# Matrix Lie Groups And Lie Groups Michigan State University

**In this new textbook, acclaimed author John Stillwell presents a lucid introduction to Lie theory suitable for junior and senior level undergraduates. In order to achieve this, he focuses on the so-called "classical groups'' that capture the symmetries of real, complex, and quaternion spaces. These symmetry groups may be represented by matrices, which allows them to be studied by elementary methods from calculus and linear algebra. This naive approach to Lie theory is originally due to von Neumann, and it is now possible to streamline it by using standard results of undergraduate mathematics. To compensate for the limitations of the naive approach, end of chapter discussions introduce important results beyond those proved in the book, as part of an informal sketch of Lie theory and its history. John Stillwell is Professor of Mathematics at the University of San Francisco. He is the author of several highly regarded books published by Springer, including The Four Pillars of Geometry (2005), Elements of Number Theory (2003), Mathematics and Its History (Second Edition, 2002), Numbers and Geometry (1998) and Elements of Algebra (1994).**

**This self-contained text is an excellent introduction to Lie groups and their actions on manifolds. The authors start with an elementary discussion of matrix groups, followed by chapters devoted to the basic structure and representation theory of finite dimensinal Lie algebras. They then turn to global issues, demonstrating the key issue of the interplay between differential geometry and Lie theory. Special emphasis is placed on homogeneous spaces and invariant geometric structures. The last section of the book is dedicated to the structure theory of Lie groups. Particularly, they focus on maximal compact subgroups, dense subgroups, complex structures, and linearity. This text is accessible to a broad range of mathematicians and graduate students; it will be useful both as a graduate textbook and as a research reference.**

**This book has grown out of a set of lecture notes I had prepared for a course on Lie groups in 1966. When I lectured again on the subject in 1972, I revised the notes substantially. It is the revised version that is now appearing in book form. The theory of Lie groups plays a fundamental role in many areas of mathematics. There are a number of books on the subject currently available -most notably those of Chevalley, Jacobson, and Bourbaki-which present various aspects of the theory in great depth. However, 1 feei there is a need for a single book in English which develops both the algebraic and analytic**

**aspects of the theory and which goes into the representation theory of semi simple Lie groups and Lie algebras in detail. This book is an attempt to fiii this need. It is my hope that this book will introduce the aspiring graduate student as well as the nonspecialist mathematician to the fundamental themes of the subject. I have made no attempt to discuss infinite-dimensional representations. This is a very active field, and a proper treatment of it would require another volume (if not more) of this size. However, the reader who wants to take up this theory will find that this book prepares him reasonably well for that task.**

**This book is an introduction to semisimple Lie algebras; concise and informal, with numerous exercises and examples.**

**An Introduction Through Linear Groups**

**An Introduction for Physicists, Engineers and Chemists**

**Structure and Geometry of Lie Groups**

**Lie Groups**

**An Introduction to Lie Group Theory**

This book offers a first taste of the theory of Lie groups, focusing mainly on matrix groups: closed subgroups of real and complex general linear groups. The first part studies examples and describes classical families of simply connected compact groups. The second section introduces the idea of a lie group and explores the associated notion of a homogeneous space using orbits of smooth actions. The emphasis throughout is on accessibility.

This book reproduces J-P. Serre's 1964 Harvard lectures. The aim is to introduce the reader to the "Lie dictionary": Lie algebras and Lie groups. Special features of the presentation are its emphasis on formal groups (in the Lie group part) and the use of analytic manifolds on p-adic fields. Some knowledge of algebra and calculus is required of the reader, but the text is easily accessible to graduate students, and to mathematician at large.

This book is intended as an introductory text on the subject of Lie groups and algebras and their role in various fields of mathematics and physics. It is written by and for researchers who are primarily analysts or physicists, not algebraists or geometers. Not that we have eschewed the algebraic and geo metric developments. But we wanted to present them in a concrete way and to show how the subject interacted with physics, geometry, and mechanics. These interactions are, of course, manifold; we have discusse many of them here-in particular, Riemannian geometry, elementary particle physics, sym metries of differential equations, completely integrable Hamiltonian systems, and spontaneous symmetry breaking. Much ofthe material we have treated is standard and widely available; but we have tried to steer a course between the descriptive approach such as found in Gilmore and Wybourne, and the abstract mathematical approach of Helgason or Jacobson. Gilmore and Wybourne address themselves to the physics community whereas Helgason and Jacobson address themselves to the mathematical community. This book is an attempt to synthesize the two points of view and address both audiences simultaneously. We wanted to present the subject in a way which is at once intuitive, geometric, applications oriented, mathematically rigorous, and accessible to students and researchers without an extensive background in physics, algebra, or geometry.

Describing many of the most important aspects of Lie group theory, this book presents the subject in a 'hands on' way. Rather than concentrating on theorems and proofs, the book shows the applications of the material to physical sciences and applied mathematics. Many examples of Lie groups and Lie algebras are given throughout the text. The relation between Lie group theory and algorithms for solving ordinary differential equations is presented and shown to be analogous to the relation between Galois groups and algorithms for solving polynomial equations. Other chapters are devoted to differential geometry, relativity, electrodynamics, and the hydrogen atom. Problems are given at the end of each chapter so readers can monitor their understanding of the materials. This is a fascinating introduction to Lie groups for graduate and undergraduate students in physics, mathematics and electrical engineering as well as researchers in these fields.

Differential Geometry and Lie Groups

Lie Groups, Lie Algebras, and Representations

Lie Groups Beyond an Introduction

Theory Of Groups And Symmetries: Finite Groups, Lie Groups, And Lie Algebras

Matrix Lie Groups & Their Corresponding Lie Algebras

*This book is based on the notes of the authors' seminar on algebraic and Lie groups held at the Department of Mechanics and Mathematics of Moscow University in 1967/68. Our guiding idea was to present in the most economic way the theory of semisimple Lie groups on the basis of the theory of algebraic groups. Our main sources were A. Borel's paper [34], C. ChevalIey's seminar [14], seminar "Sophus Lie" [15] and monographs by C. Chevalley [4], N. Jacobson [9] and J-P. Serre [16, 17]. In preparing this book we have completely rearranged these notes and added two new chapters: "Lie groups" and "Real semisimple Lie groups". Several traditional topics of Lie algebra theory, however, are left entirely disregarded, e.g. universal enveloping algebras, characters of linear representations and (co)homology of Lie algebras. A distinctive feature of this book is that almost all the material is presented as a sequence of problems, as it had been in the first draft of the seminar's notes. We believe that solving these problems may help the reader to feel the seminar's atmosphere and master the theory. Nevertheless, all the non-trivial ideas, and sometimes solutions, are contained in hints given at the end of each section. The proofs of certain theorems, which we consider more difficult, are given directly in the main text. The book also contains exercises, the majority of which are an essential complement to the main contents.*

*This book starts with the elementary theory of Lie groups of matrices and arrives at the definition, elementary properties, and first applications of cohomological induction, which is a recently discovered algebraic* *construction of group representations. Along the way it develops the computational techniques that are so important in handling Lie groups. The book is based on a one-semester course given at the State University of New York, Stony Brook in fall, 1986 to an audience having little or no background in Lie groups but interested in seeing connections among algebra, geometry, and Lie theory. These notes develop what is needed beyond a first graduate course in algebra in order to appreciate cohomological induction and to see its first consequences. Along the way one is able to study homological algebra with a significant application in mind; consequently one sees just what results in that subject are fundamental and what results are minor.*

*The book presents the main approaches in study of algebraic structures of symmetries in models of theoretical and mathematical physics, namely groups and Lie algebras and their deformations. It covers the commonly encountered quantum groups (including Yangians). The second main goal of the book is to present a differential geometry of coset spaces that is actively used in investigations of models of quantum field theory, gravity and statistical physics. The third goal is to explain the main ideas about the theory of conformal symmetries, which is the basis of the AdS/CFT correspondence. The theory of groups and symmetries is an important part of theoretical physics. In elementary particle physics, cosmology and related fields, the key role is played by Lie groups and algebras corresponding to continuous symmetries. For example, relativistic physics is based on the Lorentz and Poincare groups, and the modern theory of elementary particles — the Standard Model — is based on gauge (local) symmetry with the gauge group SU(3) x SU(2) x U(1). This book presents constructions and results of a general nature, along with numerous concrete examples that have direct applications in modern theoretical and mathematical physics. Contents: Preface Groups and Transformations Lie Groups Lie Algebras Representations of Groups and Lie Algebras Compact Lie Algebras Root Systems and Classification of Simple Lie Algebras Homogeneous Spaces and their Geometry Solutions to Selected Problems Selected Bibliography References Index Readership: Graduate students and researchers in theoretical physics and mathematical physics. Keywords: Lie Groups;Lie Algebras;Representation Theory;Conformal Symmetries;Yangians;Coset Spaces;Differential Geometry;Casimir Operators;Root Systems;AdS Spaces;Lobachevskian GeometryReview:0*

*From the reviews of the French edition: "This is a rich and useful volume. The material it treats has relevance well beyond the theory of Lie groups and algebras, ranging from the geometry of regular polytopes and paving problems to current work on finite simple groups having a (B,N)-pair structure, or 'Tits systems'". --G.B. Seligman in MathReviews.*

*Lie Algebras In Particle Physics*

*Matrix Groups for Undergraduates*

*Theory of Lie Groups*

*1964 Lectures Given at Harvard University*
*Introduction to Lie Algebras*

**This textbook offers an introduction to differential geometry designed for readers interested in modern geometry processing. Working from basic undergraduate prerequisites, the authors develop manifold theory and Lie groups from scratch; fundamental topics in Riemannian geometry follow, culminating in the theory that underpins manifold optimization techniques. Students and professionals working in computer vision, robotics, and machine learning will appreciate this pathway into the mathematical concepts behind many modern applications. Starting with the matrix exponential, the text begins with an introduction to Lie groups and group actions. Manifolds, tangent spaces, and cotangent spaces follow; a chapter on the construction of manifolds from gluing data is particularly relevant to the reconstruction of surfaces from 3D meshes. Vector fields and basic point-set topology bridge into the second part of the book, which focuses on Riemannian geometry. Chapters on Riemannian manifolds encompass Riemannian metrics, geodesics, and curvature. Topics that follow include submersions, curvature on Lie groups, and the Log-Euclidean framework. The final chapter highlights naturally reductive homogeneous manifolds and symmetric spaces, revealing the machinery needed to generalize important optimization techniques to Riemannian manifolds. Exercises are included throughout, along with optional sections that delve into more theoretical topics. Differential Geometry and Lie Groups: A Computational Perspective offers a uniquely accessible perspective on differential geometry for those interested in the theory behind modern computing applications. Equally suited to classroom use or independent study, the text will appeal to students and professionals alike; only a background in calculus and linear algebra is assumed. Readers looking to continue on to more advanced topics will appreciate the authors' companion volume Differential Geometry and Lie Groups: A Second Course.**

**This textbook treats Lie groups, Lie algebras and their representations in an elementary but fully rigorous fashion requiring minimal prerequisites. In particular, the theory of matrix Lie groups and their Lie algebras is developed using only linear algebra, and more motivation and intuition for proofs is provided than in most classic texts on the subject. In addition to its accessible treatment of the basic theory of Lie groups and Lie algebras, the book is also noteworthy for including: a treatment of the Baker–Campbell–Hausdorff formula and its use in place of the Frobenius theorem to establish deeper results about the relationship between Lie groups and Lie algebras motivation for the machinery of roots, weights and the Weyl group via a concrete and detailed exposition of the representation theory of sl(3;C) an unconventional definition of semisimplicity that allows for a rapid development of the structure theory of semisimple Lie algebras a self-contained construction of the representations of compact groups, independent of Lie-algebraic arguments The second edition of Lie Groups, Lie Algebras, and Representations contains many substantial improvements and additions, among them: an entirely new part devoted to the structure and representation theory of compact Lie groups; a complete derivation of the main properties of root systems; the construction of finite-dimensional representations of semisimple Lie algebras has been elaborated; a treatment of universal enveloping algebras, including a proof of the Poincaré–Birkhoff–Witt theorem and the existence of Verma modules; complete proofs of the Weyl character formula, the Weyl dimension formula and the Kostant multiplicity formula. Review of the first edition: This is an excellent book. It deserves to, and undoubtedly will, become the standard text for early graduate courses in Lie group theory ... an important addition to the textbook literature ... it is highly recommended. — The Mathematical Gazette**

**This new in paperback edition provides a clear introduction to the theory of Lie groups and their representations for advanced undergraduates and graduate students in mathematics. Starting from basic undergraduate level mathematics, the text proceeds through the fundamentals of Lie theory up to topics in representation theory.**

**There exist two correspondences between groups and Lie algebras. One occurs between matrix Lie groups and Lie algebras. The other concerns itself with complete groups of unitriangular matrices and Lie algebras. Titled the Lie and Mal'cev correspondences respectively, the purpose of this paper is to explore the two. We begin with an introduction to the basic properties of Lie algebras and other preliminary material followed by a construction of free Lie rings and algebras as well as by other interesting material discovered along the way. We then dive into the Lie correspondence, with which we contrast the Mal'cev correspondence in the section after.**

**Chapters 4-6**

**Second Edition**

**Naive Lie Theory**

**An Introduction to Lie Groups and Lie Algebras**

**Notes on Lie Algebras**

***"[Lectures in Lie Groups] fulfills its aim admirably and should be a useful reference for any mathematician who would like to learn the basic results for compact Lie groups. . . . The book is a well written basic text [and Adams] has done a service to the mathematical community."—Irving Kaplansky***

***This book is intended to serve as a textbook for a one-semester course for M.Sc/M.Phil. Students at Indian universities. Students of theoretical physics will also find this exposition useful. The general theory of Lie groups appears formidable to an M.Sc./M.Phil. student.***

***Designed to acquaint students of particle physics already familiar with SU(2) and SU(3) with techniques applicable to all simple Lie algebras, this text is especially suited to the study of grand unification theories. 1984 edition.***

***In this reprint edition, the character of the book, especially its focus on classical representation theory and its computational aspects, has not been changed***

***Lectures on Lie Groups***

***Lie Groups and Lie Algebras - A Physicist's Perspective***

***Lie Groups, Lie Algebras, and Their Representations***

***Matrix Groups and Lie Algebras***

***Problems and Solutions for Groups, Lie Groups, Lie Algebras with Applications***

This book is intended for a one-year graduate course on Lie groups and Lie algebras. The book goes beyond the representation theory of compact Lie groups, which is the basis of many texts, and provides a carefully chosen range of material to give the student the bigger picture. The book is organized to allow different paths through the material depending on one's interests. This second edition has substantial new material, including improved discussions of underlying principles, streamlining of some proofs, and many results and topics that were not in the first edition. For compact Lie groups, the book covers the Peter–Weyl theorem, Lie algebra, conjugacy of maximal tori, the Weyl group, roots and weights, Weyl character formula, the fundamental group and more. The book continues with the study of complex analytic groups and general noncompact Lie groups, covering the Bruhat decomposition, Coxeter groups, flag varieties, symmetric spaces, Satake diagrams, embeddings of Lie groups and spin. Other topics that are treated are symmetric function theory, the representation theory of the symmetric group, Frobenius–Schur duality and GL(n) × GL(m) duality with many applications including some in random matrix theory, branching rules, Toeplitz determinants, combinatorics of tableaux, Gelfand pairs, Hecke algebras, the "philosophy of cusp forms" and the cohomology of Grassmannians. An appendix introduces the reader to the use of Sage mathematical software for Lie group computations.

This two-volume set covers stochastic processes, information theory and Lie groups in a unified setting, bridging topics rarely studied together. The emphasis is on using stochastic, geometric, and group-theoretic concepts for modeling physical phenomena.

Lie groups has been an increasing area of focus and rich research since the middle of the 20th century. In Lie Groups: An Approach through Invariants and Representations, the author's masterful approach gives the reader a comprehensive treatment of the classical Lie groups along with an extensive introduction to a wide range of topics associated with Lie groups: symmetric functions, theory of algebraic forms, Lie algebras, tensor algebra and symmetry, semisimple Lie algebras, algebraic groups, group representations, invariants, Hilbert theory, and binary forms with fields ranging from pure algebra to functional analysis. By covering sufficient background material, the book is made accessible to a reader with a relatively modest mathematical background. Historical information, examples, exercises are all woven into the text. This unique exposition is suitable for a broad audience, including advanced undergraduates, graduates, mathematicians in a variety of areas from pure algebra to functional analysis and mathematical physics.

The subject of Lie groups is one that slips by many a mathematician. Many claim that the topic is not accessible to undergraduate research. The book Lie Groups by Harriet Pollatsek came out a few years ago, and it was meant to be a new way to be introduced to the topic. However, the book does not quite get far enough to give a formal definition of a Lie group. The goal of this project is to "bridge the gap." The objective of this thesis is to include all the introductory material required to get to where the definition of a Lie group is no longer something so complicated. We will illustrate the major concepts by examples. Many matrix groups are Lie groups. Matrix groups are well-known, and they are an ideal place to start learning about what a Lie group can do. We then look at tangent spaces of the matrix groups, or the Lie algebra that is associated with each Lie group. After some motivation behind Lie algebras, we finally get to the feature presentation: a group and a differentiable manifold, put together into one super structure known as a Lie group.

An Approach through Invariants and Representations
An Elementary Introduction
Stochastic Models, Information Theory, and Lie Groups, Volume 2
Lie Groups, Lie Algebras, and Some of Their Applications
Introduction to Lie Algebras and Representation Theory

*Lie Groups Beyond an Introduction takes the reader from the end of introductory Lie group theory to the threshold of infinite-dimensional group representations. Merging algebra and analysis throughout, the author uses Lie-theoretic methods to develop a beautiful theory having wide applications in mathematics and physics. A feature of the presentation is that it encourages the reader's comprehension of Lie group theory to evolve from beginner to expert: initial insights make use of actual matrices, while later insights come from such structural features as properties of root systems, or relationships among subgroups, or patterns among different subgroups.*

*This book is designed to introduce the reader to the theory of semisimple Lie algebras over an algebraically closed field of characteristic 0, with emphasis on representations. A good knowledge of linear algebra (including eigenvalues, bilinear forms, euclidean spaces, and tensor products of vector spaces) is presupposed, as well as some acquaintance with the methods of abstract algebra. The first four chapters might well be read by a bright undergraduate; however, the remaining three chapters are admittedly a little more demanding. Besides being useful in many parts of mathematics and physics, the theory of semisimple Lie algebras is inherently attractive, combining as it does a certain amount of depth and a satisfying degree of completeness in its basic results. Since Jacobson's book appeared a decade ago, improvements have been made even in the classical parts of the theory. I have tried to incor porate some of them here and to provide easier access to the subject for non-specialists. For the specialist, the following features should be noted: (I) The Jordan-Chevalley decomposition of linear transformations is emphasized, with "toral" subalgebras replacing the more traditional Cartan subalgebras in the semisimple case. (2) The conjugacy theorem for Cartan subalgebras is proved (following D. J. Winter and G. D. Mostow) by elementary Lie algebra methods, avoiding the use of algebraic geometry.*

*Howard Georgi is the co-inventor (with Sheldon Glashow) of the SU(5) theory. This extensively revised and updated edition of his classic text makes the theory of Lie groups accessible to graduate students, while offering a perspective on the way in which knowledge of such groups can provide an insight into the development of unified theories of strong, weak, and electromagnetic interactions.*

*Blending algebra, analysis, and topology, the study of compact Lie groups is one of the most beautiful areas of mathematics and a key stepping stone to the theory of general Lie groups. Assuming no prior knowledge of Lie groups, this book covers the structure and representation theory of compact Lie groups. Coverage includes the construction of the Spin groups, Schur Orthogonality, the Peter-Weyl*

*Theorem, the Plancherel Theorem, the Maximal Torus Theorem, the Commutator Theorem, the Weyl Integration and Character Formulas, the Highest Weight Classification, and the Borel-Weil Theorem. The book develops the necessary Lie algebra theory with a streamlined approach focusing on linear Lie groups.*

*A First Course on Representation Theory and Linear Lie Groups*

*Lie Groups and Algebras with Applications to Physics, Geometry, and Mechanics*

*Analytic Methods and Modern Applications*

*Compact Lie Groups*

*Lie Algebras and Lie Groups*

***This book addresses Lie groups, Lie algebras, and representation theory. The author restricts attention to matrix Lie groups and Lie algebras. This approach keeps the discussion concrete, allows the reader to get to the heart of the subject quickly, and covers all of the most interesting examples.From the reviews:"Sure to become a standard textbook for graduate students in mathematics and physics with little or no prior exposure to Lie theory." --L'Enseignement Mathematique***

***The standard text on the subject for many years, this introductory treatment covers classical linear groups, topological groups, manifolds, analytic groups, differential calculus of Cartan, and compact Lie groups and their representations. 1946 edition.***

***The book presents examples of important techniques and theorems for Groups, Lie groups and Lie algebras. This allows the reader to gain understandings and insights through practice. Applications of these topics in physics and engineering are also provided. The book is self-contained. Each chapter gives an introduction to the topic.***

***Lie groups and Lie algebras have become essential to many parts of mathematics and theoretical physics, with Lie algebras a central object of interest in their own right. This book provides an elementary introduction to Lie algebras based on a lecture course given to fourth-year undergraduates. The only prerequisite is some linear algebra and an appendix summarizes the main facts that are needed. The treatment is kept as simple as possible with no attempt at full generality. Numerous worked examples and exercises are provided to test understanding, along with more demanding problems, several of which have solutions. Introduction to Lie Algebras covers the core material required for almost all other work in Lie theory and provides a self-study guide suitable for undergraduate students in their final year and graduate students and researchers in mathematics and theoretical physics.***

***Lie Groups, Lie Algebras, and Cohomology***

***A Computational Perspective***

***Semi-Simple Lie Algebras and Their Representations***

***from Isospin To Unified Theories***

***Lie Groups, Physics, and Geometry***

This (post) graduate text gives a broad introduction to Lie groups and algebras with an emphasis on differential geometrical methods. It analyzes the structure of compact Lie groups in terms of the action of the group on itself by conjugation, culminating in the classification of the representations of compact Lie groups and their realization as sections of holomorphic line bundles over flag manifolds. Appendices provide background reviews.

This textbook is a complete introduction to Lie groups for undergraduate students. The only prerequisites are multi-variable calculus and linear algebra. The emphasis is placed on the algebraic ideas, with just enough analysis to define the tangent space and the differential and to make sense of the exponential map. This textbook works on the principle that students learn best when they are actively engaged. To this end nearly 200 problems are included in the text, ranging from the routine to the challenging level. Every chapter has a section called 'Putting the pieces together' in which all definitions and results are collected for reference and further reading is suggested.

This text introduces upper-level undergraduates to Lie group theory and physical applications. It further illustrates Lie group theory's role in several fields of physics. 1974 edition. Includes 75 figures and 17 tables, exercises and problems.

(Cartan sub Lie algebra, roots, Weyl group, Dynkin diagram, . . . ) and the classification, as found by Killing and Cartan (the list of all semisimple Lie algebras consists of (1) the special- linear ones, i. e. all matrices (of any fixed dimension) with trace 0, (2) the orthogonal ones, i. e. all skewsymmetric ma trices (of any fixed dimension), (3) the symplectic ones, i. e. all matrices M (of any fixed even dimension) that satisfy M J = - J MT with a certain non-degenerate skewsymmetric matrix J, and (4) five special Lie algebras G2, F , E , E , E , of dimensions 14,52,78,133,248, the "exceptional Lie 4 6 7 s algebras" , that just somehow appear in the process). There is also a discus sion of the compact form and other real forms of a (complex) semisimple Lie algebra, and a section on automorphisms. The third chapter brings the theory of the finite dimensional representations of a semisimple Lie alge bra, with the highest or extreme weight as central notion. The proof for the existence of representations is an ad hoc version of the present standard proof, but avoids explicit use of the Poincare-Birkhoff-Witt theorem. Complete reducibility is proved, as usual, with J. H. C. Whitehead's proof (the first proof, by H. Weyl, was analytical-topological and used the exis tence of a compact form of the group in question). Then come H.

Lie Groups and Algebraic Groups

A Survey of Lie Groups and Lie Algebra with Applications and Computational Methods

Lie Groups And Lie Algebras For Physicists

A Problem Oriented Introduction Via Matrix Groups

Matrix Groups

**This book is intended for graduate students in Physics, especially Elementary Particle Physics. It gives an introduction to group theory for physicists with a focus on Lie groups and Lie algebras.**

**The book is intended for graduate students of theoretical physics (with a background in quantum mechanics) as well as researchers interested in applications of Lie group theory and Lie algebras in physics. The emphasis is on the inter-relations of representation theories of Lie groups and the corresponding Lie algebras.**

**Matrix groups touch an enormous spectrum of the mathematical arena. This textbook brings them into the undergraduate curriculum. It makes an excellent one-semester course for students familiar with linear and abstract algebra and prepares them for a graduate course on Lie groups. Matrix Groups for Undergraduates is concrete and example-driven, with geometric motivation and rigorous proofs. The story begins and**

**ends with the rotations of a globe. In between, the author combines rigor and intuition to describe the basic objects of Lie theory: Lie algebras, matrix exponentiation, Lie brackets, maximal tori, homogeneous spaces, and roots. This second edition includes two new chapters that allow for an easier transition to the general theory of Lie groups.**

**Lie Groups and Lie Algebras**

**An Algebraic Treatment**