



# Numerically Solving Polynomial Systems with Bertini (Software, Environments and Tools)

*Daniel J. Bates, Jonathan D. Haunstein, Andrew J. Sommese, Charles W. Wampler*

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This book is a guide to concepts and practice in numerical algebraic geometry - the solution of systems of polynomial equations by numerical methods. The authors show how to apply the well-received and widely used open-source Bertini software package to compute solutions, including a detailed manual on syntax and usage options. The authors also maintain a complementary webpage where readers can find supplementary materials and Bertini input files.

*Numerically Solving Polynomial Systems with Bertini* approaches numerical algebraic geometry from a user's point of view with numerous examples of how Bertini is applicable to polynomial systems. It treats the fundamental task of solving a given polynomial system and describes the latest advances in the field, including algorithms for intersecting and projecting algebraic sets, methods for treating singular sets, the nascent field of real numerical algebraic geometry, and applications to large polynomial systems arising from differential equations.

Those who wish to solve polynomial systems can start gently by finding isolated solutions to small systems, advance rapidly to using algorithms for finding positive-dimensional solution sets (curves, surfaces, etc.), and learn how to use parallel computers on large problems. These techniques are of interest to engineers and scientists in fields where polynomial equations arise, including robotics, control theory, economics, physics, numerical PDEs, and computational chemistry.

**Audience:** The book is designed to serve the following audiences: scientists and engineers needing to quickly solve systems of polynomial equations to find all the isolated roots or, if desired, to find all the solution components of any dimension; engineers or scientists and senior undergraduate or beginning graduate students with a computational focus who have a knowledge of calculus, linear algebra, and undergraduate-level ODEs; and those with a more mathematical bent who wish to explore the underpinnings of the methods, delve into more technical details, and read descriptions of the latest developments.

**Contents:** List of Figures; Conventions; Preface; Part I: Isolated Systems; Chapter 1: Polynomial Systems; Chapter 2: Basic Polynomial Continuation; Chapter 3: Adaptive Precision and Endgames; Chapter 4: Projective Space; Chapter 5: Types of Homotopies; Chapter 6: Parameter Homotopies; Chapter 7: Advanced Topics about Isolated Solutions; Part II: Positive-Dimensional Solution Sets; Chapter 8: Positive-Dimensional Components; Chapter 9: Computing Witness Supersets; Chapter 10: The Numerical Irreducible Decomposition; Chapter 11: Advanced Topics about Positive-Dimensional Solution Sets; Part III: Further Algorithms and Applications; Chapter 12: Intersection; Chapter 13: Singular Sets; Chapter 14: Real Solutions; Chapter 15: Applications to Algebraic Geometry; Chapter 16: Projections of Algebraic Sets; Chapter 17: Big Polynomial Systems Arising from Differential Equations; Part IV: Bertini Users Manual; Appendix A: Bertini Quick Start Guide; Appendix B: Input Format; Appendix C: Calling Options; Appendix D: Output Files; Appendix E: Configuration Settings; Appendix F: Tips and Tricks; Appendix G: Parallel Computing; Appendix H: Related Software; Bibliography; Software Index; Subject Index.

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