

## Calculus on Manifolds: Exercises

These notes reflect material from our text, *Analysis on Manifolds*, by James R. Munkres, published in the Advanced Books Classics collection by Westview Press, Perseus Book Group, 1991.

### Chapter 1. The Algebra and Topology of $\mathbb{R}^n$

- §1. *Review of Linear Algebra*: 2, 3, 4a
- §2. *Matrix Inversion and Determinants*: 1, 2, 3, 4, 5
- §3. *Review of Topology in  $\mathbb{R}^n$* : 1, 2, 3, 5, 7, 8, 9
- §4. *Compact Subspaces and Connected Subspaces of  $\mathbb{R}^n$* : 1, 2, 3, 4

### Chapter 2. Differentiation

- §5. *The Derivative*: 2, 3, 4, 6
- §6. *Continuously Differentiable Functions*: 1, 2, 5, 6, 7, 10
- §7. *The Chain Rule*: 1, 2, 3
- §8. *The Inverse Function Theorem*: 1, 2, 3, 4, 5
- §9. *The Implicit Function Theorem*: 1, 2, 5

### Chapter 3. Integration

- §10. *The Integral over a Rectangle*: 1, 2, 3, 4, 5
- §11. *Existence of the Integral*: 1, 2, 3, 6, 8
- §12. *Evaluation of the Integral*: 1, 4
- §13. *The Integral over a Bounded Set*: 1, 4
- §14. *Rectifiable Sets*: 1, 2, 5, 6, 7
- §15. *Improper Integrals*: 1, 2, 4, 5

### Chapter 4. Change of Variables

- §16. *Partitions of Unity*: 1, 2, 3
- §17. *The Change of Variables Theorem*: 1, 2, 3, 4, 5, 6, 7
- §18. *Diffeomorphisms in  $\mathbb{R}^n$* : 1, 3, 4
- §19. *Proof of the Change of Variables Theorem*: 1, 2, 3, 4, 5
- §20. *Applications of Change of Variables*: 1, 2, 3, 4, 5

### Chapter 5. Manifolds

- §21. *The Volume of a Parallelepiped*: 1, 2, 3, 5
- §22. *The Volume of a Parametrized Manifold*: 1, 2, 3

§23. *Manifolds in  $\mathbb{R}^n$* : 1, 2, 3, 4, 5, 6

§24. *The Boundary of a Manifold*: 1, 2, 3, 4, 5, 6

§25. *Integrating a Scalar Function over a Manifold*: 1, 2, 3, 4, 5, 8

### Chapter 6. Differential Forms

§26. *Multilinear Algebra*: 1, 2, 3, 4, 5, 6, 8

§27. *Alternating Tensors*: 4

§28. *The Wedge Product*: 1 (part a and c), 5, 6

§29. *Tangent Vectors and Differential Forms*: 1, 2

§30. *The Differential Operator*: 1, 2, 3, 4, 5

§31. *Application to Vector and Scalar Fields*: 3

§32. *The Action of a Differentiable Map*: 1, 2, 3, 4

### Chapter 7. Stokes' Theorem

§33. *Integrating Forms over Parametrized-Manifolds*: 1, 2, 3

§34. *Orientable Manifolds*: 4, 5, 6, 7, 8

§35. *Integrating Forms over Oriented Manifolds*: 1

§36. *A Geometric Interpretation of Forms and Integrals*: 1

§37. *The Generalized Stokes' Theorem*: 2, 4, 5

§38. *Applications to Vector Analysis*: 1, 2, 3, 4, 5