

Second AP\* Edition  
— with GridWorld

# *Java*

# *Methods*

Object-Oriented Programming  
and  
Data Structures

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Library of Congress Control Number: 2010915303

ISBN 978-0-9824775-7-1

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Printed in the United States of America

## Preface

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This book offers a thorough introduction to the concepts and practices of object-oriented programming in Java. It also introduces the most common data structures and related algorithms and their implementations in the Java collections framework.

Chapters 1-14 follow the syllabus of the AP Computer Science course. They will prepare you well for the AP CS exam. Chapters 15-18 on file input and output, graphics, graphical user interfaces, and events handling in Java will give you a better sense of real-world Java programming; this material also makes case studies, labs, and exercises more fun. Chapters 19-26 deal with more advanced data structures and algorithms. The last chapter, Design Patterns, discusses more intricate aspects of object-oriented design and serves as an introduction to design patterns.

This edition builds on our earlier book, *Java Methods A & AB: OOP and Data Structures* (Skylight Publishing, 2006). The AB-level AP CS exam was discontinued by the College Board in 2009, but we have decided to keep the data structures chapters in the book for teachers who continue teaching this material and for students who want to learn it on their own.

The book follows four main threads: OOP concepts and techniques, algorithms, Java syntax and style, and Java libraries. As in the software engineering profession itself, these threads are interwoven into an inseparable braid.

Our book strives to present the technical details while grounding them in clear explanations of the underlying concepts. OOP has an extensive conceptual layer and complex terminology. Fortunately, many OOP concepts are more straightforward than the terminology makes them appear. Most of the key elements are actually quite intuitive: *objects* (entities that combine data elements and functions), *classes* (definitions of types of objects), *methods* (functions that carry out certain tasks), *instantiation* (creating an object of a particular class), *inheritance* (one class extending the features of another class), *encapsulation* (hiding the implementation details of a class), *polymorphism* (calling the correct methods automatically for specific objects disguised as objects of more generic types), and *event-driven applications* (where the operating system, the user, or events in the program trigger certain actions).

We also emphasize good programming style, an element not mandated by formal Java language specifications but essential for writing readable and professional programs.

Our labs and case studies aim to demonstrate the most appropriate uses of the programming techniques and data structures we cover. OOP is widely believed to facilitate teamwork, software maintenance, and software reuse. While it is not possible for an introductory textbook to present a large-scale real-world project as a case study, the case studies and labs in this book offer a taste of how these OOP benefits can play out in larger projects.

Several labs and exercises in this book are based on GridWorld. The GridWorld case study was developed by the College Board for AP CS courses and exams. The GridWorld Student Manual and Java code are available free of charge at the College Board's web site, [www.collegeboard.com](http://www.collegeboard.com). The code is distributed under the GNU license. The GridWorld Solutions Manual is available to teachers at the GridWorld case study page at <http://apcentral.collegeboard.com>.

We introduce GridWorld's Parts 1 and 2 in Chapter 3, Objects and Classes. We use examples from Part 2 and Part 3 in Chapter 11, Class Hierarchies and Interfaces. We discuss Part 4 in Chapter 13, `java.util.ArrayList`. And we include examples and exercises based on GridWorld in other chapters, too.

It is not our goal to teach all the details of the GridWorld case study in this textbook. If you are preparing for the AP exam, you'll need to use the College Board materials and our review book, *Be Prepared for the AP Computer Science Exam in Java* (Skylight Publishing). Be sure to allocate sufficient time for GridWorld, perhaps a few weeks.

We assume that at least two or three class periods each week will be held in a computer lab with students working independently or in small groups. A set of *Student Files* downloadable from this book's web site contains files for all the case studies, labs, and exercises in the book; a downloadable set of *Teacher Files*, available to teachers only, provides complete solutions to all the labs and exercises.

Still, with all the examples and case studies, we leave a lot of work to you, the student. This is not a *Java-in-n-days* book or an *n-hours-to-complete* book. It is a book for learning essential concepts and technical skills at a comfortable pace, for acquiring a repertoire of techniques and examples to work from, and for consulting as needed when you start writing your own Java programs professionally or for fun.

Working through this book will not make you a Java expert right away, but it will bring you to the level of an entry-level Java programmer with a better than average understanding of the fundamental concepts. Object-oriented programming was originally meant to make software development more accessible to beginners, and *Java Methods* is written in that spirit.



Since our first book came out in 1998, many of our colleagues, too many to name, have become good friends. We are grateful to them for their loyal support, encouragement, and the many things they have taught us over the years.

We thank the students in Maria's AP Computer Science classes for their patience while studying from a draft of this book; they have caught some typos and mistakes and made many useful suggestions.

Our special thanks to Margaret Litvin for her thorough and thoughtful editing.



Without further delay, let us begin learning object-oriented programming in Java!

## About the Authors

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**Maria Litvin** has taught computer science and mathematics at Phillips Academy in Andover, Massachusetts, since 1987. She is an Advanced Placement Computer Science exam reader and Table Leader and, as a consultant for The College Board, provides AP training for high school computer science teachers. Maria has received the 1999 Siemens Award for Advanced Placement for Mathematics, Science, and Technology for New England and the 2003 RadioShack National Teacher Award. Prior to joining Phillips Academy, Maria taught computer science at Boston University. Maria is a co-author of *C++ for You++: An Introduction to Programming and Computer Science*(1998), which became one of the leading high school textbooks for AP Computer Science courses, and of the earlier editions of the *Java Methods* books. Maria is also the co-author of *Be Prepared for the AP Computer Science Exam in Java* and *Mathematics for the Digital Age and Programming in Python* (Skylight Publishing, 2010).

**Gary Litvin** has worked in many areas of software development including artificial intelligence, pattern recognition, computer graphics, and neural networks. As founder of Skylight Software, Inc., he developed SKYLIGHTS/GX, one of the first GUI prototyping and development tools for C and C++ programmers. Gary led in the development of several state-of-the-art software products including interactive touch screen development tools, OCR and handwritten character recognition systems, and credit card fraud detection software. He is the co-author of *C++ for You++*, the *Java Methods* series, *Be Prepared for the AP Computer Science Exam in Java*, and *Mathematics for the Digital Age and Programming in Python*.