
Sage Reference Manual

Release 9.3

The Sage Development Team

May 10, 2021

CONTENTS

1	User Interfaces	3
2	Graphics	5
3	Mathematics	7
3.1	Parents and Categories	7
3.2	Basic Rings and Fields	7
3.3	Linear Algebra	7
3.4	Calculus and Analysis	8
3.5	Probability and Statistics	8
3.6	Mathematical Structures	8
3.7	Discrete Mathematics	8
3.8	Geometry and Topology	9
3.9	Number Fields, Function Fields, and Valuations	9
3.10	Number Theory	9
3.11	Algebraic and Arithmetic Geometry	9
3.12	Miscellaneous	10
4	Programming	11
4.1	Facilities	11
4.2	Interfaces	11
5	General Information	13
6	Indices and Tables	15

Welcome to the Sage reference manual. Here you find documentation for all of Sage's features, illustrated with lots of examples. A thematic index follows.

This documentation is licensed under the [Creative Commons Attribution-Share Alike 3.0 License](#).

USER INTERFACES

- Command Line Interface
- Jupyter Notebook Interface

GRAPHICS

- 2D Graphics
- 3D Graphics

3.1 Parents and Categories

- Parents and Elements
- Coercion
- Categories

3.2 Basic Rings and Fields

- Integers and Rational Numbers
- Real and Complex Numbers
- Commutative Polynomials
- Power Series and Laurent Series
- Finite Rings and Fields
- p -adic Numbers
- Noncommutative Polynomials
- Quaternion Algebras

3.3 Linear Algebra

- Matrices and Spaces of Matrices
- Vectors and Modules
- Tensors on Free Modules of Finite Rank

3.4 Calculus and Analysis

- Symbolic Calculus
- Mathematical Constants
- Elementary and Special Functions
- Asymptotic Expansions
- Numerical Optimization

3.5 Probability and Statistics

- Probability
- Statistics
- Quantitative Finance

3.6 Mathematical Structures

- Sets
- Monoids
- Groups
- Semirings
- Rings
- Algebras

3.7 Discrete Mathematics

- Combinatorics
- Graph Theory
- Quivers
- Matroid Theory
- Discrete Dynamics
- Coding Theory
- Cryptography
- Game Theory
- Symbolic Logic
- SAT solvers

3.8 Geometry and Topology

- Euclidean Spaces and Vector Calculus
- Combinatorial and Discrete Geometry
- Cell Complexes and their Homology
- Manifolds and Differential Geometry
- Hyperbolic Geometry
- Parametrized Surfaces
- Knot Theory

3.9 Number Fields, Function Fields, and Valuations

- Number Fields
- Function Fields
- Discrete Valuations

3.10 Number Theory

- Diophantine approximation
- Quadratic Forms
- L -Functions
- Arithmetic Subgroups of $SL_2(\mathbb{Z})$
- General Hecke Algebras and Hecke Modules
- Modular Symbols
- Modular Forms
- Modular Forms for Hecke Triangle Groups
- Modular Abelian Varieties
- Miscellaneous Modular-Form-Related Modules

3.11 Algebraic and Arithmetic Geometry

- Schemes
- Plane and Space Curves
- Elliptic and Hyperelliptic Curves

3.12 Miscellaneous

- Databases
- Games

PROGRAMMING

4.1 Facilities

- Data Structures
- Utilities
- Test Framework
- Parallel Computing

4.2 Interfaces

- Interpreter Interfaces
- C/C++ Library Interfaces
- Python Technicalities

GENERAL INFORMATION

- External Packages (by type)
- External Packages (alphabetical)
- Bibliographic References
- History and License

INDICES AND TABLES

- `genindex`
- `modindex`
- `search`