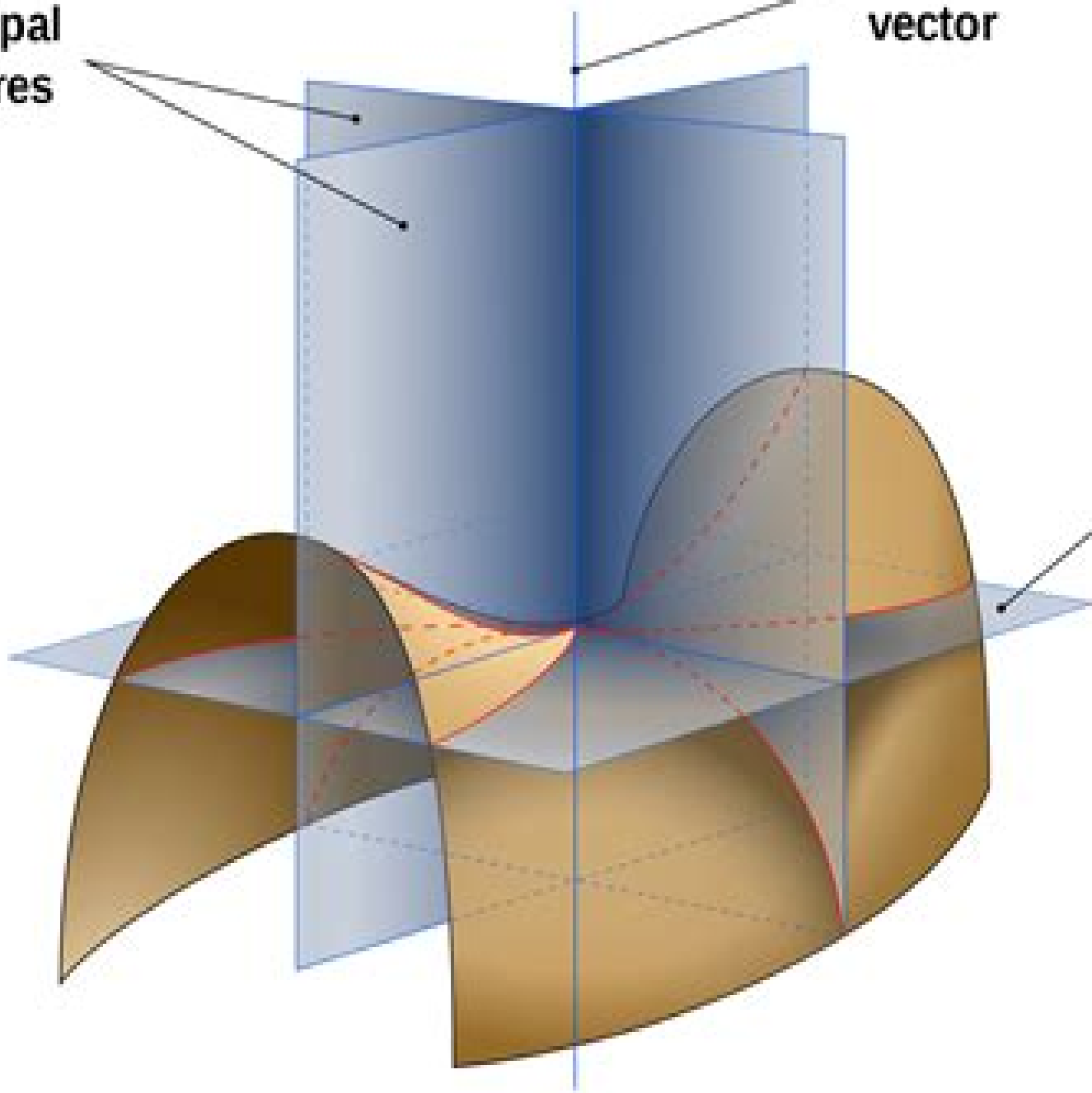


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Hyperbolic Geometry

Abraham Albert Ungar



Hyperbolic Geometry:

Hyperbolic Geometry James W. Anderson, 2006-02-28 Thoroughly updated featuring new material on important topics such as hyperbolic geometry in higher dimensions and generalizations of hyperbolicity Includes full solutions for all exercises Successful first edition sold over 800 copies in North America Introduction to Hyperbolic Geometry Arlan Ramsay, Robert D. Richtmyer, 2013-03-09 This book is an introduction to hyperbolic and differential geometry that provides material in the early chapters that can serve as a textbook for a standard upper division course on hyperbolic geometry For that material the students need to be familiar with calculus and linear algebra and willing to accept one advanced theorem from analysis without proof The book goes well beyond the standard course in later chapters and there is enough material for an honors course or for supplementary reading Indeed parts of the book have been used for both kinds of courses Even some of what is in the early chapters would surely not be necessary for a standard course For example detailed proofs are given of the Jordan Curve Theorem for Polygons and of the decomposability of polygons into triangles These proofs are included for the sake of completeness but the results themselves are so believable that most students should skip the proofs on a first reading The axioms used are modern in character and more user friendly than the traditional ones The familiar real number system is used as an ingredient rather than appearing as a result of the axioms However it should not be thought that the geometric treatment is in terms of models this is an axiomatic approach that is just more convenient than the traditional ones

Foundations of Hyperbolic Manifolds John G. Ratcliffe, 1994 This book is an exposition of the theoretical foundations of hyperbolic manifolds It is intended to be used both as a textbook and as a reference The reader is assumed to have a basic knowledge of algebra and topology at the first year graduate level of an American university The book is divided into three parts The first part Chapters 1-7 is concerned with hyperbolic geometry and discrete groups The second part Chapters 8-12 is devoted to the theory of hyperbolic manifolds The third part Chapter 13 integrates the first two parts in a development of the theory of hyperbolic orbifolds There are over 500 exercises in this book and more than 180 illustrations *The Non-Euclidean, Hyperbolic Plane* P. Kelly, G. Matthews, 2012-12-06 The discovery of hyperbolic geometry and the subsequent proof that this geometry is just as logical as Euclid's had a profound influence on man's understanding of mathematics and the relation of mathematical geometry to the physical world It is now possible due in large part to axioms devised by George Birkhoff to give an accurate elementary development of hyperbolic plane geometry Also using the Poincaré model and inversive geometry the equiconsistency of hyperbolic plane geometry and Euclidean plane geometry can be proved without the use of any advanced mathematics These two facts provided both the motivation and the two central themes of the present work Basic hyperbolic plane geometry and the proof of its equal footing with Euclidean plane geometry is presented here in terms accessible to anyone with a good background in high school mathematics The development however is especially directed to college students who may become secondary teachers For that reason the treatment is designed to emphasize

those aspects of hyperbolic plane geometry which contribute to the skills knowledge and insights needed to teach euclidean geometry with some mastery *Analytic Hyperbolic Geometry* Abraham A. Ungar,2005 This is the first book on analytic hyperbolic geometry fully analogous to analytic Euclidean geometry Analytic hyperbolic geometry regulates relativistic mechanics just as analytic Euclidean geometry regulates classical mechanics The book presents a novel gyrovector space approach to analytic hyperbolic geometry fully analogous to the well known vector space approach to Euclidean geometry A gyrovector is a hyperbolic vector In the resulting gyrolanguage of the book one attaches the prefix gyro to a classical term to mean the analogous term in hyperbolic geometry The book begins with the definition of gyrogroups which is fully analogous to the definition of groups Gyrogroups both gyrocommutative and nongyrocommutative abound in group theory Surprisingly the seemingly structureless Einstein velocity addition of special relativity turns out to be a gyrocommutative gyrogroup operation Introducing scalar multiplication some gyrocommutative gyrogroups of gyrovectors become gyrovector spaces The latter in turn form the setting for analytic hyperbolic geometry just as vector spaces form the setting for analytic Euclidean geometry By hybrid techniques of differential geometry and gyrovector spaces it is shown that Einstein Mobius gyrovector spaces form the setting for Beltrami Klein Poincare ball models of hyperbolic geometry Finally novel applications of Mobius gyrovector spaces in quantum computation and of Einstein gyrovector spaces in special relativity are presented Complex Hyperbolic Geometry William Mark Goldman,1999 Complex hyperbolic geometry is a particularly rich area of study enhanced by the confluence of several areas of research including Riemannian geometry complex analysis symplectic and contact geometry Lie group theory and harmonic analysis The boundary of complex hyperbolic geometry known as spherical CR or Heisenberg geometry is equally rich and although there exist accounts of analysis in such spaces there is currently no account of their geometry This book redresses the balance and provides an overview of the geometry of both the complex hyperbolic space and its boundary Motivated by applications of the theory to geometric structures moduli spaces and discrete groups it is designed to provide an introduction to this fascinating and important area and invite further research and development **Hyperbolic Geometry from a Local Viewpoint** Linda Keen,Nikola Lakic,2007-03-08 A self contained text on hyperbolic geometry for plane domains ideal for graduate students and academic researchers **Sources of**

Hyperbolic Geometry John Stillwell,1996 This book presents for the first time in English the papers of Beltrami Klein and Poincare that brought hyperbolic geometry into the mainstream of mathematics A recognition of Beltrami comparable to that given the pioneering works of Bolyai and Lobachevsky seems long overdue not only because Beltrami rescued hyperbolic geometry from oblivion by proving it to be logically consistent but because he gave it a concrete meaning a model that made hyperbolic geometry part of ordinary mathematics The models subsequently discovered by Klein and Poincare brought hyperbolic geometry even further down to earth and paved the way for the current explosion of activity in low dimensional geometry and topology By placing the works of these three mathematicians side by side and providing commentaries this

book gives the student historian or professional geometer a bird's eye view of one of the great episodes in mathematics. The unified setting and historical context reveal the insights of Beltrami, Klein, and Poincaré in their full brilliance. **The**

Poincaré Half-plane Saul Stahl, 1993. The Poincaré Half Plane provides an elementary and constructive development of this geometry that brings the undergraduate major closer to current geometric research. At the same time, repeated use is made of high school geometry, algebra, trigonometry, and calculus, thus reinforcing the student's understanding of these disciplines as well as enhancing their perception of mathematics as a unified endeavor. *Hyperbolic Geometry* Birger

Iversen, 1992-12-17. Although it arose from purely theoretical considerations of the underlying axioms of geometry, the work of Einstein and Dirac has demonstrated that hyperbolic geometry is a fundamental aspect of modern physics. In this book, the rich geometry of the hyperbolic plane is studied in detail, leading to the focal point of the book: Poincaré's polygon theorem and the relationship between hyperbolic geometries and discrete groups of isometries. Hyperbolic 3-space is also discussed, and the directions that current research in this field is taking are sketched. This will be an excellent introduction to

hyperbolic geometry for students new to the subject and for experts in other fields. *Lectures on Hyperbolic Geometry* Riccardo Benedetti, Carlo Petronio, 2012-12-06. In recent years, hyperbolic geometry has been the object and the preparation

for extensive study that has produced important and often amazing results and also opened up new questions. The book concerns the geometry of manifolds and, in particular, hyperbolic manifolds; its aim is to provide an exposition of some fundamental results and to be as far as possible self-contained, complete, detailed, and unified. Since it starts from the basics and it reaches recent developments of the theory, the book is mainly addressed to graduate-level students approaching research, but it will also be a helpful and ready-to-use tool to the mature researcher. After collecting some classical material about the geometry of the hyperbolic space and the Teichmüller space, the book centers on the two fundamental results: Mostow's rigidity theorem, of which a complete proof is given following Gromov and Thurston and Margulis lemma. These results form the basis for the study of the space of the hyperbolic manifolds in all dimensions. Chabauty and geometric topology: a unified exposition is given of Wang's theorem and the Jorgensen-Thurston theory. A large part is devoted to the three-dimensional case: a complete and elementary proof of the hyperbolic surgery theorem is given based on the possibility of representing three manifolds as glued ideal tetrahedra. The last chapter deals with some related ideas and generalizations: bounded cohomology, flat fiber bundles, amenable groups. This is the first book to collect this material together from numerous scattered sources to give a detailed presentation at a unified level accessible to novice readers.

Non-Euclidean Geometry: Sixth Edition H. S. M. Coxeter, 1998-12-31. A reissue of Professor Coxeter's classic text on non-Euclidean geometry. *Analytic Hyperbolic Geometry And Albert Einstein's Special Theory Of Relativity (Second Edition)* Abraham Albert Ungar, 2022-02-22. This book presents a powerful way to study Einstein's special theory of relativity and its underlying hyperbolic geometry, in which analogies with classical results form the right tool. The premise of analogy as

a study strategy is to make the unfamiliar familiar Accordingly this book introduces the notion of vectors into analytic hyperbolic geometry where they are called gyrovectors Gyrovectors turn out to be equivalence classes that add according to the gyroparallelogram law just as vectors are equivalence classes that add according to the parallelogram law In the gyrolanguage of this book accordingly one prefixes a gyro to a classical term to mean the analogous term in hyperbolic geometry As an example the relativistic gyrotrigonometry of Einstein's special relativity is developed and employed to the study of the stellar aberration phenomenon in astronomy Furthermore the book presents for the first time the relativistic center of mass of an isolated system of noninteracting particles that coincided at some initial time t_0 It turns out that the invariant mass of the relativistic center of mass of an expanding system like galaxies exceeds the sum of the masses of its constituent particles This excess of mass suggests a viable mechanism for the formation of dark matter in the universe which has not been detected but is needed to gravitationally glue each galaxy in the universe The discovery of the relativistic center of mass in this book thus demonstrates once again the usefulness of the study of Einstein's special theory of relativity in terms of its underlying hyperbolic geometry

Analytic Hyperbolic Geometry: Mathematical Foundations And Applications Abraham Albert Ungar, 2005-09-05 This is the first book on analytic hyperbolic geometry fully analogous to analytic Euclidean geometry Analytic hyperbolic geometry regulates relativistic mechanics just as analytic Euclidean geometry regulates classical mechanics The book presents a novel gyrovector space approach to analytic hyperbolic geometry fully analogous to the well known vector space approach to Euclidean geometry A gyrovector is a hyperbolic vector Gyrovectors are equivalence classes of directed gyrosegments that add according to the gyroparallelogram law just as vectors are equivalence classes of directed segments that add according to the parallelogram law In the resulting gyrolanguage of the book one attaches the prefix gyro to a classical term to mean the analogous term in hyperbolic geometry The prefix stems from Thomas gyration which is the mathematical abstraction of the relativistic effect known as Thomas precession Gyrolanguage turns out to be the language one needs to articulate novel analogies that the classical and the modern in this book share The scope of analytic hyperbolic geometry that the book presents is cross disciplinary involving nonassociative algebra geometry and physics As such it is naturally compatible with the special theory of relativity and particularly with the nonassociativity of Einstein velocity addition law Along with analogies with classical results that the book emphasizes there are remarkable disanalogies as well Thus for instance unlike Euclidean triangles the sides of a hyperbolic triangle are uniquely determined by its hyperbolic angles Elegant formulas for calculating the hyperbolic side lengths of a hyperbolic triangle in terms of its hyperbolic angles are presented in the book The book begins with the definition of gyrogroups which is fully analogous to the definition of groups Gyrogroups both gyrocommutative and non gyrocommutative abound in group theory Surprisingly the seemingly structureless Einstein velocity addition of special relativity turns out to be a gyrocommutative gyrogroup operation Introducing scalar multiplication some gyrocommutative

gyrogroups of gyrovectors become gyrovector spaces The latter in turn form the setting for analytic hyperbolic geometry just as vector spaces form the setting for analytic Euclidean geometry By hybrid techniques of differential geometry and gyrovector spaces it is shown that Einstein M bius gyrovector spaces form the setting for Beltrami Klein Poincar ball models of hyperbolic geometry Finally novel applications of M bius gyrovector spaces in quantum computation and of Einstein gyrovector spaces in special relativity are presented

Non-Euclidean Geometry Roberto Bonola, 2012-08-15 Examines various attempts to prove Euclid's parallel postulate by the Greeks Arabs and Renaissance mathematicians It considers forerunners and founders such as Saccheri Lambert Legendre W Bolyai Gauss others Includes 181 diagrams

Non-Euclidean Geometries András Prékopa, Emil Molnár, 2006-06-03 From nothing I have created a new different world wrote J nos Bolyai to his father Wolfgang Bolyai on November 3 1823 to let him know his discovery of non Euclidean geometry as we call it today The results of Bolyai and the co discoverer the Russian Lobachevskii changed the course of mathematics opened the way for modern physical theories of the twentieth century and had an impact on the history of human culture The papers in this volume which commemorates the 200th anniversary of the birth of J nos Bolyai were written by leading scientists of non Euclidean geometry its history and its applications Some of the papers present new discoveries about the life and works of J nos Bolyai and the history of non Euclidean geometry others deal with geometrical axiomatics polyhedra fractals hyperbolic Riemannian and discrete geometry tilings visualization and applications in physics

A Simple Non-Euclidean Geometry and Its Physical Basis I.M. Yaglom, 2012-12-06 There are many technical and popular accounts both in Russian and in other languages of the non Euclidean geometry of Lobachevsky and Bolyai a few of which are listed in the Bibliography This geometry also called hyperbolic geometry is part of the required subject matter of many mathematics departments in universities and teachers colleges a reflection of the view that familiarity with the elements of hyperbolic geometry is a useful part of the background of future high school teachers Much attention is paid to hyperbolic geometry by school mathematics clubs Some mathematicians and educators concerned with reform of the high school curriculum believe that the required part of the curriculum should include elements of hyperbolic geometry and that the optional part of the curriculum should include a topic related to hyperbolic geometry I The broad interest in hyperbolic geometry is not surprising This interest has little to do with mathematical and scientific applications of hyperbolic geometry since the applications for instance in the theory of automorphic functions are rather specialized and are likely to be encountered by very few of the many students who conscientiously study and then present to examiners the definition of parallels in hyperbolic geometry and the special features of configurations of lines in the hyperbolic plane The principal reason for the interest in hyperbolic geometry is the important fact of non uniqueness of geometry of the existence of many geometric systems

Introduction to Non-Euclidean Geometry Harold E. Wolfe, 2011-03-23 This book has been written in an attempt to provide a satisfactory textbook to be used as a basis for elementary courses in Non Euclidean Geometry The need for such

a volume definitely intended for classroom use and containing substantial lists of exercises has been evident for some time It is hoped that this one will meet the requirements of those instructors who have been teaching the subject regularly and also that its appearance will encourage others to institute such courses The benefits and amenities of a formal study of Non Euclidean Geometry are generally recognized Not only is the subject matter itself valuable and intensely fascinating well worth the time of any student of mathematics but there is probably no elementary course which exhibits so clearly the nature and significance of geometry and indeed of mathematics in general However a mere cursory acquaintance with the subject will not do One must follow its development at least a little way to see how things come out and try his hand at demonstrating propositions under circumstances such that intuition no longer serves as a guide Euclidean and Non-Euclidean Geometries Marvin J. Greenberg, 1993-07-15 This classic text provides overview of both classic and hyperbolic geometries placing the work of key mathematicians philosophers in historical context Coverage includes geometric transformations models of the hyperbolic planes and pseudospheres **Analytic Hyperbolic Geometry in N Dimensions** Abraham Albert Ungar, 2014-12-17 The concept of the Euclidean simplex is important in the study of n dimensional Euclidean geometry This book introduces for the first time the concept of hyperbolic simplex as an important concept in n dimensional hyperbolic geometry Following the emergence of his gyroalgebra in 1988 the author crafted gyrolanguage the algebraic language t

Hyperbolic Geometry Book Review: Unveiling the Magic of Language

In an electronic digital era where connections and knowledge reign supreme, the enchanting power of language has become more apparent than ever. Its ability to stir emotions, provoke thought, and instigate transformation is truly remarkable. This extraordinary book, aptly titled "**Hyperbolic Geometry**," published by a highly acclaimed author, immerses readers in a captivating exploration of the significance of language and its profound impact on our existence. Throughout this critique, we will delve in to the book is central themes, evaluate its unique writing style, and assess its overall influence on its readership.

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