CALIFORNIA INSTITUTE OF TECHNOLOGY
Department of Mechanical Engineering

CDS 202 - Geometry of Nonlinear Systems
Winter 2004

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Lectures
MWF 8:30-10, 125 Steele

Course description CDS 202. Geometry of Nonlinear Systems. 9 units (3-0-6); second term. Prerequisites: CDS 201 or AM 125 a. Basic differential geometry, oriented toward applications in control and dynamical systems. Topics include smooth manifolds and mappings, tangent and normal bundles. Vector fields and flows. Distributions and Frobeniuss theorem. Matrix Lie groups and Lie algebras. Exterior differential forms, Stokes theorem.

Lecture format and schedule CDS 202 will meet twice per week, on average, with the schedule adjust to match the availability of the instructor. The first class meeting of the "week" (which might be on Monday, Wednesday, or Friday) will give an overview of the material to be covered. Homework and reading assignments will be handed out at this lecture. The second meeting will be a class discussion of the homework for the week, with students expected to be able to discuss how they would approach the problems. The homework set for the week will be due at the first lecture of the following week. The course schedule will be maitained on the class homepage.

Class homepage Information on the class is available via the class homepage:

`http://www.cds.caltech.edu/~murray/cds202`

All course handouts and other administrative data about the course are available via the class homepage.

Grading The final grade will be based on homework and a final exam.

- Homework: 75%
  There will be 8 one-week problem sets, due in class. Late homework will not be accepted without prior permission from the instructor.
- Final exam: 25%
  The final will be handed out the last day of class and is due back at the end of finals week. Open book, time limit to be decided.

If your score on the final is higher than the weighted average of your homework and final, your final will be used to determine your course grade.

Homework and exam policy Collaboration on homework assignments is encouraged. You may consult outside reference materials, other students, the TA, or the instructor. All solutions that are handed should reflect your understanding of the subject matter at the time of writing.

No collaboration is allowed on the final exam.

Course Text and References The following texts will be used for this course:

1. W. Boothby, *An Introduction to Differentiable Manifolds and Riemannian Geometry*, Revised Second Edition, Academic Press, 2002.

2. R. Abraham, J. E. Marsden, and T. Ratiu, *Manifolds, Tensors, Analysis, and Applications*, 3rd ed. Springer-Verlag, 2004.

Boothby is available in the Caltech bookstore. Abraham, Marsden, and Ratiu is available online, via the course homepage.

The following books may also be helpful:

1. V. Guilleman and A. Pollak, *Differential Topology.* Prentice-Hall, 1974.

2. M. Spivak, *A Comprehensive Introduction to Differentiable Geometry*, vol I. Publish or Perish, 1970.

3. J. Milnor, *Topology From the Differentiable Viewpoint.* University Press of Virginia, 1965.

Course outline The following is a tentative outline of the material to be covered this term. Some topics may be omitted due to time limitations.

Week	Topics	Reference
1	Introductory comments, point set topology	AMR Ch 2
2	Manifolds, mappings, tangent space	B3.1–3
3	Immersions, submersions	B3.4–3.5
4	Inverse function theorem, transversality	B2.6, AMR 3.5
5	Tangent bundle, vector fields	B4.1–4
6	Distributions, Frobenius theorem	B4.7–8
7	Lie groups and Lie algebras	B3.6–7, B4.6–7, AMR S-1
8	Tensor fields	B5.1–5.3
9	Exterior forms	B5.6–8
10	Integration on manifolds	B5.9–10