

# SymPy Tutorial

Aaron Meurer, Ondřej Čertík, Amit Kumar, Jason Moore,  
Sartaj Singh, Harsh Gupta



July 11, 2016

All materials for today's tutorial are at  
<http://www.sympy.org/scipy-2016-tutorial/>

# Outline

## SymPy Introduction

- Goal
- Features
- History
- Present
- Future

## Tutorial

- Intro to SymPy and Basic features
- Solving real life problems

# SymPy Goal

## Goal

Provide a symbolic manipulation library in Python.

# SymPy Goal

## Goal

Provide a symbolic manipulation library in Python.

“SymPy is an open source Python library for symbolic mathematics. It aims to become a full-featured computer algebra system (CAS) while keeping the code as simple as possible in order to be comprehensible and easily extensible. SymPy is written entirely in Python and does not require any external libraries.”

# Why SymPy?

- Standalone
- Full featured
- BSD licensed
- Embraces Python
- Usable as a library

# Features

## ■ Core Capabilities

- Basic arithmetic: Support for operators such as  $+$ ,  $-$ ,  $*$ ,  $/$ ,  $**$  (power)
- Simplification
- Expansion
- Functions: trigonometric, hyperbolic, exponential, roots, logarithms, absolute value, spherical harmonics, factorials and gamma functions, zeta functions, polynomials, special functions, ...
- Substitution
- Numbers: arbitrary precision integers, rationals, and floats
- Noncommutative symbols
- Pattern matching

## ■ Polynomials

- Basic arithmetic: division, gcd, ...
- Factorization
- Square-free decomposition
- Gröbner bases
- Partial fraction decomposition
- Resultants

## ■ Calculus

- Limits:  $\lim_{x \rightarrow 0} x \log(x) = 0$
- Differentiation
- Integration: It uses extended Risch-Norman heuristic
- Taylor (Laurent) series

## ■ Solving equations

- Polynomial equations
- Algebraic equations
- Differential equations
- Difference equations
- Systems of equations

## ■ Combinatorics

- Permutations
- Combinations
- Partitions
- Subsets
- Permutation Groups: Polyhedral, Rubik, Symmetric, ...
- Prufer and Gray Codes

# Features

## ■ Discrete math

- ☐ Binomial coefficients
- ☐ Summations
- ☐ Products
- ☐ Number theory: generating prime numbers, primality testing, integer factorization, ...
- ☐ Logic expressions

## ■ Matrices

- ☐ Basic arithmetic
- ☐ Eigenvalues/eigenvectors
- ☐ Determinants
- ☐ Inversion
- ☐ Solving
- ☐ Abstract expressions

## ■ Geometric Algebra

## ■ Geometry

- ☐ points, lines, rays, segments, ellipses, circles, polygons, ...
- ☐ Intersection
- ☐ Tangency
- ☐ Similarity

## ■ Plotting

- ☐ Coordinate modes
- ☐ Plotting Geometric Entities
- ☐ 2D and 3D
- ☐ Interactive interface
- ☐ Colors

## ■ Physics

- ☐ Units
- ☐ Mechanics
- ☐ Quantum
- ☐ Gaussian Optics
- ☐ Pauli Algebra

## ■ Statistics

- ☐ Normal distributions
- ☐ Uniform distributions
- ☐ Probability

## ■ Printing

- ☐ Pretty printing: ASCII/Unicode pretty printing, LaTeX
- ☐ Code generation: C, Fortran, Python

# History

## History

- Ondřej Čertík started the project in 2006.
- Development took off in 2007 when SymPy first participated in Google Summer of Code. We have participated in every Google Summer of Code since.
- In 2011, Aaron Meurer (who also joined from Google Summer of Code) took over as lead developer.



# Present

## Current Status

- Over 450 contributors.
- Current code base has over 400,000 lines of code and documentation.
- We have crossed the point of “sympy a toy” to “sympy a tool”

# Future

## GSoC (1/2)

These are our current GSoC projects. Expect to see these features by the end of the summer.

- Group Theory, Gaurav Dhingra
- Extending solveset, Kshitij Saraogi
- Completing Solveset, Shekhar Prasad Rajak
- Implementation of Holonomic Functions, Shubham Tibra
- Implementation of Singularity Functions to solve Beam Bending problems, Sampad Kumar Saha

# Future

## GSoC (2/2)

These are our current GSoC projects. Expect to see these features by the end of the summer.

- Adding to SymEngine's Polynomial functionality and interfacing it with FLINT & Piranha Srajan Garg
- Implementing Finite Fields and Set module in SymEngine Nishant Nikhil

# Future

## Other Plans

- New assumptions
- Make things faster
- Implement more algorithms, so we can compute more things (and also make them faster)
- Make it easier for people to define custom behavior of their own objects in Add and Mul
- Encourage people to use SymPy for many applications
- <https://github.com/sympy/sympy/wiki/gsoc-2016-ideas> for full list of things we want done

# Authors

Chris Smith  
Aaron Meurer  
Mateusz Paprocki  
Ondřej Čertík  
Matthew Rocklin  
Julien Rioux  
Sergey B Kirpichev  
Raoul Bourquin  
Ronan Lamy  
Kirill Smelkov  
Øyvind Jensen  
Tom Bachmann  
Mario Pernici  
Sergiu Ivanov  
Saptarshi Mandal  
Thilina Rathnayake  
Stefan Krastanov  
Sean Vig  
David Li  
Rick Muller  
Brian E. Granger

Vinzent Steinberg  
Gilbert Gede  
Vladimir Perić  
Raymond Wong  
Sachin Joglekar  
Fredrik Johansson  
Fabian Pedregosa  
Bharath M R  
Timothy Reluga  
Addison Cugini  
Thomas Hisch  
Jason Moore  
Manoj Kumar  
Guru Devanla  
Alexey U.  
Gudchenko  
hm  
Priit Laes  
Prasoon Shukla  
Matt Habel  
Francesco Bonazzi

Alan Bromborsky  
Kundan Kumar  
Sudhanshu Mishra  
Tomo Lazovich  
Matt Curry  
Mary Clark  
Pablo Puente  
Jason Gedge  
Christopher Dembia  
Katja Sophie Hotz  
Aleksandar Makelov  
Ramana Venkata  
Brian Jorgensen  
Robert Johansson  
Kendhia  
Björn Dahlgren  
Joachim Durchholz  
Andy R. Terrel  
Grzegorz Świrski  
Sebastian Krämer  
Pearu Peterson

Anurag Sharma  
Toon Verstraelen  
Joan Creus  
Siddhanathan  
Shanmugam  
Cristóvão Sousa  
Jorn Baayen  
Christian Muişe  
Jeremias Yehdegheo  
Matthew Hoff  
Kevin Hunter  
Riccardo Gori  
Alexander Hirzel  
Steve Anton  
Sanket Agarwal  
rathmann  
Robert Schwarz  
David Ju  
Angadh Nanjangud  
Luke Peterson  
Sahil Shekhawat

Stephen Loo  
Harsh Gupta  
Yuriy Demidov  
Oliver Lee  
Comer Duncan  
Renato Coutinho  
Stepan Roucka  
Bilal Akhtar  
Miha Marolt  
Chetna Gupta  
Shipra Banga  
Randy Heydon  
Saurabh Jha  
Nathan Alison  
Niklas Thörne  
jerryma1121  
Sachin Irukula  
Sam Sleight

# Authors (continued)

Amit Saha  
Alkiviadis G. Akritas  
Akshay  
Brian Stephanik  
Robert Kern  
Angus Griffith  
Avichal Dayal  
Jim Crist  
Patrick Lacasse  
Swapnil Agarwal  
Gary Kerr  
Nicolas Pourcelot  
Natalia Nawara  
Mike Boyle  
Sherjil Ozair  
Huijun Mai  
Ljubiša Močić  
Prafullkumar P. Tale  
Jim Zhang  
Ankit Agrawal  
Marek Šuppa

Mark Shoulson  
Soumya Dipta  
Biswas  
Freddie Witherden  
Roberto Nobrega  
Felix Kaiser  
David Joyner  
Saroj Adhikari  
Sean Ge  
Zamrath Nizam  
Friedrich Hagedorn  
Jaroslaw Tworek  
Lennart Fricke  
Eric Nelson  
CJ Carey  
Aditya Shah  
Yuri Karadzhov  
Alexey Subach  
Rishabh Dixit  
Ryan Krauss  
Rajat Aggarwal

Christian Bühler  
Min Ragan-Kelley  
Ananya H  
Mark Dewing  
Raphael Michel  
Demian Wassermann  
Dammina  
Sahabandu  
Andreas Kloeckner  
Sam Magura  
carstimon  
Tim Swast  
Roland Puntaier  
Chancellor Arkantos  
Chris Wu  
Christophe  
Saint-Jean  
Davy Mao  
Tomasz Buchert  
Tobias Lenz  
Harold Erbin

richierichrawr  
Tarun Gaba  
Khagesh Patel  
Manish Gill  
Matthew Brett  
Nichita Utiu  
Piotr Korgul  
Stas Kelvich  
Varun Joshi  
shashank-agg  
Nimish Telang  
Stefano Maggiolo  
Óscar Nájera  
Chris Conley  
Sebastian Kreft  
Jochen Voss  
Stefen Yin  
Florian Mickler  
Tiffany Zhu  
Zeel Shah  
Tristan Hume

Ben Lucato  
Stefan van der Walt  
Pramod Ch  
Abderrahim Kitouni  
Alexandr Popov  
Rom le Clair  
David Roberts  
Imran Ahmed  
Manzoor  
Benjamin McDonald  
Barry Wardell  
Andrew Straw  
Luis Garcia  
Manoj Babu K.  
Luca Weihs  
Amit Jamadagni  
Shravas K Rao  
Martin Povišer  
Julio Idichkop Filho  
Ted Horst

# Authors (continued)

Jens H. Nielsen	Bradley Froehle	Oleksandr Gituliar	Or Dvory	Kaushik Varanasi
Raffaele De Feo	Colleen Lee	Oscar Benjamin	Nicholas J.S. Kinar	Stepan Simsa
Heiner Kirchhoffer	David Marek	Patrick Poitras	Max Hutchinson	Kaifeng Zhu
George Waksman	Dmitry Batkovich	Pavel Fedotov	Matthias Toews	Joseph Dougherty
Geoffry Song	Fernando Perez	Pradyumna	Seshagiri Prabhu	Jorge E. Cardona
Emma Hogan	Goutham	QuaBoo	Shai 'Deshe'	vishal
Edward	Lakshminarayan	Rajath S	Wyborski	Jonathan Miller
Tuomas Airaksinen	Henrik Johansson	Sai Nikhil	Matthew Tadd	Takafumi Arakaki
Akshit Agarwal	Henry Gebhardt	Sushant Hiray	Matt Rajca	Tarang Patel
Nikolay Lazarov	Jack McCaffery	Thomas Wiecki	Markus Müller	John Connor
Akshay Srinivasan	James Aspnes	Tomáš Bambas	Shruti Mangipudi	Johann
Venkatesh Halli	James Fiedler	tsmars15	Shukla	Cohen-Tanugi
Case Van Horsen	Jezreel Ng	Rizgar Mella	Marcin Kostrzewa	Jeremy
Buck Shlegeris	Juan Luis Cano	Sambuddha Basu	Siddhant Jain	James Pearson
Pan Peng	Rodríguez	Puneeth Chaganti	Madeleine Ball	James Goppert
Bill Flynn	Jurjen N.E. Bos	Prateek Papiwal	Srinivas Vasudevan	Thomas Sidoti
Thomas Dixon	Kalevi Suominen	Pierre Haessig	Lars Buitinck	Alexander
Arpit Goyal	Kunal Arora	Pauli Virtanen	Konrad Meyer	Eberspächer
Ashwini Oruganti	Maciej Baranski	Paul Strickland	Kibeom Kim	James Abbatiello
Ben Goodrich	Michael Mayorov	Paul Scott	Kevin Goodsell	Tim Lahey
Boris Timokhin	Nikhil Sarda	Sebastian Krause	Kazuo Thow	Hubert Tsang

# Authors (continued)

Gregory Ksionda  
Gert-Ludwig Ingold  
Fawaz Alazemi  
Faisal Anees  
Erik Welch  
Abhinav Chanda  
Elrond der  
Elbenfuerst

Eh Tan  
Dhruvesh Vijay  
Parikh  
Tyler Pirtle  
David Lawrence  
Vasily Povalyaev  
Christian Schubert  
Vinay Kumar

Vinit Ravishankar  
Carsten Knoll  
Vlad Seghete  
Vladimir Lagunov  
Bernhard R. Link  
Benjamin Gudehus  
Benjamin Fishbein  
Bastian Weber

Andrew Docherty  
Andrej Tokarčík  
Andre de Fortier  
Smit  
Anatolii Koval  
marshall2389  
Ambar Mehrotra  
Ali Raza Syed

sevaader  
Alexandr Gudulin  
Roberto Colistete,  
Jr.  
Robert Cimrman  
Robert  
Łukasz Pankowski  
Ralph Bean



# Here at SciPy

## Talks

- Jason Moore, *Multibody Dynamics and Control with Python* (Tutorial).  
Monday 8:00 AM - 12:00 PM - Rm 105
- Matthew Rocklin, *Taking Control - Enabling Mathematicians and Scientists*.  
Tuesday 2:15 PM - 2:45 PM - Grand Ballroom
- Matthew Rocklin, *Blaze: Building a Foundation for Array-Oriented Computing in Python*.  
Thursday 11:15 - 11:45 - Rm 204
- Aaron Meurer, *Conda: a Cross-Platform Package Manager for Any Binary Distribution*.  
Wednesday 11:45 AM - 12:15 PM - Rm 204

# Here at SciPy

## BoF

- SymPy BoF - Wednesday 5:30 PM - 6:30 PM - Rm 203

## Sprints

Come sprint with us!

- Releasing SymPy 0.7.6
- Assumptions
- Whatever interests you
- Lot's of tasks that are easy for new contributors
- Friday and Saturday

Let's begin!