

Chapter 1

The Foundations of Geometry

1.1. The axiomatic method

Perhaps the most significant contribution to the foundations of mathematics made by the ancient Greeks was the axiomatic method and the notion of proof. The idea is this: there are a number of fundamental mathematical truths, called axioms or postulates, from which other true statements may be derived in a finite number of steps. The mathematical statements that can be proved are called theorems.

An axiomatic system is a list of primitive (undefined) notions together with a list of statements (called "axioms") that are presupposed to be "true." A theorem is any statement that can be proved using logical deduction from the axioms. Generally, a mathematical theory that is generated by the axiomatic method includes:

- *Primitive notions:* A primitive notion is an undefined concept. It is not defined in terms of previously defined concepts. In a formal theory, primitive notions usually include primitive terms and primitive relations.
- *System of axioms:* A set of propositions that are taken to be true (axioms). These axioms describe the nature and properties of the primitive notions.
- *Derived notions and theorems:* A derived notion is a concept defined by previous notions. A theorem is a statement that has been proved based on previously established statements, such as other theorems, and generally accepted statements, such as axioms.

For example, the primitive notions of Hilbert's axiom system for Euclidean Geometry are:

- Primitive terms: point, straight line, plane
- Primitive relations: *Lies on* (Incidence, containment), *betweenness*, and *congruence*.

Here are some of Hilbert's axioms:

- Axiom I.1: Two given points always determine a straight line.

Foundations Of Mathematics Chapter 1 Foundations Of Geometry

C. K. Raju



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Fundamental Concepts of Geometry Bruce E. Meserve, 2014-12-08 Demonstrates relationships between different types of geometry Provides excellent overview of the foundations and historical evolution of geometrical concepts Exercises no solutions Includes 98 illustrations Cultural Foundations of Mathematics C. K. Raju, 2007 The Volume Examines In Depth The Implications Of Indian History And Philosophy For Contemporary Mathematics And Science The Conclusions Challenge Current Formal Mathematics And Its Basis In The Western Dogma That Deduction Is Infallible Or That It Is Less Fallible Than Induction The Development Of The Calculus In India Over A Thousand Years Is Exhaustively Documented In This Volume Along With Novel Insights And Is Related To The Key Sources Of Wealth Monsoon Dependent Agriculture And Navigation Required For Overseas Trade And The Corresponding Requirement Of Timekeeping Reflecting The Usual Double Standard Of Evidence Used To Construct Eurocentric History A Single New Standard Of Evidence For Transmissions Is Proposed Using This It Is Pointed Out That Jesuits In Cochin Following The Toledo Model Of Translation Had Long Term Opportunity To Transmit Indian Calculus Texts To Europe The European Navigational Problem Of Determining Latitude Longitude And Loxodromes And The 1582 Gregorian Calendar Reform Provided Ample Motivation The Mathematics In These Earlier Indian Texts Suddenly Starts Appearing In European Works From The Mid 16Th Century Onwards Providing Compelling Circumstantial Evidence While The Calculus In India Had Valid Pramana This Differed From Western Notions Of Proof And The Indian Algorismus Notion Of Number Differed From The European Abacus Notion Hence Like Their Earlier Difficulties With The Algorismus Europeans Had Difficulties In Understanding The Calculus Which Like Computer Technology Enhanced The Ability To Calculate Albeit In A Way Regarded As Epistemologically Insecure Present Day Difficulties In Learning Mathematics Are Related Via Phylogeny Is Ontogeny To These Historical Difficulties In Assimilating Imported Mathematics An Appendix Takes Up Further Contemporary Implications Of The New Philosophy Of Mathematics For The Extension Of The Calculus Which Is Needed To Handle The Infinities Arising In The Study Of Shock Waves And The Renormalization Problem Of Quantum Field Theory **David Hilbert's Lectures on the Foundations of Arithmetic and Logic 1917-1933** William Ewald, Wilfried Sieg, 2013-05-14 The core of Volume 3 consists of lecture notes for seven sets of lectures Hilbert gave often in collaboration with Bernays on the foundations of mathematics between 1917 and 1926 These texts make possible for the first time a detailed reconstruction of the rapid development of Hilbert's foundational thought during this period and show the increasing dominance of the metamathematical perspective in his logical work the emergence of modern mathematical logic the explicit raising of questions of completeness consistency and decidability for logical systems the investigation of the relative strengths of various logical calculi the birth and evolution of proof theory and the parallel emergence of Hilbert's finitist standpoint The lecture notes are accompanied by numerous supplementary documents both published and unpublished including a complete version of Bernays's Habilitationsschrift of 1918 the text of

the first edition of Hilbert and Ackermann's *Grundgesetze der theoretischen Logik* 1928 and several shorter lectures by Hilbert from the later 1920s. These documents which provide the background to Hilbert and Bernays's monumental *Grundgesetze der Mathematik* 1934-1938 are essential for understanding the development of modern mathematical logic and for reconstructing the interactions between Hilbert, Bernays, Brouwer and Weyl in the philosophy of mathematics.

Grassmann Algebra Volume 1: Foundations John Browne, 2012-10-25. *Grassmann Algebra Volume 1 Foundations* Exploring extended vector algebra with Mathematica. Grassmann algebra extends vector algebra by introducing the exterior product to algebraicize the notion of linear dependence. With it, vectors may be extended to higher grade entities: bivectors, trivectors, multivectors. The extensive exterior product also has a regressive dual, the regressive product. The pair behaves a little like the Boolean duals of union and intersection. By interpreting one of the elements of the vector space as an origin, points can be defined and the exterior product can extend points into higher grade located entities from which lines, planes, and multiplanes can be defined. Theorems of Projective Geometry are simply formulae involving these entities and the dual products. By introducing the orthogonal complement operation, the scalar product of vectors may be extended to the interior product of multivectors, which in this more general case may no longer result in a scalar. The notion of the magnitude of vectors is extended to the magnitude of multivectors; for example, the magnitude of the exterior product of two vectors, a bivector, is the area of the parallelogram formed by them. To develop these foundational concepts, we need only consider entities which are the sums of elements of the same grade. This is the focus of this volume. But the entities of Grassmann algebra need not be of the same grade and the possible product types need not be constricted to just the exterior, regressive, and interior products. For example, quaternion algebra is simply the Grassmann algebra of scalars and bivectors under a new product operation. Clifford geometric and higher order hypercomplex algebras, for example the octonions, may be defined similarly. If to these we introduce Clifford's invention of a scalar which squares to zero, we can define entities, for example dual quaternions, with which we can perform elaborate transformations. Exploration of these entities, operations, and algebras will be the focus of the volume to follow this. There is something fascinating about the beauty with which the mathematical structures that Hermann Grassmann discovered describe the physical world and something also fascinating about how these beautiful structures have been largely lost to the mainstreams of mathematics and science. He wrote his seminal *Ausdehnungslehre*. Die *Ausdehnungslehre* Vollständig und in strenger Form in 1862. But it was not until the latter part of his life that he received any significant recognition for it, most notably by Gibbs and Clifford. In recent times, David Hestenes' *Geometric Algebra* must be given the credit for much of the emerging awareness of Grassmann's innovation. In the hope that the book be accessible to scientists and engineers, students and professionals alike, the text attempts to avoid any terminology which does not make an essential contribution to an understanding of the basic concepts. Some familiarity with basic linear algebra may however be useful. The book is written using Mathematica, a powerful system for doing mathematics on a

computer This enables the theory to be cross checked with computational explorations However a knowledge of Mathematica is not essential for an appreciation of Grassmann s beautiful ideas *New Foundations in Mathematics* Garret

Sobczyk,2012-10-26 The first book of its kind *New Foundations in Mathematics* The Geometric Concept of Number uses geometric algebra to present an innovative approach to elementary and advanced mathematics Geometric algebra offers a simple and robust means of expressing a wide range of ideas in mathematics physics and engineering In particular geometric algebra extends the real number system to include the concept of direction which underpins much of modern mathematics and physics Much of the material presented has been developed from undergraduate courses taught by the author over the years in linear algebra theory of numbers advanced calculus and vector calculus numerical analysis modern abstract algebra and differential geometry The principal aim of this book is to present these ideas in a freshly coherent and accessible manner *New Foundations in Mathematics* will be of interest to undergraduate and graduate students of mathematics and physics who are looking for a unified treatment of many important geometric ideas arising in these subjects at all levels The material can also serve as a supplemental textbook in some or all of the areas mentioned above and as a reference book for professionals who apply mathematics to engineering and computational areas of mathematics and physics **Essays on the**

Foundations of Mathematics by Moritz Pasch Stephen Pollard,2010-08-03 Moritz Pasch 1843 1930 is justly celebrated as a key figure in the history of axiomatic geometry Less well known are his contributions to other areas of foundational research This volume features English translations of 14 papers Pasch published in the decade 1917 1926 In them Pasch argues that geometry and more surprisingly number theory are branches of empirical science he provides axioms for the combinatorial reasoning essential to Hilbert s program of consistency proofs he explores implicit definition a generalization of definition by abstraction and indicates how this technique yields an empiricist reconstruction of set theory he argues that we cannot fully understand the logical structure of mathematics without clearly distinguishing between decidable and undecidable properties he offers a rare glimpse into the mind of a master of axiomatics surveying in detail the thought experiments he employed as he struggled to identify fundamental mathematical principles and much more This volume will Give English speakers access to an important body of work from a turbulent and pivotal period in the history of mathematics help us look beyond the familiar triad of formalism intuitionism and logicism show how deeply we can see with the help of a guide determined to present fundamental mathematical ideas in ways that match our human capacities will be of interest to graduate students and researchers in logic and the foundations of mathematics **The IIT Foundation Series -**

Mathematics Class 7 , The IIT Foundation Series - Mathematics Class 9, 2/e , [The IIT Foundation Series - Mathematics Class 8, 2/e](#) , [The IIT Foundation Series - Mathematics Class 10, 2/e](#) , **Foundation Mathematics for Computer Science** John Vince,2024-09-26 In this book John Vince has reviewed and edited the third edition and added chapters on statistics Georg Riemann s hypothesis eigen vectors curves analytic geometry and Fourier analysis These

subjects complement the existing chapters on visual mathematics numbers algebra logic combinatorics probability modular arithmetic trigonometry coordinate systems determinants vectors complex numbers matrices geometric matrix transforms differential and integral calculus During this journey the author touches upon more esoteric topics such as quaternions octonions Grassmann algebra barycentric coordinates transfinite sets and prime numbers John Vince describes a range of mathematical topics that provide a solid foundation for an undergraduate course in computer science starting with a review of number systems and their relevance to digital computers and finishing with calculating area and volume using calculus Readers will find that the author's visual approach should greatly improve their understanding as to why certain mathematical structures exist together with how they are used in real world applications This book includes new full colour illustrations to clarify the mathematical descriptions and in some cases equations are also coloured to reveal vital algebraic patterns The numerous worked examples will help consolidate the understanding of abstract mathematical concepts Whether you intend to pursue a career in programming scientific visualization artificial intelligence systems design or real time computing you should find the author's literary style refreshingly lucid and engaging and prepare you for more advanced texts

Reverse Mathematics John Stillwell, 2019-09-24 This volume presents reverse mathematics to a general mathematical audience for the first time Stillwell gives a representative view of this field emphasizing basic analysis finding the right axioms to prove fundamental theorems and giving a novel approach to logic to logic

Process Grammar: The Basis of Morphology Michael Leyton, 2012-02-02 Leyton's Process Grammar has been applied by scientists and engineers in many disciplines including medical diagnosis geology computer aided design meteorology biological anatomy neuroscience chemical engineering etc This book demonstrates the following The Process Grammar invents several entirely new concepts in biological morphology and manufacturing design and shows that these concepts are fundamentally important The Process Grammar has process inference rules that give to morphological transitions powerful new causal explanations Remarkably the book gives a profound unification of biological morphology and vehicle design The book invents over 30 new CAD operations that realize fundamentally important functions of a product A crucial fact is that the Process Grammar is an example of the laws in Leyton's Generative Theory of Shape which give the ability to recover the design intents for which the shape features of a CAD model were created The book demonstrates that the Process Grammar recovers important design intents in biological morphology and manufacturing design In large scale manufacturing systems the recovery of design intents is important for solving the interoperability problem and product lifecycle management This book is one of a series of books in Springer that elaborates Leyton's Generative Theory of Shape

New Foundations for Classical Mechanics D. Hestenes, 2005-12-17 revised This is a textbook on classical mechanics at the intermediate level but its main purpose is to serve as an introduction to a new mathematical language for physics called geometric algebra Mechanics is most commonly formulated today in terms of the vector algebra developed by the American physicist J Willard Gibbs but for some

applications of mechanics the algebra of complex numbers is more efficient than vector algebra while in other applications matrix algebra works better Geometric algebra integrates all these algebraic systems into a coherent mathematical language which not only retains the advantages of each special algebra but possesses powerful new capabilities This book covers the fairly standard material for a course on the mechanics of particles and rigid bodies However it will be seen that geometric algebra brings new insights into the treatment of nearly every topic and produces simplifications that move the subject quickly to advanced levels That has made it possible in this book to carry the treatment of two major topics in mechanics well beyond the level of other textbooks A few words are in order about the unique treatment of these two topics namely rotational dynamics and celestial mechanics Resources in Education ,2000-10 **Foundation Mathematics for the Physical Sciences** K. F. Riley,M. P. Hobson,2011-03-31 This tutorial style textbook develops the basic mathematical tools needed by first and second year undergraduates to solve problems in the physical sciences Students gain hands on experience through hundreds of worked examples self test questions and homework problems Each chapter includes a summary of the main results definitions and formulae Over 270 worked examples show how to put the tools into practice Around 170 self test questions in the footnotes and 300 end of section exercises give students an instant check of their understanding More than 450 end of chapter problems allow students to put what they have just learned into practice Hints and outline answers to the odd numbered problems are given at the end of each chapter Complete solutions to these problems can be found in the accompanying Student Solutions Manual Fully worked solutions to all problems password protected for instructors are available at www.cambridge.org/foundation *IIT JEE Foundation Mathematics Class 9th: Comprehensive Study Notes* , Foundation Mathematics For Non-Mathematicians Shott, Milo,1990-01-01 This book is for students who either never obtained any formal qualifications in mathematics or whose knowledge became rusty through prolonged lack of use It explains mathematical concepts and topics which are prerequisites for a student embarking on any science or other numerically based course in further and higher education The text contains many worked examples illustrations and exercises with solutions to reinforce understanding of the material The emphasis is on a user friendly approach and simplicity of style which makes the book easy to study on its own without any editorial help Mathematics for Elementary School Teachers Student Solutions Manual Bassarear,Tom Bassarear,2000-12 *IIT JEE Foundation Mathematics Class 10th: Comprehensive Study Notes* ,

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