing in Context****495**

- 21.1 Prologue 496
  - 21.2 Be Creative!
  - 21.3 Rules of Digital Citizenship
    - 28.3.1 Formulating Ethical Guidelines
    - 28.3.2 Maintaining Professional Standards
    - 28.3.3 Regulating Users
  - 21.4 System Reliability and Security
    - 28.4.1 Avoiding System Failure
    - 28.4.2 Maintaining Data Integrity
    - 28.4.3 Protecting Secure Systems and Databases
  - 21.5 Legal Issues
    - 28.5.1 Privacy
    - 28.5.2 Censorship vs. Free Speech
    - 28.5.3 Intellectual Property and Copyright Issues
  - 21.6 Summary
    - Suggested Activities
-  [www.skylit.com/javamethods4/JM-Chapter21-www.pdf](http://www.skylit.com/javamethods4/JM-Chapter21-www.pdf)

**Appendices**

- A. The 17 Bits of Style
  - B. Common Syntax Error Messages
  - C. GUI Examples Index
  - D. The EasyReader, EasyWriter, EasySound,  
and EasyDate Classes
-  [www.skylit.com/javamethods4](http://www.skylit.com/javamethods4)

**Solutions to Selected Exercises**  [www.skylit.com/javamethods4](http://www.skylit.com/javamethods4)**Index 499**