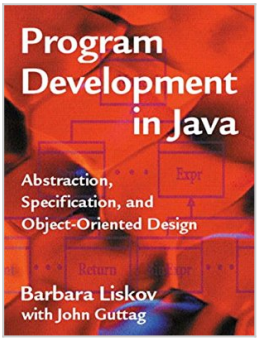

Program Development in Java: Abstraction, Specification, and Object-Oriented Design

By Barbara Liskov, John Guttag

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Written by a world-renowned expert on programming methodology, and the winner of the 2008 Turing Award, this book shows how to build production-quality programs--programs that are reliable, easy to maintain, and quick to modify. Its emphasis is on modular program construction: how to get the modules right and how to organize a program as a collection of modules. The book presents a methodology effective for either an individual programmer, who may be writing a small program or a single module in a larger one; or a software engineer, who may be part of a team developing a complex program comprised of many modules. Both audiences will acquire a solid foundation for object-oriented program design and component-based software development from this methodology.
Because each module in a program corresponds to an abstraction, such as a collection of documents or a routine to search the collection for documents of interest, the book first explains the kinds of abstractions most useful to programmers: procedures; iteration abstractions; and, most critically, data abstractions. Indeed, the author treats data abstraction as the central paradigm in object-oriented program design and implementation. The author also shows, with numerous examples, how to develop informal specifications that define these abstractions--specifications that describe what the modules do--and then discusses how to implement the modules so that they do what they are supposed to do with acceptable performance.
Other topics discussed include:

- Encapsulation and the need for an implementation to provide the behavior defined by the specification
- Tradeoffs between simplicity and performance
- Techniques to help readers of code understand and reason about it, focusing on such properties as rep invariants and abstraction functions
- Type hierarchy and its use in defining families of related data abstractions
- Debugging, testing, and requirements analysis
- Program design as a top-down, iterative process, and design patterns

The Java programming language is used for the book's examples. However, the

techniques presented are language independent, and an introduction to key Java concepts is included for programmers who may not be familiar with the language.

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Editorial Review

From the Inside Flap
Constructing production-quality programs--programs that are used over an extended period of time--is well known to be extremely difficult. The goal of this book is to improve the effectiveness of programmers in carrying out this task. I hope the reader will become a better programmer as a result of reading the book. I believe the book succeeds at improving programming skills because my students tell me that it happens for them. What makes a good programmer? It is a matter of efficiency over the entire production of a program. The key is to reduce wasted effort at each stage. Things that can help include thinking through your implementation before you start coding, coding in a way that eliminates errors before you test, doing rigorous testing so that errors are found early, and paying careful attention to modularity so that when errors are discovered, they can be corrected with minimal impact on the program as a whole. This book covers techniques in all these areas. Modularity is the key to writing good programs. It is essential to break up a program into small modules, each of which interacts with the others through a narrow, well-defined interface. With modularity, an error in one part of a program can be corrected without having to consider all the rest of the code, and a part of the program can be understood without having to understand the entire thing. Without modularity, a program is a large collection of intricately interrelated parts. It is difficult to comprehend and to modify such a program, and also difficult to get it to work correctly.

The focus of this book therefore is on modular program construction: how to organize a program as a collection of well-chosen modules. The book relates modularity to abstraction. Each module corresponds to an abstraction, such as an index that keeps track of interesting words in a large collection of documents or a procedure that uses the index to find documents that match a particular query. Particular emphasis is placed on object-oriented programming--the use of data abstraction and objects in developing programs. The book uses Java for its programming examples. Familiarity with Java is not assumed. It is worth noting, however, that the concepts in this book are language independent and can be used to write programs in any programming language. How Can the Book Be Used? Program Development in Java can be used in two ways. The first is as the text for a course that focuses on an object-oriented methodology for the design and implementation of complex systems. The second is use by computing professionals who want to improve their programming skills and their knowledge of modular, object-oriented design.

When used as a text, the book is intended for a second or third programming course; we have used the book for many years in the second programming course at MIT, which is taken by sophomores and juniors. At this stage, students already know how to write small programs. The course builds on this material in two ways: by getting them to think more carefully about small programs, and by teaching them how to construct large programs using smaller ones as components. This book could also be used later in the curriculum, for example, in a software engineering course.

A course based on the book is suitable for all computer science majors. Even though many students will never be designers of truly large programs, they may work at development organizations where they will be responsible for the design and implementation of subsystems that must fit into the overall structure. The material on modular design is central to this kind of a task. It is equally important for those who take on larger design tasks. What Is This Book About? Roughly two-thirds of the book is devoted to the issues that arise in building individual program modules. The remainder of the book is concerned with how to use these modules to construct large programs.

Program Modules This part of the book focuses on abstraction mechanisms. It discusses procedures and exceptions, data abstraction, iteration abstraction, families of data abstractions, and polymorphic abstractions.

Three activities are emphasized in the discussion of abstractions. The first is deciding on exactly what the abstraction is: what behavior it is providing to its users. Inventing abstractions is a key part of design, and the book discusses how to choose among possible alternatives and what goes into inventing good abstractions.

The second activity is capturing the meaning of an abstraction by giving a specification for it. Without some description, an abstraction is too vague to be useful. The specification provides the needed description. This book defines a format for specifications, discusses the properties of a good specification, and provides many examples.

The third activity is implementing abstractions. The book discusses how to design an implementation and the trade-off between simplicity and performance. It emphasizes encapsulation and the need for an implementation to provide the behavior defined by the specification. It also presents techniques--in particular, the use of representation invariants and abstraction functions--that help readers of code to understand and reason about it. Both rep invariants and abstraction functions are implemented to the extent possible, which is useful for debugging and testing.

The material on type hierarchy focuses on its use as an abstraction technique--a way of grouping related data abstractions into families. An important issue here is whether it is appropriate to define one type to be a subtype of another. The book defines the {substitution principle}--a methodical way for deciding whether the subtype relation holds by examining the specifications of the subtype and the supertype.

This book also covers debugging and testing. It discusses how to come up with a sufficient number of test cases for thorough black box and glass box tests, and it emphasizes the importance of regression testing. Programming in the Large The latter part of Program Development in Java is concerned with how to design and implement large programs in a modular way. It builds on the material about abstractions and specifications covered in the earlier part of the book.

The material on programming in the large covers four main topics. The first concerns requirements analysis--how to develop an understanding of what is wanted of the program. The book discusses how to carry out requirements analysis and also describes a way of writing the resulting requirements specification, by making use of a {data model} that describes the abstract state of the program. Using the model leads to a more precise specification, and it also makes the requirements analysis more rigorous, resulting in a better understanding of the requirements.

The second programming in the large topic is program design, which is treated as an iterative process. The design process is organized around discovering useful abstractions, ones that can serve as desirable building blocks within the program as a whole. These abstractions are carefully specified during design so that when the program is implemented, the modules that implement the abstractions can be developed independently. The design is documented by a design notebook, which includes a module dependency diagram that describes the program structure.

The third topic is implementation and testing. The book discusses the need for design analysis prior to implementation and how design reviews can be carried out. It also discusses implementation and testing order. This section compares top-down and bottom-up organizations, discusses the use of drivers and stubs, and emphasizes the need to develop an ordering strategy prior to implementation that meets the needs of the development organization and its clients.

This book concludes with a chapter on design patterns. Some patterns are introduced in earlier chapters; for example, iteration abstraction is a major component of the methodology. The final chapter discusses patterns not covered earlier. It is intended as an introduction to this material. The interested reader can then go on to read more complete discussions contained in other books. Barbara Liskov 0201657686P04062001

From the Back Cover
Written by a world-renowned expert on programming methodology, and the winner of the 2008 Turing Award, this book shows how to build production-quality programs--programs that are reliable, easy to maintain, and quick to modify. Its emphasis is on modular program construction: how to get the modules right and how to organize a program as a collection of modules. The book presents a methodology effective for either an individual programmer, who may be writing a small program or a single module in a larger one; or a software engineer, who may be part of a team developing a complex program comprised of many modules. Both audiences will acquire a solid foundation for object-oriented program design and component-based software development from this methodology. Because each module in a program corresponds to an abstraction, such as a collection of documents or a routine to search the collection for documents of interest, the book first explains the kinds of abstractions most useful to programmers: procedures; iteration abstractions; and, most critically, data abstractions. Indeed, the author treats data abstraction as the central paradigm in object-oriented program design and implementation. The author also shows, with numerous examples, how to develop informal specifications that define these abstractions--specifications that describe what the modules do--and then discusses how to implement the modules so that they do what they are supposed to do with acceptable performance. Other topics discussed include:

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About the Author

Barbara Liskov is professor of computer science at MIT. Well known for her contributions to programming methodology and software engineering, she is co-author (with John Guttag) of the influential book, *Abstraction and Specification in Program Development.* Barbara is the recipient of the 2008 A.M. Turing Award, one of the highest honors in science and engineering.

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Typically the book Program Development in Java: Abstraction, Specification, and Object-Oriented Design

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