Fall 2017 **Classical Dynamics** **Phys 701**

Instructor: Charles R. Evans

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TR 11:00-12:15

This course considers various aspects of classical dynamics, especially Lagrangian and Hamiltonian mechanics, canonical variables, canonical transformations, and Hamilton-Jacobi theory. The course emphasizes variational principles, symmetry, conservation laws, and generalized coordinates and transformations. A brief presentation of key principles of differential geometry is provided. Some generalization to dynamics of continuous systems is considered. The course has two primary goals: emphasizing practical problem solving with Lagrangian dynamics and showing how Hamiltonian dynamics bridges between classical dynamics and quantum physics and statistical mechanics.

The required text is *Classical Mechanics,* third edition, by Goldstein, Poole, and Safko. The third edition maintains the advantages of the older versions in terms of order of development and coverage of topics, while improving somewhat the mathematical presentation. The text is not based upon a modern geometrical formulation, so some differential geometry is introduced separately. You may find the book by Jose and Saletan worth consulting.

To learn classical dynamics, or any physics, working a lot of problems is essential. Roughly three problems per week will be assigned. Working these problems will be an important measure of progress in the course, accounting for 40 percent of the grade in the class. Each assignment should be turned in, even if partially completed. You may discuss homework with each other, but the write-up of each problem should be the product of your own work. There will be a take-home midterm (30 percent of the grade) with the date TBD but near mid-October. There will be a three-hour in-class exam at the end of the semester, scheduled on December 14 at 12 PM. In keeping with departmental policy this exam will serve two purposes. From the standpoint of the course it will count as a final exam worth 30% of the grade. It will separately be scored, with oversight from the graduate exam committee, as the classical dynamics part of the qualifying exam. The UNC Honor Code applies in this course.

Some suggested reading on classical mechanics and nonlinear dynamics:

H. Goldstein, Poole, & Safko, *Classical Mechanics,* third edition

J. Jose & Eugene Saletan, *Classical Dynamics: A Contemporary Approach*

L. Landau & E.M. Lifshitz, *Mechanics,* third edition

A.L. Fetter & J.D. Walecka, *Theoretical Mechanics of Particles and Continua*

C. Lanczos, *The Variational Principles of Mechanics*

V.I. Arnold, *Mathematical Methods of Classical Mechanics,* second edition

E. Ott, *Chaos in Dynamical Systems*

Some suggested reading on differential geometry:

B. Schutz, *Geometrical Methods of Mathematical Physics*

W. Burke, *Applied Differential Geometry*

Rough Outline of Topics, by week

Week 1	Course introduction, systems of particles, constraints
Week 2	d'Alembert's principle, non-Cartesian coordinates, intro to differential geometry
Week 3	Metric, connection, covariant derivative, Euler-Lagrange
Week 4	Hamilton's principle, Lagrange multipliers, conservation, Noether's theorem
Week 5	Two-body problem & central force laws
Week 6	Scattering theory
Week 7	Rigid body kinematics and dynamics
Oct 12	UNIVERSITY DAY, no class
Week 8	Rigid bodies and small oscillations
Oct 19	FALL BREAK, no class
Week 9	Small oscillations, chains, strings, continuum dynamics, Hamilton's equations of motion
Week 10	Canonical transformations, symplectic structure, Poisson brackets
Week 11	Direct test of canonical transformation, Hamilton-Jacobi theory
Week 12	Separability of Hamilton-Jacobi equation, action-angle variables
Nov 22	THANKSGIVING, no class
Week 13	Action-angles and adiabatic invariants, canonical perturbation theory
Week 14	Review and other topics
Dec 14	FINAL/WRITTEN EXAM, Thursday, 12 PM to 3 PM