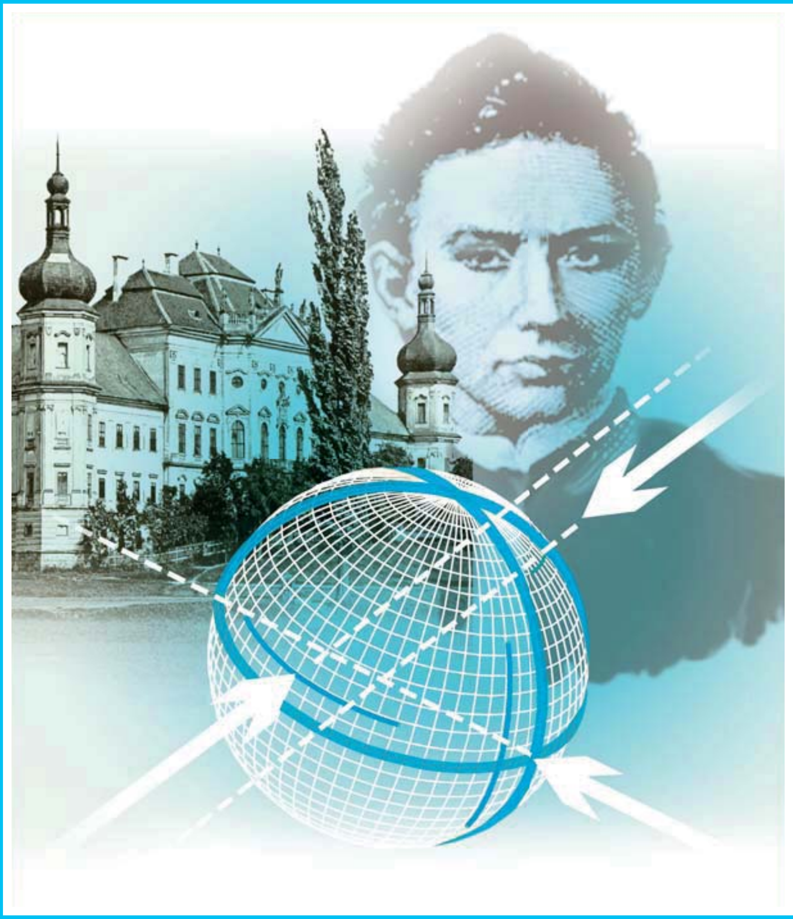

# DIFFERENTIAL GEOMETRY

## OF SPECIAL MAPPINGS

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Palacký University, Olomouc
Faculty of Science

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Olomouc 2015

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evropský sociální fond v ČR
EVROPSKÁ UNIE
MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY
OP Vzdělávání pro konkurenceschopnost
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

This product is co-financed by the European Social Fund and the state budget of the Czech Republic, project POST-UP, reg. number CZ.1.07/2.3.00/30.0004.

First Edition



ISBN 978-80-244-4671-4

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**Differential Geometry of Special Mappings**

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Responsible Editor Mgr. Jana Kopečková
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Published and printed by Palacky University, Olomouc
Křížkovského 8, 771 47 Olomouc
www.vydavatelstvi.upol.cz
www.e-shop.cz
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First Edition

Olomouc 2015

Edition Series – Monographs

ISBN 978-80-244-4671-4

Not for sale

# CONTENTS

# INTRODUCTION

During the last 50 years, many new and interesting results have appeared in the theory of conformal, geodesic, holomorphically projective, $F$-planar and others mappings and transformations of manifolds with affine connection, Riemannian, Kähler and Riemann-Finsler manifolds. The authors dedicate the present monograph to the exposition of this topic.

Problems connected with this field were considered in many monographs, surveys (pp. 513–518) and dissertation theses (pp. 519–520).

In the theory of geodesic, conformal and holomorphically projective mappings and some generalizations, three main directions have been specified:

- the investigation of general laws and rules;
- the integration of basic equations, and
- the investigations for special spaces.

Recently, new results that were not reflected in the papers mentioned above have been obtained. On the one hand, some results of a general character, on the other hand, results concerning mappings of special manifolds with affine connection and Riemannian spaces, including spaces of constant curvature, Kählerian, Einsteinian spaces, conformally flat spaces, etc.

Many works have been dedicated to the problem of non-existence of conformal, geodesic and holomorphically projective mappings and transformations, and concircular vector fields in spaces of a special kind. Such problems are often closely related. However, much attention has not been paid to their investigation yet. New results on the integration of basic geodesic mappings equations are considered in the review [9, 11] and in the monograph [10] by A.V. Aminova.

We give the basic concepts of the theory of manifolds with affine connection, Riemannian, Kählerian and Riemann-Finsler manifolds, using the notation from [50, 51, 118, 119, 121, 122, 139, 156, 170, 173, 200].

Unless otherwise stated, the investigations are carried out in tensor form, locally, in the class of sufficiently smooth real functions. The dimension $n$ of the spaces under consideration is supposed to be higher than two, as a rule. This fact is not explicitly stipulated in the text. All the spaces are assumed to be connected. Under Riemannian manifolds we mean both positive as well as pseudo-Riemannian manifolds.

The book was edited by J. Mikeš, E. Stepanova, A. Vanžurová. The book consists of 15 chapters. The first four chapters of the book are of introductory character, and include also some historical remarks.

*Chapter 1* treats the basic concepts of topological spaces (Vanžurová, Mikeš).

*Chapter 2* treats the theory of manifolds with affine connection. Particularly, the problem of semi-geodesic coordinates (Mikeš, Hinterleitner, Vanžurová).

*Chapter 3* is devoted to Riemannian and Kähler manifolds. Particularly, reconstruction of a metric (Mikeš, Vanžurová), equidistant spaces (Mikeš, Chepurna, Chodorová, Hinterleitner), variational problems in Riemannian spaces (Mikeš, Hinterleitner, Smetanová, Stepanova, Vanžurová), $SO(3)$-structure as a model of statistical manifolds (Mikeš, Stepanova), decomposition of tensors (Mikeš, Jukl, Juklová).

*Chapter 4* is devoted to the theory of differentiable mappings and transformations of manifolds. Among others we mention the problem of metrization of affine connection (Vanžurová), harmonic diffeomorphisms (Stepanov, Shandra).

*Chapter 5* treats conformal mappings and transformations. Especially conformal mappings onto Einstein spaces (Mikeš, Gavrilchenko), conformal transformations of Riemannian manifolds (Mikeš, Moldobayev).

*Chapter 6* is devoted to geodesic mappings (GM). We stress geodesic equivalence of a manifold with affine connection to an equiaffine manifold (Mikeš, Hinterleitner).

*Chapter 7.* We examine GM onto Riemannian manifolds (Mikeš, Berezovski, Hinterleitner).

*Chapter 8* treats GM between Riemannian manifolds. Among others GM of equidistant spaces, GM of $\mathbb{V}_n(B)$ spaces (Mikeš, Hinterleitner), and its field of symmetric linear endomorphisms (Mikeš, Stepanova, Tsyganok).

*Chapter 9* is devoted to GM of special spaces, particularly Einstein, Kähler, pseudo-symmetric manifolds and their generalizations (Mikeš, Hinterleitner, Shiha, Sobchuk).

*Chapter 10* treats global geodesic mappings and deformations, GM between Riemannian manifolds of different dimensions (Stepanov), global GM (Mikeš, Chudá, Hinterleitner). Geodesic deformations of hypersurfaces in Riemannian spaces (Mikeš, Gavrilchenko, Hinterleitner).

*Chapter 11.* We give some applications of GM to general relativity, namely we present three invariant classes of the Einstein equations and geodesic mappings (Stepanov, Jukl, Mikeš).

*Chapter 12* treats $F$-planar mappings of spaces with affine connection (Mikeš, Chudá, Hinterleitner, Peška).

*Chapter 13.* We examine holomorphically projective mappings (HPM) of Kähler manifolds. Among others fundamental equations of HPM, HPM of special Kähler manifolds(Mikeš, Chudá, Haddad, Hinterleitner), HPM of parabolic Kähler manifolds (Mikeš, Chudá, Peška, Shiha).

*Chapter 14* deals with almost geodesic mappings, which generalize geodesic mappings (Berezovski, Mikeš, Vanžurová).

*Chapter 15* is devoted to Riemann-Finsler spaces and their geodesic mappings (Bácsó), geodesic mappings of Berwald spaces onto Riemannian spaces (Bácsó, Berezovski, Mikeš).

We would like to stress that we use here the classical definition of geodesics, i.e. with a general parameter, which is widely used in applications in theoretical physics. Further note that the definition of the Ricci tensor was splitted, since 1950' its sign is used with an opposite sign, see [170]. We go back to the original notation, L.P. Eisenhart [50].

Some parts of the text are based on several graduate courses on topology, differential geometry, tensor analysis, Riemannian geometry, geodesic mappings, holomorphically mappings and Lie groups given by N.S. Sinyukov, M.L. Gavrilchenko and J. Mikeš at Odessa State University and topology by A. Vanžurová at Palacky University in Olomouc.

The authors believe that the text might evoke interest and might be helpful for post-graduate students in mathematics, geometry or physics as well as for research-work specialists in these fields.

We wish to express our deep appreciation to our referees, Professors M. Doupovec, M. Kureš.

We are also grateful to M. Závodný, L. Rachůnek and V. Heinz for preparing the figures and the final camera-ready copy of the text.

We appologize to our readers for all pertinent mistakes.

This work was supported by the project POST-UP CZ 1.07/2.3.00/30.0004.

May 2015

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# SUBJECT INDEX

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**Differential Geometry of Special Mappings**

Executive Editor prof. RNDr. Zdeněk Dvořák, DrSc.
Responsible Editor Mgr. Jana Kopečková
Layout prof. RNDr. Josef Mikeš, DrSc.
Cover Design Vilém Heinz

The autors take response for contents and correctness of their texts.

Published and printed by Palacky University, Olomouc
Křížkovského 8, 771 47 Olomouc
www.vydavatelstvi.upol.cz
www.e-shop.cz
vup@upol.cz

First Edition

Olomouc 2015

Edition Series – Monographs

ISBN 978-80-244-4671-4

Not for sale

## János Bolyai, *1802–1860*

*Born in Kolozsvár (Cluj), a Hungarian soldier and mathematician. Between 1820 and 1823 J. Bolyai prepared a treatise on a complete concept of non-Euclidean geometry, independently of the results of N. I. Lobachevski (1792–1856) and K. Gauss (1777–1855). Bolyai's work was published in 1832 as an Appendix to a mathematics textbook written by his father.*

*I tis of interest to mention that for a short period (1832–1833) of his military service J. Bolyai was soldier of a garrison in Olomouc (Czech Republic, late Olmütz) as evidenced by his memory inscription at his bust set up in the Olomouc Army House.*

*Ivestigation of geodesic mappings by Beltrami in 1865 marked the beginning of the general acceptance of Bolyai, Gauss and Lobachevski results.*

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