

CALIFORNIA INSTITUTE OF TECHNOLOGY  
Control and Dynamical Systems

**ACM/CDS 202**  
**Problem Set #9**

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Due: 7 Jun 2013

Reading: Abraham, Marsden, and Ratiu (MTA), Sections 7.4–7.5, 8.1–8.2

Problems:

1. Calculate exterior derivatives of the following forms in  $\mathbb{R}^3$ :

(a)  $z^2 dx \wedge dy + (z^2 + 2y) dx \wedge dz$

(b)  $13x dx + y^2 dy + xyz dz$

(c)  $f dg$ , where  $f$  and  $g$  are functions on  $\mathbb{R}^3$

(d)  $(x + 2y^3)(dz \wedge dx + \frac{1}{2} dy \wedge dx)$

2. MTA, 7.4-3: practice with exterior derivatives

3. MTA, 8.2-1: pullback and exterior derivatives

4. Consider the locomotion system given by a disk rolling on the plane from homework #7. Using the exterior derivative of the kinematic connection, determine if the system is totally controllable and/or fiber controllable.