

I. Algebra

1. Vector Spaces

- 1A. Linearity
- 1B. Bases and Dimension
- 1C. New Spaces from Old

2. Hom and Tensor

- 2A. Hom
- 2B. Multilinearity
- 2C. Tensor Products

3. Functors

- 3A. Covariant Functors
- 3B. Contravariant Functors
- 3C. Multifunctors
- 3D. Composed Functors

4. Naturality

- 4A. Introduction to Naturality
- 4B. Duality
- 4C. Naturality and Multifunctors

5. Tensor Algebra

6. Inner Products and Orthonormality

- 6A. Inner Products
- 6B. Orthonormality
- 6C. Some Inequalities

II. Topology

1. Manifolds

2. Vector Bundles

- 2A. Manifolds Over M
- 2B. Trivializations and Vector Bundles
- 2C. Patching
- 2D. Sections

3. From Functors to Vector Bundles

- 3A. Smooth Functors
- 3B. Hom, Sections and Duality
- 3C. Tensor Product Bundles
- 3D. Naturality

4. Cotangent Spaces, Tangent Spaces, and Tensor Spaces

- 4A. Cotangents
- 4B. Tangents
- 4C. Tensors

5. Cotangent Bundles, Tangent Bundles, and Tensor Bundles

- 5A. The Cotangent Bundle
- 5B. The Tangent Bundle
- 5C. Tensor Bundles

6. One-Forms and Vector Fields

- 6A. One-Forms
- 6B. Vector Fields
- 6C. One-Parameter Groups
- 6D. Derivations

III. Geometry

1. Metrics

- 1A. Basic Definitions
- 1B. Induced Metrics
- 1C. Metrics on Vector Spaces

2. Covariant Derivatives

3. Parallel Translation

- 3A. Parallelism
- 3B. The Covariant Derivative as a Derivative

4. Riemann Curvature

- 4A. Noncommutativity of Parallel Translation
- 4B. The Riemann Curvature Tensor

5. Geodesics and the Exponential Map

- 5A. Geodesics
- 5B. Geodesic Deviation
- 5C. Ricci Curvature
- 5D. The Exponential Map

IV. Physics

V. Cosmology

VI. Philosophy