

# Preface

This book describes a new tool for mathematical modeling: the Python Optimization Modeling Objects (Pyomo) software. Pyomo supports the formulation and analysis of mathematical models for complex optimization applications. This capability is commonly associated with algebraic modeling languages (AMLs), which support the description and analysis of mathematical models with a high-level language. Although most AMLs are implemented in custom modeling languages, Pyomo's modeling objects are embedded within Python, a full-featured high-level programming language that contains a rich set of supporting libraries.

Modeling is a fundamental process in many aspects of scientific research, engineering and business, and the widespread availability of computing resources has made the numerical analysis of mathematical models a commonplace activity. Furthermore, AMLs have emerged as a key capability for robustly formulating large models for complex, real-world applications [40]. AMLs simplify the process of formulating complex models by simplifying the management of sparse data and supporting the natural expression of model components. Additionally, AMLs like Pyomo support scripting with model objects which facilitates rapid development of new analysis tools.

## Goals of the Book

In this book, we provide an introduction to the Pyomo modeling software. A key goal of this book is to provide a comprehensive reference that will enable the user to develop optimization models with Pyomo. The book contains many example models, and the presentation of Pyomo's capabilities highlights different techniques that can be used to formulate models. The presentation in the book is roughly broken down into three parts:

1. Introduction - Introducing mathematical modeling and Pyomo, an overview of Pyomo's design, and an illustration of Pyomo with increasingly complex models.
2. Modeling Components - Detailed descriptions of the core modeling components that are supported by Pyomo.
3. Advanced Capabilities - Presentations of advanced features, including modeling of non-linear and stochastic programs, as well as high-level scripting with Python.

Another goal of this book is to illustrate the breadth of the modeling and analysis capabilities that are supported by Pyomo. Pyomo supports the formulation and analysis of common optimization models, including linear programs, mixed-integer linear programs, nonlinear programs, mixed-integer nonlinear programs and stochastic programs. Additionally, Pyomo includes solver interfaces for a variety of widely used optimization software packages, including CBC, CPLEX, GLPK, GUROBI, and PICO. Additionally, Pyomo can execute optimizers that employ the AMPL Solver Library interface.

Finally, this book provides the information needed to install and get started with Pyomo. Pyomo is a component of the Coopr software project. This book documents the capabilities of the Coopr 3.1 release, which includes version 3.0 of `coopr.pyomo`, which defines Pyomo. Appendix A describes installation options for Coopr. Coopr leverages a variety of third-party Python packages, and installation options described in the appendix include the installation of these auxiliary packages.

## Who Should Read This Book

This book is intended to be a reference for students, academic researchers and practitioners. The design of Pyomo is simple enough that it has been effectively used in the classroom with undergraduate and graduate students. However, we assume that the reader is generally familiar with optimization and mathematical modeling. Although this book does not contain a glossary, we recommend the Mathematical Programming Glossary [35] as a reference for the reader.

A goal of this book is to help users get started with Pyomo even if they have little knowledge of Python. Appendix B provides a quick introduction to Python, but we have been impressed with how well standard Python reference texts support new Pyomo users. Although Pyomo introduces Python objects and a process for applying

them, the expression of models with Pyomo strongly reflects Python's clean, concise syntax.

Note that our discussion of Pyomo's advanced modeling capabilities assumes some background in object-oriented design and features of the Python programming language. For example, our discussion of modeling components distinguishes between class definitions and class instances. Similarly, our discussion of Pyomo expressions requires a description of how operator overloading is used. We have not attempted to describe these advanced features of Python in the book. Thus, a user should expect to develop some familiarity with Python in order to effectively understand and use advanced modeling features.

Pyomo is also a valuable tool for academic researchers and practitioners. A key focus of Pyomo development has been on the ability to support the formulation and analysis of real-world applications. Pyomo supports our work with complex, real-world applications, so key issues like run-time performance and robust solver interfaces are a priority.

Additionally, we believe that researchers will find that CoopR provides an effective framework for developing high-level optimization and analysis tools. For example, Pyomo supports stochastic programming with extensions that are defined in CoopR's PySP package. PySP provides generic solvers for stochastic programming, and it leverages the fact that Pyomo's modeling objects are embedded within a full-featured high-level programming language. This allows for transparent parallelization of sub-problems using Python parallel communication libraries. This ability to support generic solvers for complex models is very powerful, and we believe that it can be used with many other optimization analysis techniques.

## Comments and Questions

Further information about Pyomo and Coopr is available on the Coopr wiki:

<https://software.sandia.gov/trac/coopr>

Coopr is also hosted at COIN-OR:

<https://projects.coin-or.org/Coopr>

We strongly encourage feedback from readers, either through direct communication with the authors or with the Coopr Forum:

[coopr-forum@googlegroups.com](mailto:coopr-forum@googlegroups.com)

We hope this will include feedback on typos and errors in our examples. Additionally, we welcome comments on the presentation of this material, and suggestions for material that we should develop in the other book chapters.

Good Luck!

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