

## Preface

The Modelica modeling language and technology is being warmly received by the world community in modeling and simulation with major applications in virtual prototyping. It is bringing about a revolution in this area, based on its ease of use, visual design of models with combination of lego-like predefined model building blocks, its ability to define model libraries with reusable components, its support for modeling and simulation of complex applications involving parts from several application domains, and many more useful facilities. To draw an analogy—Modelica is currently in a similar phase as Java early on, before the language became well known, but for virtual prototyping instead of Internet programming.

## About this Book

This book teaches modeling and simulation and gives an introduction to the Modelica language to people who are familiar with basic programming concepts. It gives a basic introduction to the concepts of modeling and simulation, as well as the basics of object-oriented component-based modeling for the novice, and a comprehensive overview of modeling and simulation in a number of application areas. In fact, the book has several goals:

- Being a useful textbook in introductory courses on modeling and simulation.
- Being easily accessible for people who do not previously have a background in modeling, simulation and objectorientation.
- Introducing the concepts of physical modeling, object-oriented modeling, and component-based modeling.
- Providing a complete but not too formal reference for the Modelica language.
- Demonstrating modeling examples from a wide range of application areas.
- Being a reference guide for the most commonly used Modelica libraries.

The book contains many examples of models in different application domains, as well as examples combining several domains. However, it is not primarily intended for the advanced modeler who, for example, needs additional insight into modeling within very specific application domains, or the person who constructs very complex models where special tricks may be needed.

All examples and exercises in this book are available in an electronic self-teaching material called DrModelica, based on this book, that gradually guides the reader from simple introductory examples and exercises to more advanced ones. Part of this teaching material can be freely downloaded from the book web site, [www.DrModelica.org](http://www.DrModelica.org), where additional (teaching) material related to this book can be found, such as the exact version of the Modelica standard library (September 2003) used for the examples in this book. The main web site for Modelica and Modelica libraries, including the most recent versions, is the Modedica Association website, [www.Modelica.org](http://www.Modelica.org).

## Reading Guide

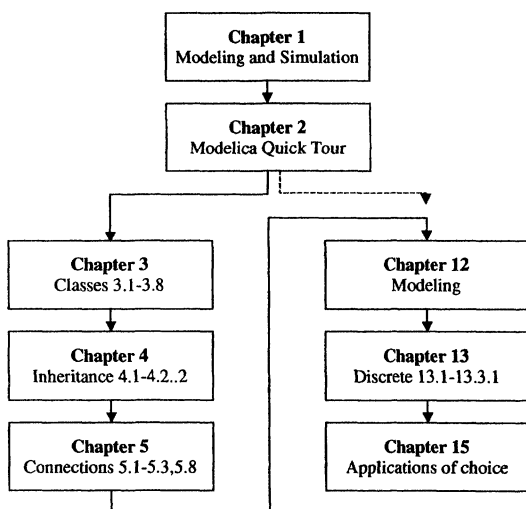
This book is a combination of a textbook for teaching modeling and simulation, a textbook and reference guide for learning how to model and program using Modelica, and an application guide on how to do

physical modeling in a number of application areas. The book can be read sequentially from the beginning to the end, but this will probably not be the typical reading pattern. Here are some suggestions:

- Very quick introduction to modeling and simulation – an object-oriented approach: Chapters 1 and 2.
- Basic introduction to the Modelica language: Chapter 2 and first part of Chapter 13.
- Full Modelica language course: Chapters 1–13.
- Application-oriented course: Chapter 1, and 2, most of Chapter 5, Chapters 12–15. Use Chapters 3–11 as a language reference, and Chapter 16 and appendices as a library reference.
- Teaching object orientation in modeling: Chapters 2–4, first part of Chapter 12.
- Introduction to mathematical equation representations, as well as numeric and symbolic techniques, Chapter 17–18.
- Modelica environments, with three example tools, Chapter 19.

An interactive computer-based self-teaching course material called DrModelica is available as electronic live notebooks. This material includes all the examples and exercises with solutions from the book, and is designed to be used in parallel when reading the book, with page references, etc.

The diagram below is yet another reading guideline, giving a combination of important language concepts together with modeling methodology and application examples of your choice. The selection is of necessity somewhat arbitrary – you should also take a look at the table of contents of other chapters and part of chapters so that you do not miss something important according to your own interest.



## Acknowledgements

The members of the Modelica Association created the Modelica language, and contributed have many examples of Modelica code in the *Modelica Language Rationale* and *Modelica Language Specification* (see <http://www.modelica.org>), some of which are used in this book. The members who contributed to various versions of Modelica are mentioned further below.

First, thanks to my wife, Anita, who has supported and endured me during this writing effort.

Very special thanks to Peter Bunus for help with model examples, some figures, MicroSoft Word formatting, and for many inspiring discussions. Without your help this project might have been too hard, especially considering the damage to my hands from too much typing on computer keyboards.

Many thanks to Hilding Elmqvist for sharing the vision about a declarative modeling language, for starting off the Modelica design effort by inviting people to form a design group, for serving as the first chairman of Modelica Association, and for enthusiasm and many design contributions including pushing for a unified class concept. Also thanks for inspiration regarding presentation material including finding historical examples of equations.

Many thanks to Martin Otter for serving as the second chairman of the Modelica Association, for enthusiasm and energy, design and Modelica library contributions, as well as inspiration regarding presentation material.

Many thanks to Eva-Lena Lengquist Sandelin and Susanna Monemar for help with the exercises, for help with preparing certain appendices, and for preparing the DrModelica interactive notebook teaching material which makes the examples in this book more accessible for interactive learning and experimentation.

Thanks to Peter Aronsson, Bernhard Bachmann, Peter Beater, Jan Brugård, Dag Brück, Brian Elmegaard, Hilding Elmqvist, Vadim Engelson, Rüdiger Franke, Dag Fritzon, Torkel Glad, Pavel Grozman, Daniel Hedberg, Andreas Idebrant, Mats Jirstrand, Olof Johansson, David Landén, Emma Larsdotter Nilsson, Håkan Lundvall, Sven-Erik Mattsson, Iakov Nakhimovski, Hans Olsson, Adrian Pop, Per Sahlin, Levon Saldamli, Hubertus Tummescheit, and Hans-Jürg Wiesmann for constructive comments, and in some cases other help, on parts of the book, and to Peter Bunus and Dan Costello for help in making MicroSoft Word more cooperative.

Thanks to Hans Olsson and Dag Brück, who edited several versions of the Modelica Specification, and to Michael Tiller for sharing my interest in programming tools and demonstrating that it is indeed possible to write a Modelica book.

Thanks to Bodil Mattsson-Kihlström for handling many administrative chores at the Programming Environment Laboratory while I have been focusing on book writing, to Ulf Nässén for inspiration and encouragement, and to Uwe Assmann for encouragement and sharing common experiences on the hard task of writing books.

Thanks to all members of PELAB and employees of MathCore Engineering, who have given comments and feedback.

Finally, thanks to the staff at Vårdnäs Stiftgård, who have provided a pleasant atmosphere for important parts of this writing effort.

A final note: approximately 95 per cent of the running text in this book has been entered by voice using Dragon Naturally Speaking. This is usually slower than typing, but still quite useful for a person like me, who has acquired RSI (Repetitive Strain Injury) due to too much typing. Fortunately, I can still do limited typing and drawing, e.g., for corrections, examples, and figures. All Modelica examples are hand-typed, but often with the help of others. All figures except the curve diagrams are, of course, hand drawn.

Linköping, September 2003

Peter Fritzon