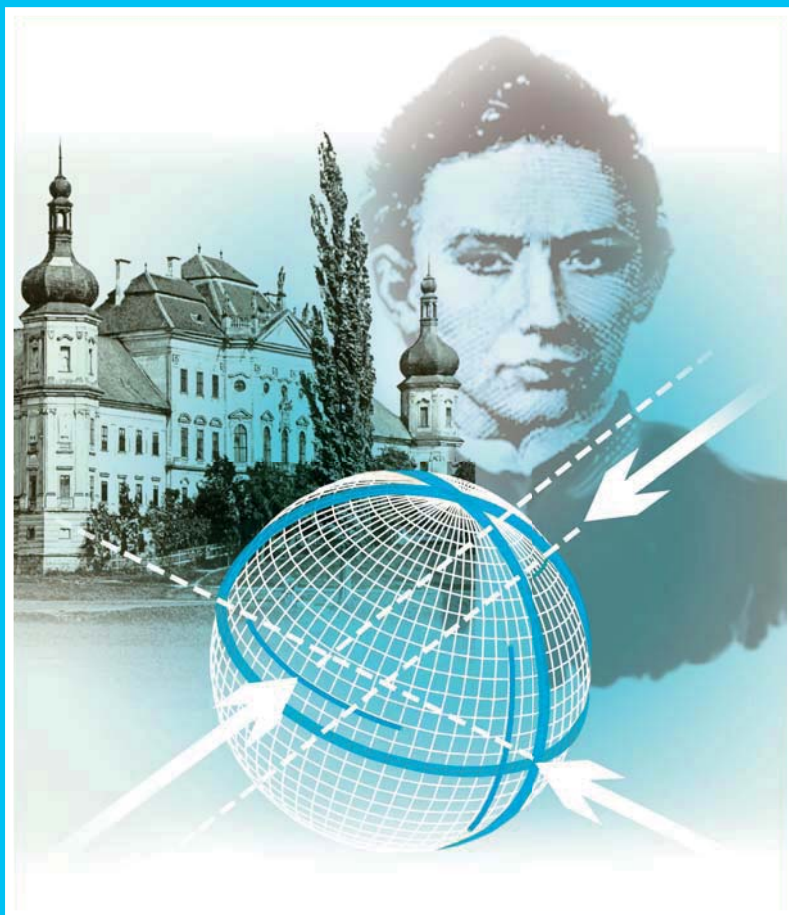




DIFFERENTIAL GEOMETRY

OF
SPECIAL MAPPINGS

Josef Mikeš
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Palacký University, Olomouc
Faculty of Science

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Olomouc 2015

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CONTENTS

INTRODUCTION	17
1 TOPOLOGICAL SPACES	21
1.1 From metric spaces to abstract topological spaces	21
1.1.1 A couple of examples	22
1.1.2 Euclidean space	23
1.1.3 Natural topology on metric space	23
1.1.4 Isometry of metric spaces	24
1.1.5 Abstract topological spaces, topology	25
1.1.6 Examples of topological spaces	25
1.2 Generating of topologies	27
1.2.1 Closed sets	27
1.2.2 Closure operator. Accumulation points	28
1.2.3 Interior, exterior, boundary	28
1.2.4 The lattice of topologies. Ordering	29
1.2.5 Metrization problem	30
1.2.6 Cover, subcover	30
1.2.7 Bases. Countability Axioms	30
1.2.8 Sequences in topological spaces, nets	33
1.3 Continuous maps	33
1.3.1 Continuous maps of topological spaces	34
1.3.2 Homeomorphisms	35
1.3.3 Topological invariants	36
1.4 Constructions of new topological spaces from given spaces	36
1.4.1 Projectively and inductively generated topologies	36
1.4.2 Subspace and product	37
1.4.3 Sum and quotient	38
1.4.4 The quotient topology	39
1.5 Connectedness	40
1.5.1 Path-connected spaces	40
1.5.2 Connected topological spaces	40
1.6 Separation properties	42
1.6.1 The Hausdorff separation axiom	43
1.6.2 Separation by continuous functions	44
1.6.3 Tychonoff spaces	45
1.7 Compactness	46
1.7.1 Compact topological spaces	47
1.7.2 Compactification	48
1.7.3 Local compactness	49
1.7.4 Partition of unity	49
1.7.5 Paracompactness	50

1.8	Metrization of a topological space	51
1.8.1	Metrization Theorems	51
1.8.2	Some properties of metric and metrizable spaces	52
1.8.3	Complete metric spaces	52
1.9	Topological algebraic structures	53
1.9.1	Topological groups	53
1.9.2	Topological vector spaces	55
1.10	Fundamental group	55
1.10.1	Homotopic maps	56
1.10.2	Loops	58
1.10.3	Homotopy of paths and loops	58
1.10.4	Construction of the fundamental group	59
1.11	Topological manifolds	62
1.11.1	Surfaces	62
1.11.2	Hypersurface	65
1.11.3	Topological manifold	65
1.11.4	Charts, atlas	66
1.11.5	The classification of compact connected 2-manifolds	66
2	MANIFOLDS WITH AFFINE CONNECTION	69
2.1	Differentiable manifolds	69
2.1.1	Differentiable structure (complete atlas)	69
2.1.2	Smooth map, diffeomorphism	70
2.1.3	Tangent vector, tangent space, tangent bundle	71
2.1.4	Differential map	72
2.1.5	Curve, tangent vector of a curve	73
2.1.6	Vector field, flow	74
2.1.7	Distributions	76
2.1.8	One-forms	76
2.2	Tensor fields and geometric objects	77
2.2.1	Tensors on a vector space	77
2.2.2	Tensors on manifolds	79
2.2.3	Geometric objects on manifolds	80
2.3	Manifolds with affine connection	82
2.3.1	Affine connections, manifolds with affine connection	82
2.3.2	Covariant differentiation	83
2.3.3	Curvature and Ricci tensor	84
2.3.4	Flat, Ricci flat and equiaffine manifolds	85
2.3.5	Parallel transport of vectors and tensors	86
2.3.6	Geodesics	88
2.3.7	Some remarks on definitions for geodesics	89
2.4	Special coordinate systems and reconstructions	92
2.4.1	Affine coordinates and flat manifolds	92
2.4.2	Geodesic coordinates in a point, Fermi and Riemann coordinates	92
2.4.3	Pre-semigeodesic coordinates	94
2.4.4	Reconstruction of connection	97

2.5	On systems of partial differential equations of Cauchy type	100
2.5.1	Systems of PDEs of Cauchy type in $\mathbb{R}^n$	100
2.5.2	On mixed systems of PDEs of Cauchy type in $\mathbb{R}^n$	101
2.5.3	On a mixed linear system of PDEs of Cauchy type in $\mathbb{R}^n$	102
2.5.4	Mixed PDEs in tensor form	102
2.5.5	On systems of PDEs of Cauchy type in manifolds	102
2.5.6	Application	104
3	RIEMANNIAN AND KÄHLER MANIFOLDS	107
3.1	Riemannian manifolds $\mathbb{V}_n$, i.e. Riemannian and pseudo-Riemannian manifolds	107
3.1.1	Riemannian metric	107
3.1.2	Length of vector and arc, angle and volume	109
3.1.3	Isometric diffeomorphisms	110
3.1.4	Levi-Civita connection and Riemannian tensor	110
3.1.5	Parallel transport and geodesics	112
3.2	Special Riemannian manifolds	113
3.2.1	Subspaces of Riemannian spaces	113
3.2.2	Sectional curvature and Spaces of constant curvature	114
3.2.3	Einstein spaces	115
3.2.4	Hypersurfaces	116
3.3	Special coordinates in Riemannian spaces	117
3.3.1	Normal coordinates	117
3.3.2	Coordinates generated by a system of orthogonal hypersurfaces	117
3.3.3	Semigeodesic coordinates	118
3.3.4	Reconstruction of the metric in semigeodesic coordinates	120
3.4	Variational properties in Riemannian spaces	122
3.4.1	Variational problem	122
3.4.2	Variational problem of geodesics in Riemannian spaces	123
3.4.3	Generalized variational problem for geodesics	125
3.4.4	Applications of geodesics	126
3.4.5	Isoperimetric extremals of rotation	127
3.4.6	On new equations of isoperimetric extremals of rotation	129
3.4.7	On the existence of isoperimetric extremals of rotation	131
3.5	Kähler manifolds	132
3.5.1	Definition and basic properties of Kähler manifolds	132
3.5.2	Canonical coordinates on Kähler manifolds	133
3.5.3	The operation of conjugation	135
3.5.4	Holomorphic curvature	137
3.5.5	Space of constant holomorphic curvature	137
3.5.6	Analytic vector fields	138
3.6	Equidistant spaces	140
3.6.1	Torse-forming and concircular vector fields	140
3.6.2	On differentiability of functions with special conditions	142
3.6.3	Fundamental equations of concircular vector fields for minimal differentiable conditions	143

3.6.4	A space with affine connection which admits at least two linearly independent concircular vector fields . . .	145
3.6.5	A Riemannian space which admits at least two linearly independent concircular vector fields . . .	147
3.6.6	Concircular and convergent vector fields on compact manifolds with affine connection	149
3.6.7	Applications of the achieved results	149
3.6.8	Equidistant manifolds and special coordinate system	150
3.6.9	Einstein equidistant manifolds and the theory of relativity . . .	151
3.6.10	Equidistant Kähler spaces	153
3.6.11	On Sasaki spaces and equidistant Kähler manifolds	154
3.7	A five-dimensional Riemannian manifold with an irreducible $SO(3)$-structure as a model of statistical manifold	156
3.7.1	Information geometry	156
3.7.2	An abstract statistical manifold	156
3.7.3	An irreducible $SO(3)$ -structure	157
3.7.4	The model of a statistical manifold	158
3.7.5	On a conjugate symmetric statistical manifold	160
3.7.6	On a nearly integrable $SO(3)$ -structure	163
3.8	Traceless decomposition of tensors	166
3.8.1	Introduction	166
3.8.2	On decomposition of tensors on manifolds	166
3.8.3	F -traceless decomposition	171
3.8.4	Quaternionic trace decomposition	176
3.8.5	Generalized decomposition problem for Ricci and Riemannian tensors	178
3.8.6	Traceless decomposition and recurrency	179
4	MAPPINGS AND TRANSFORMATIONS OF MANIFOLDS	181
4.1	Theory of Mappings	181
4.1.1	Introduction to mappings and transformation theory	181
4.1.2	Formalism of a “common coordinate system”	181
4.1.3	Formalism of a “common manifold”	181
4.1.4	Deformation tensor of a mapping	181
4.1.5	On equations of mappings onto Riemannian manifolds	183
4.2	Transformation Lie Groups	184
4.2.1	Introduction	184
4.2.2	Transformation Groups	184
4.2.3	Continuous transformation groups. Lie groups.	185
4.2.4	One-parameter groups of continuous transformations	186
4.2.5	Lie derivative	187
4.3	Affine mappings and transformations	189
4.3.1	Affine mappings of manifolds with affine connection	189
4.3.2	Affine mappings onto Riemannian manifolds	191
4.3.3	Product manifolds and affine mappings	191
4.3.4	Affine motions	192

4.4	Isometric mappings and transformations	193
4.4.1	Fundamental equations of isometric mappings	193
4.4.2	On local isometry of spaces of constant curvature	195
4.4.3	On local isometry of spaces of constant holomorphic curvature	195
4.4.4	Groups of motions	196
4.5	Homothetic mappings and transformations	198
4.5.1	Homothetic mappings	198
4.5.2	Groups of homothetic motions	198
4.5.3	Transformation groups and special mappings	199
4.6	Metric connections, Metrization problem	201
4.6.1	Metrization according to Eisenhart and Veblen	202
4.6.2	Application to the calculus of variations	205
4.6.3	Metrization in dimension two	206
4.6.4	Metrization via holonomy groups and holonomy algebras	212
4.6.5	Decision Algorithm	221
4.6.6	Metrization of connections with regular curvature	223
4.7	Harmonic diffeomorphisms and transformations	229
4.7.1	Harmonic diffeomorphisms	229
4.7.2	Harmonic transformations	230
5	CONFORMAL MAPPINGS AND TRANSFORMATIONS	235
5.1	Conformal and isometric mappings	235
5.1.1	Introduction to the theory of conformal and isometric mappings	235
5.2	Main properties of conformal mappings	237
5.2.1	Fundamental equations of conformal mappings	237
5.2.2	Equivalence classes of conformal mappings	237
5.3	Some geometric objects under conformal mappings	238
5.3.1	Christoffel symbols under conformal mappings	238
5.3.2	Riemannian and Ricci tensor under conformal mappings	239
5.3.3	Weyl tensor of conformal curvature	239
5.4	Conformally flat manifolds	240
5.5	Conformal mappings onto Einstein spaces	242
5.5.1	Linear equations of conformal mappings onto Einstein spaces	242
5.5.2	On the quantity of the solution's parameters	243
5.5.3	Conformal mappings onto 4-dimensional Einstein spaces	244
5.5.4	Conformal mappings from symmetric spaces onto Einstein spaces	244
5.5.5	Conformal mappings onto Einstein spaces "in the large"	246
5.6	Concircular mappings	247
5.6.1	Concircular mappings	247
5.6.2	Conformal mappings preserving the Einstein tensor	248
5.6.3	Conformal mappings between Einstein spaces	249
5.7	Conformal transformations	250
5.7.1	Groups of conformal transformations	250
5.7.2	Criterion of conformal flatness	251
5.7.3	On the lacunarity of the degree of conformal motions	253
5.7.4	Riemannian space of second lacunarity of conformal motions	255

6 GEODESIC MAPPINGS	
OF MANIFOLDS WITH AFFINE CONNECTION	257
6.1 Geodesic mappings	257
6.1.1 Introduction to geodesic mappings theory	257
6.1.2 Examples of geodesic mappings	258
6.2 Fundamental properties of geodesic mappings	259
6.2.1 Levi-Civita equations of geodesic mappings	259
6.2.2 Equivalence classes of geodesic mappings	262
6.2.3 Thomas projective parameter	263
6.2.4 Manifold with projective connection	264
6.2.5 Riemannian and Ricci tensor under geodesic mappings	265
6.2.6 Weyl tensor of projective curvature	266
6.2.7 Geodesic mappings of equiaffine manifolds	267
6.3 Projectively flat manifolds	269
6.3.1 Geodesic mappings of projectively flat manifolds	269
6.3.2 Characterization of projectively flat manifolds	270
6.4 Projective transformations	272
7 GEODESIC MAPPINGS	
ONTO RIEMANNIAN MANIFOLDS	275
7.1 Fundamental equations of GM: $\mathbb{A}_n \rightarrow \overline{\mathbb{V}}_n$	275
6.1.1 Levi-Civita equations of geodesic mappings	275
6.1.2 Cauchy type equations of GM of $\mathbb{A}_n$ onto $\overline{\mathbb{V}}_n$	276
6.1.3 On the mobility degree with respect to geodesic mappings	277
7.2 Linear equations of the theory of geodesic mappings	280
6.2.1 Mikeš-Berezovski equations of geodesic mappings	280
6.2.2 Linear equations of geodesic mappings $\mathbb{A}_n \rightarrow \overline{\mathbb{V}}_n$	282
6.2.3 Geodesic mappings $\mathbb{P}_n \rightarrow \overline{\mathbb{V}}_n$ for $\mathbb{P}_n \in C^2$ and $\overline{\mathbb{V}}_n \in C^1$	283
6.2.4 Example	285
7.3 Geodesic mappings of special manifolds	286
6.3.1 Geodesic mappings of semisymmetric manifolds	286
6.3.2 Geodesic mappings of generalized recurrent manifolds	292
8 GEODESIC MAPPINGS	
BETWEEN RIEMANNIAN MANIFOLDS	297
8.1 General results on geodesic mappings between $\mathbb{V}_n$	297
6.1.1 Levi-Civita and Sinyukov equations of geodesic mappings	297
6.1.2 Sinyukov Γ -transformations of geodesic mappings	298
8.2 Classical examples of geodesic mappings	299
6.2.1 Lagrange and Beltrami projections	299
6.2.2 Dimension two	299
6.2.3 Levi-Civita metrics	300
8.3 Geodesic mappings and equidistant spaces	301
8.4 Manifolds $\mathbb{V}_n(B)$	303
6.4.1 Geodesic mappings of $\mathbb{V}_n(B)$ spaces	303
6.4.2 Properties of the spaces $\mathbb{V}_n(B)$	305

8.4.3	Projective transformations and manifolds $\mathbb{V}_n(B)$	306
8.4.4	Geodesically complete manifolds $\mathbb{V}_n(B)$	308
8.5	GM and its field of symmetric linear endomorphisms .	311
8.5.1	Geodesic mappings in terms of linear algebra	311
8.5.2	GM of complete noncompact Riemannian manifolds	315
9	GEODESIC MAPPINGS	
	OF SPECIAL RIEMANNIAN MANIFOLDS	317
9.1	Geodesic mappings of spaces of constant curvature . .	317
9.1.1	Spaces of constant curvature	317
9.1.2	Geodesic mappings of spaces of constant curvature	318
9.2	Geodesic mappings of Einstein spaces	320
9.2.1	Einstein spaces are closed under geodesic mappings	320
9.2.2	Einstein spaces admit projective transformations	320
9.2.3	Metrics of Einstein manifolds admitting geodesic mappings . .	321
9.2.4	Local structure Theorem	323
9.2.5	Geodesic mappings of four-dimensional Einstein spaces	326
9.2.6	Petrov's conjecture on geodesic mappings of Einstein spaces . .	327
9.3	Geodesic mappings of pseudo-symmetric manifolds . .	328
9.3.1	T -pseudo-symmetric manifolds	328
9.3.2	Geodesic mappings of c_i - and c_{ij} -pseudosymmetric $\mathbb{V}_n$	330
9.3.3	Geodesic mappings of T -pseudosymmetric manifolds	332
9.4	Generalized symmetric, recurrent and semisymmetric $\mathbb{V}_n$	335
9.4.1	GM of semisymmetric spaces and their generalizations	336
9.4.2	Geodesic mappings of spaces with harmonic curvature	338
9.5	Geodesic mappings of Kähler manifolds	340
9.5.1	Introduction	340
9.5.2	GM of $\mathbb{K}_n$ which preserve the structure tensor	340
9.5.3	Geodesic mappings onto Kähler manifolds	341
9.5.4	Geodesic mappings between Kähler manifolds	342
10	GLOBAL GEODESIC MAPPINGS AND DEFORMATIONS	345
10.1	On the theory of geodesic mappings of Riemannian manifolds "in the large"	345
10.1.1	GM between Riemannian manifolds of different dimensions . .	346
10.1.2	Geodesic immersions	348
10.1.3	Geodesic submersions	348
10.2	Projective transformations and deformation of surfaces	350
10.2.1	Global projective transformation of n -sphere	350
10.2.2	Surface of revolution	353
10.2.3	On global geodesic mappings of ellipsoids	356
10.2.4	Compact orientable spaces L_n	360
10.2.5	Global geodesic mappings $\mathbb{V}_n$ onto $\overline{\mathbb{V}}_n$ with boundary	360
10.2.6	GM and principal orthonormal basis	361
10.3	On geodesic mappings with certain initial conditions .	362
10.3.1	On geodesic mappings with certain initial conditions	362

10.3.2	The first quadratic integral of a geodesic	364
10.3.3	On first quadratic integral of geodesics with initial conditions	365
10.4	Geodesic deformations of hypersurfaces	
	in Riemannian spaces	366
10.4.1	Infinitesimal deformations of Riemannian spaces	366
10.4.2	Geodesic deformations and geodesic maps	368
10.4.3	Geodesic deformations of subspaces of Riemannian spaces	369
10.4.4	Basic equations of geodesic deformations of hypersurfaces	369
10.4.5	A system of equations of Cauchy type for geodesic deformations of a hypersurface	371
11	APPLICATIONS OF GEODESIC MAPPINGS	375
11.1	Applications of geodesic mappings to general relativity	375
11.1.1	Agreement on terminology	375
11.1.2	Killing-Yano tensors	375
11.1.3	Geodesic mappings and integrals of the Killing-Yano equations	376
11.1.4	Closed conformal Killing-Yano tensors	376
11.1.5	Conformal Killing-Yano tensors	378
11.1.6	The pre-Maxwell equations	379
11.1.7	Operators of symmetries of Dirac equations	380
11.2	Three invariant classes of the Einstein equations and geodesic mappings	381
11.2.1	The Einstein equations	381
11.2.2	Invariantly defined seven classes of the Einstein equations	381
11.2.3	Einstein like manifolds of Killing type	381
11.2.4	Einstein like manifolds of Codazzi type	382
11.2.5	The class of Einstein like manifolds of Sinyukov type	383
12	F-PLANAR MAPPINGS AND TRANSFORMATIONS	385
12.1	On F-planar mappings of spaces with affine connections	385
12.1.1	Definitions of F -planar curves and F -planar mappings	385
12.1.2	Preliminary lemmas of linear and bilinear forms and operators	387
12.1.3	F -planar mappings which preserve F -structures	390
12.1.4	F -planar mappings which do not preserve F -structures	391
12.1.5	F -planar mappings for dimension $n = 2$	392
12.1.6	F -planar mappings with covariantly constant structure	392
12.2	F-planar mappings onto Riemannian manifolds	394
12.2.1	Fundamental equations of F -planar mappings onto $\mathbb{V}_n$	394
12.2.2	Equations of F -planar mappings in Cauchy form	394
12.2.3	Special F -planar mappings onto Riemannian manifolds	398
12.2.4	Fundamental equations of F_1 -planar mappings	399
12.2.5	Fundamental linear equations of F_2 -planar mappings	402
12.2.6	Generating F -planar mappings	404
12.3	Infinitesimal F-planar transformations	405
12.3.1	Definition of infinitesimal F -planar transformations	405
12.3.2	Basic equations of infinitesimal F -planar transformations	405

12.4	F-planar transformations	408
12.5	On F_2^ε-planar mappings of Riemannian manifolds	412
12.5.1	PQ^ε -projective Riemannian manifolds	412
12.5.2	Simplification of conditions (12.72) for $\varepsilon \neq 0$	413
12.5.3	F_2^ε -projective mapping with $\varepsilon \neq 0$	413
12.5.4	F_2^ε -planar mappings with the $\bar{g} = k \cdot g$ condition	415
13	HOLOMORPHICALLY PROJECTIVE MAPPINGS OF KÄHLER MANIFOLDS	417
13.1	Fundamental properties of HP mappings	418
13.1.1	Definition of holomorphically projective mappings	418
13.1.2	Equivalence classes of holomorphically projective mappings	420
13.1.3	Some geometric objects under HPM	420
13.1.4	Holomorphically projectively flat Kähler manifolds	421
13.2	Fundamental theorems of the theory of HP mappings	424
13.2.1	Linear fundamental equations of the theory of HPM	424
13.2.2	The first quadratic integral of geodesics and HP mappings	425
13.2.3	Fundamental equations of HPM in Cauchy form	426
13.2.4	Integrability conditions of fundamental equations of HPM	428
13.2.5	Reduction of fundamental equations of HP mappings	429
13.2.6	HP mappings of generalized recurrent Kähler manifolds	430
13.2.7	HP mappings with certain initial conditions	431
13.3	Manifolds $\mathbb{K}_n[B]$	432
13.3.1	Holomorphically projective mappings of $\mathbb{K}_n[B]$ spaces	432
13.3.2	Properties of the spaces $\mathbb{K}_n[B]$	434
13.3.3	On the degree of mobility of $\mathbb{K}_n$ relative to HPM	434
13.3.4	HP transformations and manifolds $\mathbb{K}_n[B]$	435
13.3.5	K -concurrent vector fields and HPM	437
13.3.6	Holomorphically complete manifolds $\mathbb{K}_n[B]$	437
13.4	HPM of special Kähler manifolds	439
13.4.1	HPM of T-k-pseudosymmetric Kähler manifolds	439
13.4.2	HPM of Einstein spaces and of their generalizations	441
13.4.3	Spaces that locally do not admit nontrivial HPM	442
13.5	HP mappings of parabolic Kähler spaces $\mathbb{K}_n^{o(m)}$	443
13.5.1	HP mappings theory for $\mathbb{K}_n^{o(m)} \rightarrow \overline{\mathbb{K}}_n^{o(\overline{m})}$	443
13.5.2	HP mappings of parabolic Kähler space of class C^2	446
13.5.3	HP mappings $\mathbb{K}_n^{o(m)} \rightarrow \overline{\mathbb{K}}_n^{o(\overline{m})}$ for $\mathbb{K}_n^{o(m)} \in C^r$ and $\overline{\mathbb{K}}_n^{o(\overline{m})} \in C^2$	447
13.5.4	Holomorphically projective flat parabolic Kähler spaces	449
13.5.5	On isometries between holomorphically-projective flat $\mathbb{K}_n^{o(m)}$	450
13.5.6	HP mappings of holomorphically-projective flat $\mathbb{K}_n^{o(m)}$	451
13.5.7	Metric of holomorphically-projective flat $\mathbb{K}_n^{o(m)}$	452

14 ALMOST GEODESIC MAPPINGS	455
14.1 Almost geodesic mappings	455
14.1.1 Almost geodesic curves	455
14.1.2 Almost geodesic mappings, basic definitions	457
14.1.3 On a classification of almost geodesic mappings	459
14.1.4 On a completeness classification of almost geodesic mappings	461
14.2 Almost geodesic mappings of type π_1	463
14.2.1 Canonical almost geodesic mappings $\tilde{\pi}_1$	463
14.2.2 Properties of the fundamental equations of $\tilde{\pi}_1$	464
14.2.3 Canonical almost geodesic mappings $\tilde{\pi}_1$ onto Riemannian spaces	466
14.2.4 Ricci-symmetric and generalized Ricci-symmetric spaces	469
14.2.5 AG mappings $\tilde{\pi}_1$ onto generalized Ricci-symmetric manifolds	470
14.3 π_1 mappings preserving n-orthogonal hypersurfaces	473
14.3.1 Mappings of $\mathbb{V}_n$ preserving a system n -orthogonal hypersurfaces	473
14.3.2 Special almost geodesic mappings of the type π_1	474
14.4 On special almost geodesic mappings of type π_1 of $\mathbb{A}_n$	477
14.4.1 Almost geodesic mappings π_1^*	477
14.4.2 An invariant object of mappings π_1^*	478
14.4.3 Mappings π_1^* of affine and projective-euclidean spaces	479
14.4.4 Examples of almost geodesic mappings π_1^*	480
15 RIEMANN-FINSLER SPACES	481
15.1 Riemann-Finsler spaces	481
15.1.1 Douglas spaces, Previous results	485
15.1.2 Douglas spaces	486
15.1.3 A generalization of Douglas spaces	492
15.2 Riemann-Finsler spaces with h-curvature tensor	493
15.2.1 Projective invariants	493
15.2.2 Q^3 -invariants	495
15.2.3 Behaviour of the Weyl tensor in Douglas spaces	496
15.2.4 On the rectifiability condition of a second ordinary differential equation	497
15.3 Riemann-Finsler spaces with h-curvature (Berwald curvature) tensor dependent on position alone	499
15.4 Projective changes between Riemann-Finsler spaces with (α, β)-metric	502
15.4.1 Preliminaries	502
15.4.2 The two-dimensional case	506
15.5 Geodesic mappings of weakly Berwald spaces and Berwald spaces onto Riemannian spaces ($\mathbb{V}_n$)	509
15.5.1 Geodesic mappings of weakly Berwald spaces onto $\mathbb{V}_n$	509
15.5.2 Geodesic mappings of Berwald spaces onto $\mathbb{V}_n$	510
15.5.3 Riemannian metrics having common geodesics with a Berwald metric	511

BIBLIOGRAPHY	513
Monographs and surveys	513
Theses	519
Papers	521
SUBJECT INDEX	547
NAME INDEX	557
AUTHORS	565

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, Čepurna, 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 $V_n(B)$ 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.

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⁹⁴⁾The symbol ▷ denotes: “English translation ▷ original”

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SUBJECT INDEX

- M – manifold, 69
- M_n – n -dimensional manifold, 69
- δ_i^h – Kronecker symbol, 84
- $\mathbb{A}_n$ – manifold with affine connection, 82
- ∇ – affine connection, 82
- Γ_{ij}^h – components of ∇ , 82
- R – curvature (Riemannian) tensor, 84
- R_{ijk}^h – components of R , 84
- Ric – Ricci tensor, 85
- R_{ij} – components of Ric , 85
- $\mathbb{V}_n$ – (pseudo-) Riemannian manifold, 108
- $\mathbb{F}_n$ – Riemann-Finsler manifold, 481
- $\mathbb{K}_n$ – Kähler manifold, 108
- $\mathcal{E}_n$ – Einstein space, 115
- g – metric tensor of $\mathbb{V}_n$, 287
- g_{ij} – components of g , 108
- g^{ij} – components of inverse of the matrix g_{ij} , 110
- ds^2 – metric form of $\mathbb{V}_n$, 113
- Γ_{ijk} – Christoffel symbol of I type, 238
- Γ_{ij}^h – Christoffel symbol of II type, 238
- R_{hijk} – components of Riemannian tensor, 110
- R – scalar curvature, 57, 111
- C – Weyl tensor of conformal curvature, 110
- W – Weyl tensor of projective, 266
- Y – Yano tensor of concircular curvature, 327
- C_{ijk}^h – components of tensor C , 240
- W_{ijk}^h – components of tensor W , 266
- Y_{ijk}^h – components of tensor Y , 248
- Z_{ijk}^h – components of tensor Z , 304
- $\mathcal{Z}_{ijk}^h$ – components of tensor $\mathcal{Z}$, 432
- “ , ” – covariant derivative on $\mathbb{A}_n$, 83
- $\mathcal{L}_X$ – Lie derivative, 187
- $\langle ij \rangle$ – differential operator, 328
- $\langle\langle ij \rangle\rangle$ – differential operator, 438
- Special manifolds:**
 - space of constant curvature, 114
 - space of constant holomorphic curvature, 137
 - A -spaces, 132
 - L_n -space, 339
 - L_n^* -space, 339
 - $V(K)$, 303
 - $\mathbb{V}_n(B)$, 303
 - $\mathbb{K}_n[B]$, 432
 - S_n^1 : symmetric, 286
 - K_n^1 : recurrent, 87
 - $RicS_n^1$: Ricci symmetric, 87
 - $RicK_n^1$: Ricci recurrent, 87
 - $TPs_n(0)$: T -semisymmetric, 329
 - $TPs_n^*(0)$: principal $TPs_n(0)$, 330
 - $Ps_n(0)$: semisymmetric, 329
 - $RicPs_n(0)$: Ricci semisymmetric, 329
 - $TPs_n(B)$: T -pseudosymmetric, 329
 - $TPs_n^*(B)$: principal $TPs_n(B)$, 330
 - $Ps_n(B)$: pseudosymmetric, 329
 - $RicPs_n(B)$: Ricci pseudosymmetric, 329
 - $TPs_n[B]$: T -k-symmetric $\mathbb{K}_n$, 438
 - $TPs_n^*[B]$: principal $TPs_n[B]$, 438
 - $Ps_n[B]$: k-symmetric $\mathbb{K}_n$, 438
 - $RicPs_n[B]$: Ricci ksymmetric $\mathbb{K}_n$, 438
 - F -planar curve, 385; mapping, 386; transformation, 408; infinitesimal, 405
 - F_1 -, F_2 - and F_3 -planar mapping, 398
 - F_2^ε -planar mapping, 412
 - F -traceless decomposition, 171

- C^r -mapping, 70
- K -concircular vector field, 435
- K -torse-forming vector, 435
- L_n -space, 339
- Q -traceless, 176
- Γ -transformation, 298
- n -dimensional Euclidean space, 26
- n -manifold, 65
- n -sphere, standard, 37

- accumulation point, 28,33
- affine coordinates, 92
- alternation of a tensor, 78
- analytically planar curve, 418
- antisymmetrization of a tensor, 78
- atlas, complete, 69
 - of the class C^0 , 66
 - real analytic, 69

- ball, open, 22
- base of topology, 31
- Bianchi identity, 84
- boundary of a set, 29
- bundle tangent, 72

- canonical parameter, 418
- Cartesian coordinate system, 108
- chart, 66
- charts C^r -related, 66
- Christoffel symbols, 110
- circle, standard, 37
- class
 - conformal, 238
 - geodesic, 263
 - holomorphically projective, 420
 - homotopy, 57
- closure of a subset, 28
- compact
 - locally, 49
 - topological space, 47
- compactification, Hausdorff, 48
- complete
 - A_n, V_n (geodesic), 89
 - of connectedness, 42
 - of the point, 40
 - vector field, 75
- components, 74
 - of a tensor, 77
 - of a vector field, 74
 - of affine connection, 82
- concircular
 - curvature tensor, 248, 327
 - mapping, 247
- conformal
 - class, 238
 - motion, 250
 - transformation, 236, 250
- congruence
 - normal equidistant, 288
- connected
 - topological space, 41
 - topological subspace, 41
- connection
 - affine, 82
 - Levi-Civita, 110
 - natural, 110
 - projective, 282, 283
 - symmetric, 83
 - torsion-free, 83
- conservation laws, 381
- continuous
 - function, 23
 - map, 23, 34
- contraction, 78, 80
- coordinate
 - expression of a mapping, 70
 - functions, 66
 - system Cartesian, 108
 - transformation, 70
- coordinates
 - affine, 92
 - Fermi, 92
 - geodesic, 118
 - normal, 117
 - pre-geodesic, 94
 - Riemann, 92
- covariant derivative
 - along the curve
 - of tensor field, 86
 - of vector field, 86
- covector, 76

- cover
 - of a set, 30
 - open, 30
- curvature, 84
 - holomorphic, 137
 - scalar, 318
 - sectional, 114
- curve
 - analytically planar, 418
 - F -planar, 385
 - geodesic, 123
 - integral, 74
 - regular, 74
 - segment, 73
- cycling of a tensor, 78
- cycloid, 90
- degree
 - of conformal motions, 250
 - of mobility, 196, 433
 - of mobility with respect
 - geodesic mappings, 257
 - HP mappings, 417
- delta Kronecker, 84
- dense, set, 28
- derivative covariant, 83
- diameter of a set, 22 3
- diffeomorphism, 70
 - local, 73
 - harmonic, 229
- Dirac equation, operator, 380
- directing, 33
- disc, 22
- displacement (vector) field, 366
- disconnected topological space, 41
- dot product, 21
- Douglas tensor, 482
- Einstein space, 114, 151
 - equidistant, 151
- Einstein-like manifold, 381
 - of Codazzi type, 382
 - of Killing type, 382
 - of Sinyukov type, 383
- elliptic Kähler manifold, 132, 208
- energy-momentum tensors, 381
- equations
 - Dirac, 380
 - Domashev-Mikeš-Kurbatova, 424
 - Euler-Lagrange, 123, 229
 - Gauss, 370
 - Levi-Civita, 275, 261
 - Mikeš-Berezovski, 276, 280
 - Sinyukov, 297
 - Weingarten, 370
- equations of mappings
 - affine, 189
 - concircular, 247
 - conformal, 235
 - F -planar, 386
 - geodesic, 130, 275, 261, 276, 280, 297
 - harmonic, 229
 - holomorphically projective, 419, 424, 446
 - homothetic, 198
 - isometric, 193
- equations of transformations
 - affine, 186
 - conformal, 250
 - F -planar, 408
 - holomorphically-projective , 435
 - homothetic, 198
 - isometric, 193
 - projective, 272
- equator, 350
- equidistant
 - manifold; vector field, 140
- equivalence classes of
 - conformal mappings, 237–238
 - geodesic mappings, 262
 - HP mappings, 420
- Euclidean space, 21, 23, 26
- Euler-Lagrange equations, 123, 229
- exterior of a set, 29
- extremal of the integral, 123
- fibre, 39
- field
 - displacement, 366
 - tensor, 79; vector, 74
- first quadratic integral
 - of geodesic, 364
- flat manifold, 85, 92, 108

- flow, local, 75
- form linear, 77; metric, 108; Ricci, 111
- formula Voss–Weyl, 111, 280
- frontier of a set, 29
- function, 81
 - continuous, 23
 - differentiable, 69
 - Lagrange, 122
 - on a manifold, 70
 - smooth, 69
- functions coordinate
 - of the chart, 66
- generalized
 - recurrent space, 293
 - semisymmetric space, 290
 - Douglas space, 490
- geodesic
 - class, 262
 - complete, 89
 - first quadratic integral, 309, 364
 - mapping, 257
 - equations, 261, 275, 276, 294
 - mobility degree, 277
 - parametrized, 91
 - canonical, 91
 - path, 91
 - pregeodesic, 91
 - transformation, 236, 258
 - unparametrized, 91
- geometry of paths, 202
- Glueing Lemma, 35
- gnomonic map (projection), 299
- group
 - first homotopy, 59, 60
 - fundamental, 59
 - local, one-parameter, 75
 - topological, 53
- group of harmonic transformations, 230
- group Lie, local, one-parameter, 184
- harmonic, 229
 - infinitesimal vector field, 230
 - diffeomorphism, 229
 - transformations, 230
- Hausdorff topological space, 47
- holomorphic curvature, 137
- holomorphically projective
 - class, 420
 - mapping, 418
 - motion, 434
 - transformation, 434
- homeomorphic spaces, 35
- homeomorphism map, 35
- homothetic
 - mapping and transformation, 198
- homotopy
 - from f to g , 56
 - relative to a subset, 57
- hyperbolic Kähler manifold, 132, 340
- hypersurface, 65
- identity Bianchi, 84; Ricci, 85; Walker, 438
- immersion, 71
- index
 - of a symmetric bilinear form, 108
 - of a tensor
 - contravariant; covariant, 77
- infinitesimal
 - deformation geodesic, 367
 - harmonic transformation, 230
 - harmonic vector fields, 230
- integrability conditions, 101
- integral stationary, 123
- interior (point) of a set, 29
- interval in an ordered set, 27
- invariant under
 - conformal maps, 239
 - geodesic maps, 263, 266
 - HP mappings, 420
- invariant, topological, 36, 81
- irreducible manifold, 192
- isometry, 24, 110; local, 110
- isotropic vector, 109
- Kähler manifold, 132, 340
 - elliptic, hyperbolic, parabolic, 132
- Killing p -form, 375
- Killing vector, 250, 375
 - affine, 192; conformal, 250
 - holomorphically projective, 435
 - homothetic, 198; projective, 272

- Killing-Yano equations, 375
- Killing-Yano tensor, 375
- Kronecker delta, 84
- Landsberg tensor, 481
- length of a vector, 109
- Levi-Civita
 - connection, 110
 - equations, 261, 275
 - metrics, 300
- limit point, 28, 52
 - of a net; of a sequence, 33
- linear form, 77
- locally finite system of subset, 49
- loop, 58
 - constant based at the point, 58
 - inverse, 58
- loops, homotopy equivalent, 58
- Lorentzian space, 108
- manifold
 - C^r -differentiable, 70
 - T -pseudosymmetric, 330
 - $\mathbb{K}_n[B]$, 431
 - $\mathbb{V}_n(B)$, 303
 - Einstein, 115, 320
 - equidistant, 140
 - Finsler, 480
 - flat, 85
 - Kähler, 132
 - irreducible, 192
 - product, 191
 - projectively flat, 269
 - Ricci flat, 85
 - Ricci-semisymmetric, 286
 - Riemannian, 108
 - Riemann-Finsler, 480
 - semisymmetric, 286, 287
 - T -pseudosymmetric, 329
 - T -semisymmetric, 329
 - topological
 - n -dimensional, 65
 - Weyl, 294
 - with affine connection, 82
 - with linear connection, 82
 - with projective connection, 264
- manifolds diffeomorphic, 70
- map
 - Cartesian, 317
 - closed, 36
 - continuous, 23, 34
 - in the point, 34
 - differentiable
 - of the class C^r , 69
 - differential, 72
 - homeomorphism, 35
 - homotopic zero, 58
 - identification, 40
 - multilinear, 77
 - open, 36
 - tangent, 72
 - topological, 35
- mapping
 - affine, 182
 - concircular, 247
 - conformal, 235
 - connection-preserving, 257
 - F_1 -, F_2 -, F_3 -planar, 398
 - geodesic, 257
 - trivial, 259, 261
 - holomorphically-projective
 - trivial, 419
 - homothetic, 198
 - of the class C^r , 70
- maps homotopic, 56
- matrix, Jacobian, 73
- meridians, 350
- metric, 21
 - discrete, 22
 - form, 108
 - product, 51
 - space, 21, 26
 - taxicab, 23
- metric
 - compatible to a connection, 201
 - Levi-Civita, 300
- Metrization Problem, 201
- Mikeš-Berezovski equations, 276
- Möbius strip (band), 64
- mobility degree: see degree mobility

- motion, 196
 - conformal, 250; homothetic, 250
 - holomorphically projective, 434
 - projective, 272
- neighbourhood, 25
 - of a point, 23; open, 34
 - base of a point, 31
- net in a topological space, 33
- norm, 21
- normal
 - coordinates, 117
 - affine connection, 264
- null vector, 109
- object, geometric, 80
- open
 - ball, 22; set, 24; subset, 22
 - coordinate
 - box, 25; parallelepiped, 25
- operator
 - Dirac, 380
- parabolic Kähler manifold, 340
- parallel along curve
 - vector, tensor, 86
- parallel transport, 86
- parameter, canonical, 124
- parameter projective (Thomas), 263
- parametrization
 - local of a manifold, 66
- partition of unity, 50
 - subordinate to an open cover, 50
- path, 40
 - joining two points, 40
- paths, 202
 - homotopy equivalent, 58
- point
 - beginning, end, 40
 - boundary and frontier, 29
 - exterior and interior of a set, 29
- poles, 350
- potence set, 25
- principal direction, 361
 - orthonormal basis, 361
 - T -pseudosymmetric space, 438
- problem variational, 205
 - generalized, 125
- product
 - manifold, 70, 191
 - of homotopies, 57
 - of loops, 58
 - scalar, 109
 - tensor, 78
 - topological
 - finite, 38
- projective, 482
 - connection, 264
 - motion, 272
 - recurrent spaces, 293
 - symmetric spaces, 293
 - transformation, 258, 272
- projectively flat, 495
- projectively related, 482, 495
- pseudo-Euclidean space, 108
- pseudometric, 21
- pseudosymmetric manifold, 290
- pseudo-Riemannian manifold, 107
- quaternionic traceless, 176
- recurrent along curve vector, 86
- recurrent spaces, 293
- reparametrization of a curve, 74
- Ricci
 - flat manifold, 85
 - form, 111
 - identity, 85
 - k -pseudosymmetric space, 438
 - pseudosymmetric space, 290
 - semisymmetric space, 286, 438,
 - soliton, 232
 - tensor, 111
- Riemannian
 - curvature tensor, 84, 110
 - manifold (space), 108
 - of the class C^r , 108
- scalar product, 109
- second fundamental form of, 229
- semisymmetric manifold, 286
- sequence, convergent, 33

- set
 - bounded in a metric space, 22
 - closed, 27; dense, co-dense, 28
 - countable, 32; derived, 28
 - directed, 33
 - nowhere dense, 28
 - open, 24, 25
 - potence, 25
- sets
 - separated, 41
- smooth atlas, 69
- space
 - see manifold
 - m -recurrent, 338
 - m -symmetric, 338
 - base, 39
 - cartesian, 23
 - cotangent, 76
 - Einstein, 114, 151
 - equidistant, 287
 - Euclidean, 21, 23, 26, 108, 317
 - flat, 108, 317
 - Finsler, 479
 - Lorentzian, 108
 - metric, 21; complete, 52
 - Minkowski, 108
 - of constant curvature, 114
 - holomorphic curvature, 198
 - paracompact, 50
 - parameter, 56
 - path-connected, 40
 - pointed, 59
 - projectively flat, 319
 - pseudo-Euclidean, 108
 - quotient, 39
 - recurrent, 293
 - generally, 338; projective 297
 - Riemannian, 108
 - classical, property, 108
 - pseudo-
 - Riemann-Finsler, 479
 - simply connected, 61
 - symmetric, 114, 293
 - topological, 25
 - Tychonoff, 45
 - space-time, 375
- spaces
 - holomorphically-projective equivalent, 420
 - conformally equivalent, 238
 - geodesically equivalent, 262
 - homeomorphic, 35, 36
- sphere
 - n -dimensional, 37
- straight line, 89
 - Sorgenfrey, 31
- structure
 - differentiable, 69
 - tensor, 132
- subbase of topology, 31
- subcover, 30
 - open, 30
- submanifold, 70
- subset open, 22
 - in metric topology, 26
- subspace
 - path-connected, 40
 - relative, 37
- surface, 62
 - (non-) orientable, 62, 63
- symbols Christoffel, 82, 110
- symmetric
 - space, 114, 293
- symmetric Killing tensor, 382
- symmetrization of a tensor, 78
- system
 - basic, 370
 - completely integrable, 101
 - coordinate, 66
 - of PDE's of Cauchy type, 100
 - parametrized, 56
- T -pseudosymmetric $\mathbb{V}_n$, 329
- T - k -pseudosymmetric $\mathbb{K}_n$, 329
- T -semisymmetric $\mathbb{V}_n$, 329
- tangent bundle, 72

- tensor
 - antisymmetric
 - with respect to a pair of indices, 77
 - Brinkmann, 239
 - Cartan, 481
 - contravariant, 77
 - covariant, 77
 - covariantly constant, 84
 - curvature, 84
 - deformation, 182
 - Douglas, 482
 - Landsberg, 481
 - metric, 108
 - of concircular curvature, 248, 327
 - of conformal curvature, 240
 - of projective curvature, 266
 - of type (r, s) , 77
 - Ricci, 111
 - Riemannian, 84, 110
 - symmetric
 - with respect to a pair of indices, 77
 - Weyl, 482
 - Weyl of conformal curvature, 239
- tensor field: see tensor
 - contravariant, 79
 - covariant, 79
 - of the class C^r , 79
- Thomas' object
 - of projective connection, 263
- topological
 - Hausdorff space, 43
 - map, 35
 - space, 25
- topology, 14
 - basis, 16
- torse-forming vector field, 76
- topological space
 - antidiscrete, 26
 - discrete, 26
 - first countable, 32
 - indiscrete, 26
 - Lindelöf, 32
 - metrizable, 30
 - second countable, 32
 - separable, 32
- topological subgroup, 54
- topology, 25
 - antidiscrete, 26
 - base, 31
 - bigger, 29
 - coarser, 29
 - discrete, 26
 - final, 37
 - finer, 29
 - generated by a neighbourhood system, 24
 - generated by closed sets, 27
 - identification, 39
 - indiscrete, 26
 - inductively generated
 - by the system of maps, 37
 - initial, 37
 - interval, 27
 - of countable complements, 26
 - of finite complements, 26
 - product, 38
 - projectively generated
 - by the system of maps, 37
 - relative, 37
 - smaller, 29
 - Sorgenfrey, 31
 - subbase, 31
 - subspace, 37
- torse-forming
 - vector, 140
- transformation
 - F -planar, 408
 - conformal, 236, 250
 - geodesic, 258
 - harmonic, 230
 - holomorphically projective, 434
 - law of a geometric object, 80
 - of coordinate system, 66
 - projective, 258, 272, 350
 - nontrivial, 350
- translation
 - left, 54

- variation
 - first, 122
 - of A
 - under an infinitesimal deformation, 367
 - of the integral, 122
 - second, 122
- vector
 - covariant, 76, 77
 - displacement, 366
 - isotropic, 109
 - null, 109
 - parallel
 - along curve, 86
 - recurrent
 - along curve, 86
 - tangent, 71
 - of a curve, 73
 - torse-forming, 140
- vector field
 - continuous, 74
 - differentiable of the class C^r , 74
- vectors
 - tangent
 - orthogonal, 109
- Voss–Weyl formula, 111
- Walker identities, 438
- warped-product, 383
- Weyl manifold, 294
- Weyl tensor
 - of conformal curvature, 239, 240, 266
 - of projective curvature, 266, 382
- Yano operator, 233
- Yano tensor
 - of concircular curvature, 248, 327
- degree of mappings
 - r_a 104
 - r_{gm} 147, 152, 177, 180, 188
 - r_{hpm} 248, 254, 256
 - r_F 224
- order (degree) of transformations
 - r_{af} 95, 97
 - r_{hom} 102–104, 180, 256
 - r_{con} 120
 - r_{pt} 143, 180, 181, 188
 - r_{hpt} 255, 256
 - r_{Ft} 236, 237

NAME INDEX

- Abdulin V.N., 192, 521
 Adati T., 521
 Afwat M., 513
 Agricola I., 513, 521
 Aikou T., 521
 Akbar-Zadeh H., 438, 521
 Aleksandrov A.D., 513
 Alekseevsky D.V., 521
 Amari S.-I., 513, 544
 Ambartzumian R.V., 513
 Aminov N.A.-M., 513, 521
 Aminova A.V., 17, 104, 274, 301, 417,
 513, 519, 521
 Amirov A.Kh., 528
 Amur K., 521
 Anastasiei M., 201, 521
 Anderson I., 522
 Antonelli P.L., 513
 Arias-Marco T., 522
 Armstrong M.A., 513
 Arnold V.I., 513
 Arsan G.G., 294, 546

 Bácsó S., 18, 104, 481, 519, 522, 535
 Bai Z.G., 522
 Bailey T.N., 522
 Baird P., 513
 Bao D., 248, 513, 522
 Barndorff-Nielsen O.E., 513, 522
 Bartels J.M.Ch., 257
 Bazylev V.T., 513, 522
 Becker-Bender J., 521
 Bejan C.-L., 522
 Bejancu A., 522
 Beklemišev D.V., 514
 Beltrami E., 91, 257, 297, 299, 303 522
 Benenti S., 523

 Benn I.M., 523
 Berezovski V.E., 18, 104, 105, 276, 280,
 281, 302, 394, 397, 459, 463,
 473, 511, 514, 519, 523, 535
 Berger M., 514
 Bernoulli J., 90
 Berwald L., 481, 523
 Beskorovainaya L.L., 519, 523
 Besse A.L., 514
 Betten D., 517
 Bidabad B., 538
 Bishop R.L., 514
 Bobiński B., 523
 Bochner S., 104, 518
 Boeckx E., 286, 514
 Bolsinov A.V., 523
 Boltyanskij V.G., 514
 Bolyai János, 257, 519
 Bolyai Farkas, 257
 Brinkmann H.W., 140, 150, 151, 239,
 242–249, 302, 523
 Brito F.G.B., 523
 Bryant R., 523
 Burlakov M., 523
 Busemann H., 514

 Camargo F., 524
 Caminha A., 523, 524
 Cariglia M., 524
 do Carmo M.P., 104, 514
 Cartan É., 87, 104, 114, 123, 184, 268,
 286, 282, 287, 493, 514, 524
 Cartan H., 91, 123, 483, 514
 Carter B., 524
 Chaki M.C., 524
 Chandrasekhar S., 514
 Charlton P., 523

- Čech E., 514,
 Chebotarev N.G., 184, 514
 Chen X., 524
 Cheng K.S., 201, 206, 524
 Cheng X., 514
 Chentsov N.N., 156, 514
 Chepurna O., 18, 519, 524
 Chern S.S., 513, 522, 524
 Chernyshenko V.M., 524
 Chiossi S.G., 524
 Chodorová M., 18, 105, 417, 431, 519,
 524, 535, 536
 Christoffel E.B., 82, 110
 Chudá H., 18, 105, 362, 412, 417, 437,
 519, 524, 525, 536
 Ćirić M.S., 525, 545
 Coburn N., 340, 525
 Cocos M., 201, 525
 Constantinescu E., 525
 Couty R., 321, 438, 521, 525
 Cox D.R., 522
 Crampin M., 525
 Crasmareanu M., 179, 525
 Crittenden R.J., 514
 Cui N., 525

 Darboux, G., 300
 Defever F., 335, 525
 Deicke A., 525
 Derdzinski A., 335, 525
 Dermanets N.V., 519
 Derrick W.R., 514
 Desai P., 521
 Deszcz R., 290, 302, 335, 336, 525
 DeTurck D.M., 115, 526
 Diblík J., 514
 Dini U., 258, 299, 360, 526
 Dirac P., 378
 Dmitrieva V.V., 526
 Dold A., 514
 Doležalová J., 545
 Domashev V.V., 394, 398, 417, 430,
 441, 526
 Douglas J., 481, 485, 484, 526
 Doupovec M., 514, 526
 Draghici T.C., 526

 Drută-Romanus S.-L., 522
 Dušek Z., 94, 526
 Dubrovin B.A., 125, 514
 Dunajski M., 523
 Dwight H.B., 514

 Eastwood M.G., 91, 104, 272, 308, 526
 Eddington A.S., 526
 Eells J., 526
 Efremovich V.A., 514
 Efron B., 526
 Egorov A.I., 104, 514
 Egorov I.P., 104, 184, 193, 197, 250,
 255, 514
 Egorov Yu.V., 514
 Einstein A., 107, 514, 526
 Eisenhart L.P., 101, 104, 184, 200–202,
 236, 303, 514, 526
 Ellis G.F.R., 515
 Engelking R., 514
 Esenov K.R., 417, 437, 519, 526
 Euler L., 90, 123
 Evtushik L.E., 514, 526

 Fecko M., 515
 Fedchenko Yu.S., 533
 Fedishchenko S.I., 247, 526
 Fedorova A., et al., 526
 Ferapontov E.V., 526
 Fialkow A., 526
 Finnikov S.P., 101, 515
 Fino A., 524
 Finsler Paul., 481, 519
 Florea D., 526
 Fomenko A.T., 514, 523
 Fomenko V.T., 125, 526
 Fomin S.V., 516
 Fomin V.E., 293, 526, 527
 Formella S., 321, 339, 527
 Friedrich T., 513, 521
 Frolov V.P., 515, 532
 Fu F., 527
 Fubini G., 104, 197, 236, 243, 258, 274,
 350, 438, 515, 527
 Fujii Masami., 527
 Fulton W., 515

- Galilei G., 90
 Garcia-Rio E., 527
 Gauss C.F., 107, 123, 257, 370, 515, 519
 Gavril'chenko M.L., 18, 91, 104, 242–245, 519, 527, 536
 Gerlich G., 527
 Gibbons G.W., 527, 528
 Gladysheva E.I., 105, 242, 243, 536
 Glodek E., 290, 528
 Golab S., 201, 528
 Golikov V.I., 301, 326, 528
 Gorbatiy E.Z., 302, 303, 528, 540
 Gover A.R., 528
 Gover R.A., 522
 Grünwald J., 515, 528
 Gray A., 515, 528
 Grebenyuk M., 528
 Gribkov I.V., 528
 Griffiths H.B., 515
 Gromoll D., 515
 Grossman S.I., 514
 Grundhöfer T., 517
 Grycak W., 335, 336, 525
 Guseva N.I., 417, 515, 525

 Hähl H., 517
 Hacisalihoglu H.H., 97, 528
 Haddad M., 417, 440–442, 519, 528, 531, 537
 Haesen S., 528
 Hall G.S., 528
 Hamilton R.S., 528
 Har'el Z., 528
 Hasegawa I., 528
 Hashiguchi M., 521, 522, 528
 Hausdorff F., 43
 Havas P., 528
 Hawking S.W., 515
 Helgason S., 91, 104, 515
 Hicks N.J., 515
 Hilton P.J., 515
 Hinterleitner I., 18, 94, 104, 105, 142, 268, 303, 356, 362, 386, 412, 417, 444, 515, 516, 519, 524, 528, 529, 536, 537, 546
 Hiramatu H., 250, 529
 Hirićă I.E., 529, 530
 Hoenselaers C., 518
 van Holten J.W., 527
 Horský J., 515
 de L'Hospital G., 90
 Hotłoś M., 335, 336, 525
 Hourī T., 530
 Hrdina J., 519, 530
 Hubert E., 530
 Hurewicz W., 515
 al Hussin S., 533

 Ichijyo Y., 528
 Igoshin V.A., 540
 Ikeda M., 338, 544
 Ilosvay F., 522
 Ingarden R.S., 513
 Ishihara S., 435, 436, 518, 530, 544
 Izumi H., 530

 Jänich K., 515
 Jakubowicz A., 201, 530
 Jeffreys H., 156, 530
 Jezierski J., 530
 Jukl M., 18, 166, 515, 516, 530, 532, 537, 543, 545
 Juklová L., 18, 166, 515, 516, 530, 541
 Jung S.D., 530

 Kagan V.F., 197, 236, 247, 258, 307, 455, 515
 Kähler E., 132, 530
 Kaigorodov V.R., 286, 338, 515, 531
 Kala V.N., 538
 Kalinin D.A., 417, 521
 Kalnins E.G., 531
 Kamke E., 515
 Kamran N., 531
 Karmasina A.V., 340, 531
 Kashiwada T., 531
 Kass R.E., 513, 515
 Katzin G.H., 531
 Kazdan J.L., 115, 526
 Kelley J.L., 515
 Kelly P.J., 514

- Keres H., 515
 Kervaire M.A., 69, 531
 Khalili N., 517
 Kikuchi S., 531
 Killing W., 184
 Kinsey L.Ch., 515
 Kinzerska N.N., 527, 531
 Kiosak V.A., 279, 524, 536
 Kis B., 522
 Kisil A.V., 531
 Klein J., 531
 Klingenberg W., 515
 Klishevich V.V., 531
 Knebelman M.J., 531
 Knebelman M.S., 531
 Kobayashi S., 104, 515
 Kolář I., 91, 515
 Kolmogorov A.N., 516
 Kora M., 340, 532
 Kovalev P.I., 287, 519, 532
 Kovantsov N.I., 516
 Kowalevska S., 516
 Kowalski O., 94, 201, 211, 286, 514,
 516, 522, 526, 532
 Krýsl S., 532
 Kramer D., 518
 Kreyszig E., 516
 Kronecker L., 84
 Krtouš P., 532
 Kruchkovich G.I., 301, 327, 516, 532
 Krupka D., 532
 Krys J., 532
 Kubizňák D., 532
 Kudrjavcev L.D., 516
 Kühnel W., 91, 516, 532
 Kurbatova I.N., 105, 340, 394, 398,
 417, 427, 430, 444, 518, 520,
 531, 532
 Kureš M., 516
 Kurose T., 532
 Lagrange J.L., 90, 122, 516
 Laitochová J., 536
 Lakomá (Juklová) L., 532
 al Lami Raad J.K., 417, 519, 524, 532
 Landau L., 516
 Lauritzen S.L., 513
 Lee I.Y., 533, 539
 Lee J.M., 516
 Leiko S.G., 127, 520, 533
 Leitner F., 533
 Levi-Civita T., 91, 110, 112, 116, 124,
 140, 261, 275, 280, 300, 516
 Levine J., 531, 533
 Li Benling, 533
 Lichnerowicz A., 232, 286, 516
 Lifschitz E., 516
 Listing M., 533
 Lobachevsky N.I., 257, 519
 Luczyszyn D., 533
 Lukasik M., 530
 Lumiste Yu.G., 286, 514, 516
 MacCallum M., 518
 Machala F., 516
 Maillot H., 533
 Manno G., 523
 Markov G., 417, 533
 Marriot P., 516
 Masca I.M., 533
 Massey W.S., 516
 Matsumoto M., 481, 490, 491, 513,
 516, 522, 533, 534
 Matveenko T.I., 518
 Matveev V.S., 91, 104, 412, 511, 523, 531
 McCarty G., 516
 McLenaghan R.G., 524, 531
 Metelka J., 516, 532, 534
 Meyer W., 515
 Michor P.W., 91, 515
 Mikeš J., 18, 91, 94, 104, 127, 142, 154,
 156, 166, 171, 242, 250, 268,
 276–281, 286, 290–293, 297,
 302, 303, 308, 311, 321, 327,
 335–340, 360, 362, 386, 394,
 430, 340, 385, 417, 514–516,
 518, 520, 523–545
 Mikhajlovskij V.I., 516
 Mikušová L., 532
 Mikulski W.M., 526
 Millman R.S., 516
 Milnor J.W., 516

- Minčić S.M., 417, 537, 538, 543, 545
 Mirzoyan V.A., 286, 517
 Misner C.W., 517
 Mo X., 524, 538
 Mocanu P., 538
 Moise E.E., 517
 Mokhtarian F., 517
 Moldobaev Dz., 18, 250, 251, 308, 520, 536, 538
 Moor A., 538
 Movchan Yu.A., 542
 Munteanu G., 517, 538
 Murray M.K., 517
 Muto Y., 437, 538

 Nagano T., 340, 546
 Nagaoka H., 513
 Nagy P.T., 517
 Najafi B., 538
 Najdanović M., 546
 Nakahara M., 517
 Nash J., 538
 Negi D.S., 538
 O'Neil B., 517
 Netsvetaev N.Yu., 513
 Newton I., 90
 Ni W.T., 201, 524
 Nicolescu L., 538, 539
 Nomizu K., 104, 287, 515, 517, 538
 Norden A.P., 104, 517
 Nore T., 538
 Nouhaud O., 538, 539
 Novikov S.P., 514
 Novotný J., 515
 Nurowski P., 523, 528

 Obata M., 308, 538
 Oboznaya E.D., 247
 Ogiue K., 538
 Olszak Z., 439, 533, 539
 Olverp J., 530
 Oota T., 530
 Ossa E., 517
 Ostianu N.M., 514
 Ōtsuki T., 200, 398, 417–419, 444, 539
 Příbyl O., 514

 Pan'zhenskii V., 523
 Papp I., 520, 522
 Park H.S., 539
 Park H.Y., 539
 Parker G.D., 516
 Penrose R., 104, 517
 Peška P., 18, 412, 417, 448, 525, 529, 536
 Petersen P., 517
 Petrov A.Z., 91, 104, 151, 242, 249, 301, 321, 326, 385, 398, 455, 517, 539
 Petrovsky I.G., 517
 Piliposyan V.A., 539
 Pinkall U., 538
 Pirklová P., 520
 Podestà F., 539
 Pogorelov A.V., 319, 539
 Pokas' S.M., 539, 542
 Pokorná O., 417, 536, 542, 544, 545
 Policht J., 527
 Pontryagin L.S., 184, 314, 517
 Popov A.G., 91, 517, 539
 Pospíšilová L., 515
 Postnikov M.M., 517
 Poznyak E.G., 91, 517, 539
 Pressley A., 517
 Pripoe G.T., 539
 Prvanović M., 286, 293, 335, 398, 417, 421, 444, 525, 539
 Pucacco G., 523

 Rachůnek L., 19, 520, 537, 539
 Rademacher H.-B., 150, 532
 Radulović Ž., 104, 339, 517, 537, 539
 Randall L., 153, 540
 Randers G., 540
 Rao C.R., 156, 540
 Rapcsák A., 540
 Rashevskij P.K., 101, 104, 517, 540
 Ray S., 524
 Razavi A., 540
 Reinhart B.L., 517
 Reynolds R.F., 540
 Rezaei B., 522, 540
 Rice J.W., 517

- Richardson K., 530
 Ried N., 522
 Riemann B., 107, 517, 519
 Rietdijk R.H., 527
 Rindler W., 517
 Rinow W., 517
 Robinson J., 540
 Rosemann S., 534
 Rosenfeld D.I., 540
 Roter W., 540
 Rowe D.J., 544
 Ruback P.J., 528
 Rund H., 104, 258, 517
 Ruse H.S., 87, 517, 540

 Sabău V.S., 533, 541
 Sabykanov A.R., 520, 536
 Sachs R.K., 517
 Sadeghzadeh N., 540
 Sakaguchi T., 430, 540
 Salmon M., 516
 Salzmann H., 517
 Sampson J.H., 526, 540
 Sanders B.C., 544
 Sasaki T., 517
 Saunders D.J., 525
 Schaefer H.H., 517
 Schmidt B.G., 201, 540
 Schouten J.A., 517
 Schwenk-Schellschmidt A., 518
 Sekizawa M., 532
 Semmelmann U., 540
 Shandra I.G., 18, 229, 434, 518, 520, 531, 540, 543
 Shapiro Ya.L., 141, 455, 540
 Shapovalov V.N., 540
 Shapovalova O.V., 540
 Shen C.I., 525
 Shen Y., 533
 Shen Y.B., 525
 Shen Z., 321, 481, 507, 513, 514, 517, 522, 524, 533, 538, 540, 541
 Shibata C., 541
 Shiha M., 18, 104, 154, 340, 394, 417, 444, 520, 524, 525, 536, 537
 Shikin E.V., 91, 517
 Shimada H., 533, 541
 Shirokov A.P., 514, 518, 541
 Shirokov P.A., 87, 286, 287, 518, 541
 Shubin M.A., 514
 Shulikovski, V.I., 300, 541
 Shurygin V.V., 518
 Šilhan J., 528
 Simon U., 518
 Simonescu C., 541
 Singer I.M., 518
 Sinyukov N.S., 19, 91, 101, 104, 140, 247, 272, 278, 280, 286, 293, 302, 338, 385, 514, 518, 520, 537, 541, 542
 Sinyukova E.N., 286, 337, 440, 520, 542
 Škodová (Chodorová) M., 417, 442, 532, 537, 544
 Slovák J., 91, 515, 530
 Smaranda D., 542
 Smetanová D., 18, 520
 Smolnikova M.V., 543
 Sobchuk V.S., 18, 293, 338, 339, 520, 537, 542
 Sochor M., 127, 537
 Sokolnikoff I.S., 518
 Solodovnikov A.S., 274, 303, 350, 518, 542
 Soos Gy., 542
 Sosov E.N., 542
 Souza P., 524
 Spanier E.H., 518
 Stanković M.S., 417, 525, 538, 543, 545
 Starko G.A., 104, 340, 417, 537, 545
 Stasheff J.D., 516
 Štefaník M., 515
 Stepanov S.E., 18, 156, 229, 518, 537, 543
 Stepanova E.S., 17, 18, 127, 156, 311, 529, 537, 543, 544
 Stephani H., 518
 Stránská J., 529
 Strambach K., 517, 537
 Struik D.J., 104, 517
 Sultanov A.Ya., 514, 536
 Sundrum R., 153, 540
 Švec A., 360, 361, 513

- Szabó Z.I., 286, 485, 518, 544
 Szilasi Z., 522
 Tachibana S.-I., 378, 435, 518, 530, 538, 544
 Takeno H., 338, 544
 Takeuchi J., 544
 Tamássy L., 201, 544
 Tanno S., 308, 339, 544
 Tashiro Y., 200, 398, 417–419, 422, 444, 539
 Taub A., 544
 Tayebi A., 538
 Taylor A.E., 518
 Thomas J.M., 104, 264, 267, 268, 282, 544
 Thomas T.Y., 264, 294, 518, 544
 Thompson A.H., 540
 Thompson G., 201, 522, 544
 Thorne K.S., 517
 Thorpe J.A., 518
 Tolobaev O.S., 537
 Topalov P., 534, 544
 Tricomi T., 518
 Trnková M., 520
 Tsyganok I.I., 18, 311, 529, 543, 544
 Tyc T., 544
 Tyumentsev V.A., 531
 Vašík P., 530
 Vanžurová A., 18, 91, 104, 417, 516, 520, 523, 536, 537, 544, 545
 Vanhecke L., 286, 514, 527
 Vashpanova T.Y., 520
 Vavříková (Chudá) H. 537, 545
 Vazquez-Abal E., 527
 Veblen O., 201, 206, 212, 526
 Vekua I.N., 518
 Velimirović Lj.S., 417, 525, 537, 538, 543, 545
 Velimirović N.M., 545
 Venzi P., 286, 302, 336, 545
 Verner A.L., 545
 Verstraelen L., 335, 525, 528
 Viesel H., 518
 Vilms J., 545
 Vishnevskij V.V., 518, 545
 Vos P.W., 515
 Voss K., 111, 545
 Vrănceanu G., 91, 104, 247, 250, 518, 546
 Vrancken, 335, 525
 Vries H.L., 546
 Wagner V., 546
 Walczak P.G., 523
 Walker A.G., 111, 152, 517, 546
 Wei X., 546
 Westlake W.J., 340, 546
 Weyl H., 236, 518, 546
 Wheeler J.A., 517
 Whitehead G.W., 518
 Willmore T.I., 517
 Wolf J.A., 518
 Wolff M.P., 517
 Wood J.C., 513, 546
 Wu H., 517
 Yıldırım, G.Ç., 294, 546
 Yablonskaya N.V., 546
 Yamada T., 546
 Yamaguchi S., 437, 521, 546
 Yamauchi K., 438, 521, 528
 Yang X., 527
 Yano K., 91, 104, 140, 184, 197, 232, 247, 274, 340, 375, 417, 455, 518, 546
 Yasui Y., 530
 Yau S.T., 315, 546
 Yuen P., 517
 Žáčková P., 545
 Zedník J., 535
 Zelnikov A., 515
 Zhang Z.-H., 546
 Zlatanović M.Lj., 525, 546
 Zudina T.V., 546
 Zund J., 540

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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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