Physics 2513—Dynamical Systems Fall Term 2022-2023
106 Allen Hall Monday, Wed, and Friday 10:00-10:50
Instructor: Joseph Boudreau (boudreau@pitt.edu)
Office 418 Allen Hall
Phone +1 412 512 8335

Zoom meeting room: 478 805 8218 is used for office hours if necessary.

Office hours Wednesday. 1:00-3:00 PM

Physics 2513 is a course in advanced classical mechanics. It introduces techniques which are useful in solving classical problems that resist more elementary means of solutions and promotes a deeper understanding of fundamental principles underlying classical mechanics, including its relationship to quantum mechanics. Topics covered include the Newtonian foundations of classical mechanics, Lagrangian and Hamiltonian formalisms, rotational dynamics, symmetries and conservation laws, and the connections to quantum mechanics in both the Schrödinger and Heisenberg pictures. The course deals with discrete classical mechanics as well as the mechanics of continuous media and the dynamics of classical fields.

Learning objectives: Upon completing the course students should have learned

- how to apply the calculus of variations to mechanical and non-mechanical problems.
- how to apply Lagrangian and Hamiltonian techniques to the solution of classical mechanical problems.
- the Lagrangian formalism for classical fields.
- how to identify symmetries of a variety of mechanical systems and associate them to symmetries of the Lagrangian and Hamiltonian functions and to conserved quantities.
- the fundamentals of Hamilton-Jacobi theory and the connection to geometrical optics
- the theory of canonical transformations, symplectic transformations, and the Poisson Bracket formalism.
- Noether's theorem relating symmetries to conservation laws in the context of discrete mechanical systems and classical fields.

Many of these topics are the foundation of further work in theoretical physics. In addition, they constitute a beautiful intellectual edifice in its own right.

All course materials are posted through the Canvas system. These include

- This syllabus. It appears on the Canvas system together with a running log of reading assignments and suggestions.
- Homework assignments.

- Their solutions.
- Solutions to the exams.
- Lecture notes.
- Other announcements.

The textbook for the course is

- *Classical Mechanics*, 3rd Edition. Herbert Goldstein, Charles Poole, and John Safko. Addison-Wesley 2002. The first edition by Goldstein was published in 1951. It is available at the reserve desk in the Engineering Library; online copies are also available through archive.org.

I will frequently draw from other sources, in particular

- *Theoretical Mechanics of Particles and Continua*, Alexander L. Fetter and John Dirk Walecka (Dover Publications, 2003, originally published by McGraw-Hill in 1980). This is available at the reserve desk in the Engineering Library; online copies are available through archive.org.

The lecture will be based on several sources, including but not limited to these two books. Students should seek additional information from these sources, beyond what is covered in lecture.

An advanced undergraduate level text is also sometimes helpful:

- Classical Dynamics of Particles and Systems, Jerry B. Marion and Stephen T. Thornton, 4th Edition, (1995, Fort Saunders Pub), available at the reserve desk in the Engineering Library, and through archive.org.

Some computations exercises will be required, these may be carried out with a computer algebra system like Mathematica, or with a programming language of your choice.

The course grade is based on a final exam (30%), two hour exams (20%) and homework (30%).

Homework will generally be assigned on a weekly basis and due on Friday by 5:00 PM.

The **first hour exam** will be held on Friday Oct 7. The **second hour exam** will be held on Friday Nov. 11. The **final exam** will be held at 9:00-11:50 AM Dec 12 in Allen Hall 106.

Academic Integrity: Working with other students on homework is highly conducive to learning and is encouraged, but on exams you must work alone. The list of external "resources" for problem solving is long and diverse and ranges from calculators, to tables of integrals, computer algebra systems like Mathematica, Wikipedia articles, the full solution manual, and even organized rackets that tacitly or actively promote cheating. On one end of this spectrum one finds important resources that facilitate learning, and on the other end one finds invitations to clear academic integrity violation. In the middle is a gray zone. Please use your judgement or ask the instructor if in doubt. Do not submit work that has been copied from another source. Stay honest,and figure it out the solution to homework exercises for yourself or together with your study group. The academic integrity policy of the University of Pittsburgh can be found at http://www.cfo.pitt.edu/policies/policy/02/02-03-02.html.

Students with disabilities: If you have a disability for which you are or may be requesting an accommodation, you are encouraged to contact both your instructor and Disability Resources and Services, 140 William Pitt Union, (412) 648-7890/(412) 383-7355 (lTY), as early as possible in the term. DRS will verify your disability and determine reasonable accommodations for this course