

ISOMETRIES OF THE PLANE

TRACY BOSWELL

ABSTRACT. First we define different kinds of isometries of the plane. Then we prove that isometries of the plane are determined by one of two equations. Using these two equations, we can determine the only four possible types of isometries of the plane: translations, rotations, reflections, and glide-reflections.

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1. WHAT IS AN ISOMETRY?

An isometry is a distance-preserving transformation. In this paper, we consider isometries of the plane $\mathbb{C}$.

Definition 1.1. A transformation $\alpha : \mathbb{C} \rightarrow \mathbb{C}$ is an *isometry* if for any two points $p, q \in \mathbb{C}$, the Euclidean distance $|\alpha(p) - \alpha(q)| = |p - q|$.

Surprisingly, there are only four types of isometries of the Euclidean plane, which together form a group under composition known as the *Euclidean group of the plane*. The next sections will formally define these four isometries and prove the classification theorem, which states that every isometry of the plane must be of one of these four types.

2. TRANSLATIONS AND ROTATIONS

Definition 2.1. A *translation* τ is a mapping from $\mathbb{C}$ to $\mathbb{C}$ defined by equations of the form

$$\begin{cases} x' = x + a \\ y' = y + b. \end{cases}$$

For any point $x + iy$ in the plane, let $x' + iy' = \tau(x + iy) = x + a + i(y + b)$. We can rewrite this as $\tau : x \mapsto x + c$, where $x = x + iy$ and $c = a + ib$. The transformation τ moves each point the same distance in the same direction.

Proposition 2.2. A translation τ is an isometry of the plane.

Date: July 21, 2009.

Plane Geometry An Approach Through Isometries

James T. Smith



Plane Geometry An Approach Through Isometries:

Plane Geometry, an Approach Through Isometries Dick Wick Hall, Steven Szabo, 1971 **Euclidean Geometry and Transformations** Clayton W. Dodge, 2004-01-01 This introduction to Euclidean geometry emphasizes transformations particularly isometries and similarities Suitable for undergraduate courses it includes numerous examples many with detailed answers 1972 edition Transformational Plane Geometry Ronald N. Umble, Zhigang Han, 2014-12-01 Designed for a one semester course at the junior undergraduate level Transformational Plane Geometry takes a hands on interactive approach to teaching plane geometry The book is self contained defining basic concepts from linear and abstract algebra gradually as needed The text adheres to the National Council of Teachers of Mathematics Principles and Standards for School Mathematics and the Common Core State Standards Initiative Standards for Mathematical Practice Future teachers will acquire the skills needed to effectively apply these standards in their classrooms Following Felix Klein s Erlangen Program the book provides students in pure mathematics and students in teacher training programs with a concrete visual alternative to Euclid s purely axiomatic approach to plane geometry It enables geometrical visualization in three ways Key concepts are motivated with exploratory activities using software specifically designed for performing geometrical constructions such as Geometer s Sketchpad Each concept is introduced synthetically without coordinates and analytically with coordinates Exercises include numerous geometric constructions that use a reflecting instrument such as a MIRA After reviewing the essential principles of classical Euclidean geometry the book covers general transformations of the plane with particular attention to translations rotations reflections stretches and their compositions The authors apply these transformations to study congruence similarity and symmetry of plane figures and to classify the isometries and similarities of the plane **A New Look at Geometry** Irving Adler, 2013-10-03 Richly detailed survey of the evolution of geometrical ideas and development of concepts of modern geometry projective Euclidean and non Euclidean geometry role of geometry in Newtonian physics calculus relativity Over 100 exercises with answers 1966 edition Geometry Turned On James King, Doris Schattschneider, 1997-10-30 Articles about the uses of active exploratory geometry carried out with interactive computer software *Methods of Geometry* James T. Smith, 2011-03-01 A practical accessible introduction to advanced geometry Exceptionally well written and filled with historical and bibliographic notes Methods of Geometry presents a practical and proof oriented approach The author develops a wide range of subject areas at an intermediate level and explains how theories that underlie many fields of advanced mathematics ultimately lead to applications in science and engineering Foundations basic Euclidean geometry and transformations are discussed in detail and applied to study advanced plane geometry polyhedra isometries similarities and symmetry An excellent introduction to advanced concepts as well as a reference to techniques for use in independent study and research Methods of Geometry also features Ample exercises designed to promote effective problem solving strategies Insight into novel uses of Euclidean geometry More than 300 figures

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group operations presentations products of groups and finite abelian and solvable groups The topics include cyclic and symmetric groups dihedral orthogonal and hyperbolic groups as well as the significant notion of Cayley graphs Self contained and requiring little beyond high school mathematics this book is aimed at undergraduate courses and features numerous exercises It will also appeal to anyone interested in the geometric approach to group theory **Selected Preserver**

Problems on Algebraic Structures of Linear Operators and on Function Spaces L. Molnár, 2006-11-15 The territory of preserver problems has grown continuously within linear analysis This book presents a cross section of the modern theory of preservers on infinite dimensional spaces operator spaces and function spaces through the author's corresponding results Special emphasis is placed on preserver problems concerning some structures of Hilbert space operators which appear in quantum mechanics In addition local automorphisms and local isometries of operator algebras and function algebras are discussed in detail **Modern Mathematics** Dirk De Bock, 2023-03-08

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Symmetry William H. Barker, Roger Howe, 2007 The fundamental idea of geometry is that of symmetry With that principle as the starting point Barker and Howe begin an insightful and rewarding study of Euclidean geometry The primary focus of the book is on transformations of the plane The transformational point of view provides both a path for deeper understanding of traditional synthetic geometry and tools for providing proofs that spring from a consistent point of view As a result proofs

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Topological Methods in Euclidean Spaces Gregory L. Naber, 2012-08-29 Extensive development of such topics as elementary combinatorial techniques Sperner's Lemma the Brouwer Fixed Point Theorem and the Stone Weierstrass Theorem New section of solutions to selected problems *Catalog of Copyright Entries. Third Series* Library of Congress. Copyright Office, 1973 □□□□□□□□, 1976

Thinking Geometrically Thomas Q. Sibley, 2015-08-14 Thinking Geometrically A Survey of Geometries is a well written and comprehensive survey of college geometry that would serve a wide variety of courses for both mathematics majors and mathematics education majors Great care and attention is spent on developing visual insights and geometric intuition while stressing the logical structure historical development and deep interconnectedness of the ideas Students with less mathematical preparation than upper division mathematics majors can successfully study the topics needed for the preparation of high school teachers There is a multitude of exercises and projects in those chapters developing all aspects of geometric thinking for these students as well as for more advanced students These chapters include Euclidean Geometry Axiomatic Systems and Models Analytic Geometry Transformational Geometry and Symmetry Topics in the other chapters including Non Euclidean Geometry Projective Geometry Finite Geometry Differential Geometry and Discrete Geometry provide a broader view of geometry The different chapters are as independent as possible while the text still manages to highlight the many connections between topics The text is self contained including appendices with the material in Euclid's first book and a high school axiomatic system as well as Hilbert's axioms Appendices give brief summaries of the parts of linear algebra and multivariable calculus needed for certain chapters While some chapters use the language of groups no prior experience with abstract algebra is presumed The text will support an approach emphasizing dynamical geometry software without being tied to any particular software

Perspectives on the Teaching of Geometry for the 21st Century C. Mammana, V. Villani, 2012-12-06 In recent years geometry seems to have lost large parts of its former central position in mathematics teaching in most countries However new trends have begun to counteract this tendency There is an increasing awareness that geometry plays a key role in mathematics and learning mathematics Although geometry has been eclipsed in the mathematics curriculum research in geometry has blossomed as new ideas have arisen from inside mathematics and other disciplines including computer science Due to reassessment of the role of geometry mathematics educators and mathematicians face new challenges In the present ICMI study the whole spectrum of teaching and learning of geometry is analysed Experts from all over the world took part in this study which was conducted on the basis of recent

international research case studies and reports on actual school practice This book will be of particular interest to mathematics educators and mathematicians who are involved in the teaching of geometry at all educational levels as well as to researchers in mathematics education

Computer Vision, Imaging and Computer Graphics - Theory and Applications Gabriela Csurka, Martin Kraus, Leonid Mestetskiy, Paul Richard, José Braz, 2013-01-03 This book constitutes the refereed proceedings of the International Conference VISIGRAPP 2011 the Joint Conference on Computer Vision Theory and Applications VISAPP on Imaging Theory and Applications IMAGAPP on Computer Graphics Theory and Applications GRAPP and on Information Visualization Theory and Applications IVAPP held in Vilamoura Portugal in March 2011 The 15 revised full papers presented together with one invited paper were carefully reviewed and selected The papers are organized in topical sections on computer graphics theory and applications imaging theory and applications information visualization theory and applications and computer vision theory and applications

Geometric Function Theory Tom Carroll, 2024-12-11 This textbook provides a second course in complex analysis with a focus on geometric aspects It covers topics such as the spherical geometry of the extended complex plane the hyperbolic geometry of the Poincaré disk conformal mappings the Riemann Mapping Theorem and uniformisation of planar domains characterisations of simply connected domains the convergence of Riemann maps in terms of Carathéodory convergence of the image domains normal families and Picard's theorems on value distribution as well as the fundamentals of univalent function theory Throughout the text the synergy between analysis and geometry is emphasised with proofs chosen for their directness The textbook is self contained requiring only a first undergraduate course in complex analysis The minimal topology needed is introduced as necessary While primarily aimed at upper level undergraduates the book also serves as a concise reference for graduates working in complex analysis

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