# General Theory of Lie Groupoids and Lie Algebroids

Kirill C. H. Mackenzie University of Sheffield



č

## Contents

- )

Prologue	<i>page</i> xi
Introduction	XV
Preface	xxxii

### PART ONE: THE GENERAL THEORY

1	Lie Groupoids: Fundamental Theory	3
1.1	Groupoids and Lie groupoids	4
1.2	Morphisms and subgroupoids	11
1.3	Local triviality	14
1.4	Bisections	21
1.5	Components and transitivity	28
1.6	Actions	34
1.7	Linear actions and frame groupoids	43
1.8	Notes	48
2	Lie Groupoids: Algebraic Constructions	53
2.1	Quotients of vector bundles	54
2.2	Base–preserving quotients of groupoids	60
2.3	Pullback groupoids	63
2.4	General quotients and fibrations	65
2.5	General semidirect products	77
2.6	Classes of morphisms	82
2.7	Notes	83

•

đ

Conte
-------

viii	viii Contents		
3	Lie Algebroids: Fundamental Theory	85	
3.1	Quotients of vector bundles by group actions	86	
3.2	The Atiyah sequence of a principal bundle	90	
3.3	Lie algebroids	99	
3.4	Linear vector fields	110	
3.5	The Lie algebroid of a Lie groupoid	119	
3.6	The exponential map	132	
3.7	Adjoint formulas	141	
3.8	Notes	143	
4	Lie Algebroids: Algebraic Constructions	148	
4.1	Actions of Lie algebroids	149	
4.2	Direct products and pullbacks of Lie algebroids	155	
4.3	Morphisms of Lie algebroids	157	
4.4	General quotients and fibrations	166	
4.5	General semidirect products	171	
4.6	Classes of morphism	175	
4.7	Notes	176	

### PART TWO: THE TRANSITIVE THEORY

5	Infinitesimal Connection Theory	181
5.1	The Darboux derivative	182
5.2	Infinitesimal connections and curvature	´ 185
5.3	The principal bundle formulation	193
5.4	Local descriptions	205
5.5	Notes	210
6	Path Connections and Lie Theory	212
6.1	The monodromy groupoid	214
6.2	Lie subalgebroids and morphisms	221
6.3	Path connections	228
6.4	Parallel sections and stabilizer subgroupoids	236
6.5	The abstract theory of transitive Lie algebroids	248
6.6	Notes	254

č

	Contents	ix
7	Cohomology and Schouten Calculus	257
7.1	Cohomology and abelian extensions	260
7.2	Couplings of Lie algebroids and $\mathscr{H}^3$	271
7.3	Non-abelian extensions of Lie algebroids	277
7.4	The spectral sequence	288
7.5	Schouten Calculus	304
7.6	Notes	308
8	The Cohomological Obstruction	311
8.1	The classical case	311
8.2	Transition forms and transition data	314
8.3	The obstruction class	323
8.4	Notes	332

#### PART THREE:

#### THE POISSON AND SYMPLECTIC THEORIES

Double Vector Bundles	339
General double vector bundles	340
Duals of double vector bundles	348
The prolongation dual	354
The cotangent double vector bundle	357
The reversal isomorphism	360
The double tangent bundle and its duals	363
The tangent prolongation Lie algebroid	367
Vector fields on Lie groupoids	372
Notes	378
Poisson Structures and Lie Algebroids	380
Poisson structures	382
Poisson cohomology	387
Linear Poisson structures	389
Coisotropic submanifolds, etc	397
Notes	405
	General double vector bundles Duals of double vector bundles The prolongation dual The cotangent double vector bundle The reversal isomorphism The double tangent bundle and its duals The tangent prolongation Lie algebroid Vector fields on Lie groupoids Notes <b>Poisson Structures and Lie Algebroids</b> Poisson structures Poisson structures Coisotropic submanifolds, etc

ĉ