Geometric Mechanics and Symmetry: From Finite to Infinite Dimensions (Oxford Texts in Applied and Engineering Mathematics)

Darryl D. Holm, Tanya Schmah, Cristina Stoica

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Classical mechanics, one of the oldest branches of science, has undergone a long evolution, developing hand in hand with many areas of mathematics, including calculus, differential geometry, and the theory of Lie groups and Lie algebras. The modern formulations of Lagrangian and Hamiltonian mechanics, in the coordinate-free language of differential geometry, are elegant and general. They provide a unifying framework for many seemingly disparate physical systems, such as n-particle systems, rigid bodies, fluids and other continua, and electromagnetic and quantum systems.

Geometric Mechanics and Symmetry is a friendly and fast-paced introduction to the geometric approach to classical mechanics, suitable for a one- or two- semester course for beginning graduate students or advanced undergraduates. It fills a gap between traditional classical mechanics texts and advanced modern mathematical treatments of the subject. After a summary of the necessary elements of calculus on smooth manifolds and basic Lie group theory, the main body of the text considers how symmetry reduction of Hamilton's principle allows one to derive and analyze the Euler-Poincaré equations for dynamics on Lie groups.

Additional topics deal with rigid and pseudo-rigid bodies, the heavy top, shallow water waves, geophysical fluid dynamics and computational anatomy. The text ends with a discussion of the semidirect-product Euler-Poincaré reduction theorem for ideal fluid dynamics.

A variety of examples and figures illustrate the material, while the many exercises, both solved and unsolved, make the book a valuable class text.

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