

Lectures in Mathematics

ETH Zürich

Anthony J. Tromba

**Teichmüller Theory
in Riemannian Geometry**

based on lecture notes by
Jochen Denzler

Birkhäuser

Teichmuller Theory In Riemannian Geometry

David Borthwick



Teichmüller Theory In Riemannian Geometry:

Teichmüller Theory in Riemannian Geometry Anthony Tromba, 2012-12-06 These lecture notes are based on the joint work of the author and Arthur Fischer on Teichmüller theory undertaken in the years 1980-1986. Since then many of our colleagues have encouraged us to publish our approach to the subject in a concise format easily accessible to a broad mathematical audience. However it was the invitation by the faculty of the ETH Zürich to deliver the ETH Nachdiplom Vorlesungen on this material which provided the opportunity for the author to develop our research papers into a format suitable for mathematicians with a modest background in differential geometry. We also hoped it would provide the basis for a graduate course stressing the application of fundamental ideas in geometry. For this opportunity the author wishes to thank Eduard Zehnder and Jürgen Moser acting director and director of the Forschungsinstitut für Mathematik at the ETH, Gisbert Wiethölz responsible for the Nachdiplom Vorlesungen and the entire ETH faculty for their support and warm hospitality. This new approach to Teichmüller theory presented here was undertaken for two reasons. First it was clear that the classical approach using the theory of extremal quasi-conformal mappings in this approach we completely avoid the use of quasi-conformal maps was not easily applicable to the theory of minimal surfaces a field of interest of the author over many years. Second many other active mathematicians who at various times needed some Teichmüller theory have found the classical approach inaccessible to them.

Handbook of Teichmüller Theory Athanase Papadopoulos, 2007 This multi-volume set deals with Teichmüller theory in the broadest sense namely as the study of moduli space of geometric structures on surfaces with methods inspired or adapted from those of classical Teichmüller theory. The aim is to give a complete panorama of this generalized Teichmüller theory and of its applications in various fields of mathematics. The volumes consist of chapters each of which is dedicated to a specific topic. The volume has 19 chapters and is divided into four parts: The metric and the analytic theory, uniformization, Weil-Petersson geometry, holomorphic families of Riemann surfaces, infinite dimensional Teichmüller spaces, cohomology of moduli space and the intersection theory of moduli space, The group theory, quasi-homomorphisms of mapping class groups, measurable rigidity of mapping class groups, applications to Lefschetz fibrations, affine groups of flat surfaces, braid groups and Artin groups, Representation spaces and geometric structures, trace coordinates, invariant theory, complex projective structures, circle packings and moduli spaces of Lorentz manifolds homeomorphic to the product of a surface with the real line, The Grothendieck Teichmüller theory, dessins d'enfants, Grothendieck's reconstruction principle and the Teichmüller theory of the solenoid. This handbook is an essential reference for graduate students and researchers interested in Teichmüller theory and its ramifications in particular for mathematicians working in topology, geometry, algebraic geometry, dynamical systems and complex analysis. The authors are leading experts in the field.

Spectral Theory of Infinite-Area Hyperbolic Surfaces David Borthwick, 2007-10 By focusing on the scattering theory of hyperbolic surfaces this work provides an introduction to the geometry of hyperbolic surfaces. Aimed at graduate students and

researchers it draws on techniques from functional analysis and differential geometry as well as some techniques from algebra and number theory

General Relativity and Gravitation Abhay Ashtekar, Beverly K. Berger, James Isenberg, Malcolm MacCallum, 2015-06-01 Explore spectacular advances in cosmology relativistic astrophysics gravitational wave science mathematics computational science and the interface of gravitation and quantum physics with this unique celebration of the centennial of Einstein's discovery of general relativity Twelve comprehensive and in depth reviews written by a team of world leading international experts together present an up to date overview of key topics at the frontiers of these areas with particular emphasis on the significant developments of the last three decades Interconnections with other fields of research are also highlighted making this an invaluable resource for both new and experienced researchers Commissioned by the International Society on General Relativity and Gravitation and including accessible introductions to cutting edge topics ample references to original research papers and informative colour figures this is a definitive reference for researchers and graduate students in cosmology relativity and gravitational science

In the Tradition of Ahlfors-Bers, IV Richard Douglas Canary, 2007 The Ahlfors Bers Colloquia commemorate the mathematical legacy of Lars Ahlfors and Lipman Bers The core of this legacy lies in the fields of geometric function theory Teichmüller theory hyperbolic manifolds and partial differential equations However the work of Ahlfors and Bers has impacted and created interactions with many other fields such as algebraic geometry mathematical physics dynamics geometric group theory number theory and topology The triannual Ahlfors Bers colloquia serve as a venue to disseminate the relevant work to the wider mathematical community and bring the key participants together to ponder future directions in the field The present volume includes a wide range of articles in the fields central to this legacy The majority of articles present new results but there are expository articles as well

Teichmüller Theory and Applications to Geometry, Topology, and Dynamics John H. Hubbard, 2006

Duration and Change Michael Artin, Hanspeter Kraft, Reinhold Remmert, 2012-12-06 A volume containing original essays from quite diverse fields in mathematics is something of a rarity especially if renowned scientists show the width of their discipline to the reader This book is just such a rarity a veritable gem It was written to celebrate the 50th anniversary of the mathematical research institute at Oberwolfach The articles span a range of topics from general reflections on the place of mathematics in contemporary culture to essays dealing with aspects of algebra analysis geometry coding theory scientific computing and topology All essays are interrelated proving the old rule that you can divide and still conquer A book in which every mathematician or scientist interested in mathematics will find something to take their fancy

Minimal Surfaces I Ulrich Dierkes, Stefan Hildebrandt, Albrecht Küster, Ortwin Wohlrab, 2013-11-27 Minimal surfaces I is an introduction to the field of minimal surfaces and a presentation of the classical theory as well as of parts of the modern development centered around boundary value problems Part II deals with the boundary behaviour of minimal surfaces Part I is particularly apt for students who want to enter this interesting area of analysis and differential geometry which during the last 25 years of mathematical

research has been very active and productive Surveys of various subareas will lead the student to the current frontiers of knowledge and can also be useful to the researcher The lecturer can easily base courses of one or two semesters on differential geometry on Vol 1 as many topics are worked out in great detail Numerous computer generated illustrations of old and new minimal surfaces are included to support intuition and imagination Part 2 leads the reader up to the regularity theory for nonlinear elliptic boundary value problems illustrated by a particular and fascinating topic There is no comparably comprehensive treatment of the problem of boundary regularity of minimal surfaces available in book form This long awaited book is a timely and welcome addition to the mathematical literature

Minimal Surfaces II Ulrich Dierkes, Stefan Hildebrandt, Albrecht Küster, Ortwin Wohlrab, 2013-03-14 Minimal Surfaces I is an introduction to the field of minimal surfaces and a presentation of the classical theory as well as of parts of the modern development centered around boundary value problems Part II deals with the boundary behaviour of minimal surfaces Part I is particularly apt for students who want to enter this interesting area of analysis and differential geometry which during the last 25 years of mathematical research has been very active and productive Surveys of various subareas will lead the student to the current frontiers of knowledge and can also be useful to the researcher The lecturer can easily base courses of one or two semesters on differential geometry on Vol 1 as many topics are worked out in great detail Numerous computer generated illustrations of old and new minimal surfaces are included to support intuition and imagination Part 2 leads the reader up to the regularity theory for nonlinear elliptic boundary value problems illustrated by a particular and fascinating topic There is no comparably comprehensive treatment of the problem of boundary regularity of minimal surfaces available in book form This long awaited book is a timely and welcome addition to the mathematical literature

Regularity of Minimal Surfaces Ulrich Dierkes, Stefan Hildebrandt, Anthony Tromba, 2010-08-16 Regularity of Minimal Surfaces begins with a survey of minimal surfaces with free boundaries Following this the basic results concerning the boundary behaviour of minimal surfaces and H surfaces with fixed or free boundaries are studied In particular the asymptotic expansions at interior and boundary branch points are derived leading to general Gauss Bonnet formulas Furthermore gradient estimates and asymptotic expansions for minimal surfaces with only piecewise smooth boundaries are obtained One of the main features of free boundary value problems for minimal surfaces is that for principal reasons it is impossible to derive a priori estimates Therefore regularity proofs for non minimizers have to be based on indirect reasoning using monotonicity formulas This is followed by a long chapter discussing geometric properties of minimal and H surfaces such as enclosure theorems and isoperimetric inequalities leading to the discussion of obstacle problems and of Plateau's problem for H surfaces in a Riemannian manifold A natural generalization of the isoperimetric problem is the so called thread problem dealing with minimal surfaces whose boundary consists of a fixed arc of given length Existence and regularity of solutions are discussed The final chapter on branch points presents a new approach to the theorem that area minimizing solutions of Plateau's problem have no interior

branch points **Quantum Field Theory I: Basics in Mathematics and Physics** Eberhard Zeidler, 2007-04-18 This is the first volume of a modern introduction to quantum field theory which addresses both mathematicians and physicists at levels ranging from advanced undergraduate students to professional scientists The book bridges the acknowledged gap between the different languages used by mathematicians and physicists For students of mathematics the author shows that detailed knowledge of the physical background helps to motivate the mathematical subjects and to discover interesting interrelationships between quite different mathematical topics For students of physics fairly advanced mathematics is presented which goes beyond the usual curriculum in physics **Geometric Methods in Physics XXXVI** Piotr Kielanowski, Anatol Odziejewicz, Emma Previato, 2019-03-11 This book collects papers based on the XXXVI Bia owie a Workshop on Geometric Methods in Physics 2017 The Workshop which attracts a community of experts active at the crossroads of mathematics and physics represents a major annual event in the field Based on presentations given at the Workshop the papers gathered here are previously unpublished at the cutting edge of current research and primarily grounded in geometry and analysis with applications to classical and quantum physics In addition a Special Session was dedicated to S Twareque Ali a distinguished mathematical physicist at Concordia University Montreal who passed away in January 2016 For the past six years the Bia owie a Workshops have been complemented by a School on Geometry and Physics comprising a series of advanced lectures for graduate students and early career researchers The extended abstracts of this year s lecture series are also included here The unique character of the Workshop and School series is due in part to the venue a famous historical cultural and environmental site in the Bia owie a forest a UNESCO World Heritage Centre in eastern Poland Lectures are given in the Nature and Forest Museum and local traditions are interwoven with the scientific activities *Compact Riemann Surfaces* R. Narasimhan, 1992-09-01 The lecture notes forming a course given by the author at the Eidgenossische Technische Hochschule Zurich from November 1984 to February 1985 Presents the basic theorems about the Jacobian from Riemann s own point of view Annotation copyrighted by Book News Inc Portland OR **The Geometric Theory of Complex Variables** Peter V. Dovbush, Steven G. Krantz, 2025-01-28 This book provides the reader with a broad introduction to the geometric methodology in complex analysis It covers both single and several complex variables creating a dialogue between the two viewpoints Regarded as one of the grand old ladies of modern mathematics complex analysis traces its roots back 500 years The subject began to flourish with Carl Friedrich Gauss s thesis around 1800 The geometric aspects of the theory can be traced back to the Riemann mapping theorem around 1850 with a significant milestone achieved in 1938 with Lars Ahlfors s geometrization of complex analysis These ideas inspired many other mathematicians to adopt this perspective leading to the proliferation of geometric theory of complex variables in various directions including Riemann surfaces Teichm ller theory complex manifolds extremal problems and many others This book explores all these areas with classical geometric function theory as its main focus Its accessible and gentle approach makes it

suitable for advanced undergraduate and graduate students seeking to understand the connections among topics usually scattered across numerous textbooks as well as experienced mathematicians with an interest in this rich field *Handbook of Global Analysis* Demeter Krupka, David Saunders, 2011-08-11 This is a comprehensive exposition of topics covered by the American Mathematical Society's classification Global Analysis dealing with modern developments in calculus expressed using abstract terminology It will be invaluable for graduate students and researchers embarking on advanced studies in mathematics and mathematical physics This book provides a comprehensive coverage of modern global analysis and geometrical mathematical physics dealing with topics such as structures on manifolds pseudogroups Lie groupoids and global Finsler geometry the topology of manifolds and differentiable mappings differential equations including ODEs differential systems and distributions and spectral theory variational theory on manifolds with applications to physics function spaces on manifolds jets natural bundles and generalizations and non commutative geometry Comprehensive coverage of modern global analysis and geometrical mathematical physics Written by world experts in the field Up to date contents **Hamiltonian Reduction by Stages** Jerrold E. Marsden, Gerard Misiolek, Juan-Pablo Ortega, Matthew Perlmutter, Tudor S. Ratiu, 2007-06-05 This volume provides a detailed account of the theory of symplectic reduction by stages along with numerous illustrations of the theory It gives special emphasis to group extensions including a detailed discussion of the Euclidean group the oscillator group the Bott Virasoro group and other groups of matrices The volume also provides ample background theory on symplectic reduction and cotangent bundle reduction Topics in Combinatorial Group Theory Gilbert Baumslag, 2012-12-06 Combinatorial group theory is a loosely defined subject with close connections to topology and logic With surprising frequency problems in a wide variety of disciplines including differential equations automorphic functions and geometry have been distilled into explicit questions about groups typically of the following kind Are the groups in a given class finite e.g. the Burnside problem Finitely generated Finitely presented What are the conjugates of a given element in a given group What are the subgroups of that group Is there an algorithm for deciding for every pair of groups in a given class whether they are isomorphic or not The objective of combinatorial group theory is the systematic development of algebraic techniques to settle such questions In view of the scope of the subject and the extraordinary variety of groups involved it is not surprising that no really general theory exists These notes bridging the very beginning of the theory to new results and developments are devoted to a number of topics in combinatorial group theory and serve as an introduction to the subject on the graduate level Differential and Riemannian Manifolds Serge Lang, 2012-12-06 This is the third version of a book on differential manifolds The first version appeared in 1962 and was written at the very beginning of a period of great expansion of the subject At the time I found no satisfactory book for the foundations of the subject for multiple reasons I expanded the book in 1971 and I expand it still further today Specifically I have added three chapters on Riemannian and pseudo Riemannian geometry that is covariant derivatives curvature and some applications up to the Hopf

Rinow and Hadamard Cartan theorems as well as some calculus of variations and applications to volume forms I have rewritten the sections on sprays and I have given more examples of the use of Stokes theorem I have also given many more references to the literature all of this to broaden the perspective of the book which I hope can be used among things for a general course leading into many directions The present book still meets the old needs but fulfills new ones At the most basic level the book gives an introduction to the basic concepts which are used in differential topology differential geometry and differential equations In differential topology one studies for instance homotopy classes of maps and the possibility of finding suitable differentiable maps in them immersions embeddings isomorphisms etc Encyclopaedia of Mathematics, Supplement III Michiel Hazewinkel, 2007-11-23 This is the third supplementary volume to Kluwer's highly acclaimed twelve volume Encyclopaedia of Mathematics This additional volume contains nearly 500 new entries written by experts and covers developments and topics not included in the previous volumes These entries are arranged alphabetically throughout and a detailed index is included This supplementary volume enhances the existing twelve volumes and together these thirteen volumes represent the most authoritative comprehensive and up to date Encyclopaedia of Mathematics available **The Index Theorem for Minimal Surfaces of Higher Genus** Friedrich Tomi, Anthony Tromba, 1995 In this paper we formulate and prove an index theorem for minimal surfaces of higher topological type spanning one boundary contour Our techniques carry over to surfaces with several boundary contours as well as to unoriented surfaces

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