

PHYS 504: Advanced Mechanics

Fall 2024

Class Information

Lecture hours: MW 12:00-1:50pm

Classroom: WPH B30

Instructor Information

Lecturer: Prof. Nathan Benjamin

Office: SSC-216C

Email: nathanbe@usc.edu

Office Hours: Tuesday, 1-3pm or by appointment

TA Information

Name: Yuxiao Hang

Email: yhang@usc.edu

Office Hours: Thursday, 3-4pm, SSC 213, or by appointment

Course Description

The main emphasis of the course will be on the Lagrangian and Hamiltonian formulations of mechanics and various standard topics such as the Kepler problem and the scattering, small oscillations, canonical transformations, the Hamilton-Jacobi theory, dynamics of a rigid body, relations to different formulations of quantum mechanics and, time permitting, canonical perturbation theory, symplectic geometry, nonlinear dynamics and chaos. *Prerequisites:* Some Newtonian mechanics undergraduate level course.

Topics to be covered

The following is a preliminary list of topics we plan to cover in the course. Depending on how fast/slow we go, the list may be slightly modified or rearranged.

- Newtonian mechanics; d'Alembert principle
- Lagrangian mechanics
- Variational principles
- Central force motion; Kepler problem
- Noether's theorem; Hamiltonian mechanics
- Symplectic geometry; Liouville's theorem
- Hamilton-Jacobi equation; canonical transformations

- Angle-action variables; adiabatic theorem; integrable systems
- Approximate methods; canonical perturbation theory
- Classical vs Quantum mechanics; WKB approximation
- Rotating coordinate systems; Euler angles; $SO(3)$ and $SU(2)$
- Kinematics of a rigid body; free motion of a rigid body
- Dynamics of a rigid body; spinning tops
- Oscillations; resonances; small oscillations

Textbook

The course will not follow any particular textbook, however, most of the material discussed in this course can be found in any standard textbook. For references I will primarily refer the following ones:

- N. Lemos, *Analytical Mechanics*, Cambridge University Press, 2018.
This book is available for free at USC Libraries at <https://libraries.usc.edu/>
- H. Goldstein, C. Poole and J. Safko, *Classical Mechanics*, third edition, Addison-Wessley, 2002.
I find this textbook a bit verbose, but certainly it is a classic and gets to the core of what we will study. It also contains a lot of problems with solutions readily available on the internet.
- L.D. Landau and E.M. Lifshitz, *Mechanics*, third edition, Course in Theoretical Physics, vol. I, Pergamon Press, 1988.
This book is a classic, and is wonderful, but can be a bit terse.
- D. Tong, *Lectures on Classical Dynamics*, Cambridge University.
Download for free from <https://www.damtp.cam.ac.uk/user/tong/dynamics.html>

Course Website

The course website is located on Brightspace (<https://brightspace.usc.edu/>). Under this home page you will find links to the course syllabus, problem sets, solutions to previous problem sets, hand-outs, grades, and other information. Please upload your completed problem sets on Brightspace.

Grading

The final course grade will be determined by:

- Problem sets 30%
- Midterm exam 30%
- Final exam 40%

Problem Sets

There will be about one problem set every week in the course (for a total of about 10). Your lowest problem set will be dropped. Please submit your problem sets on Brightspace as a single pdf file. If you have trouble with submission please email Yuxiao. Late work without prior arrangement will not be accepted. Problem sets will be posted on Fridays and due one week later.

You are encouraged to discuss and work together on your problem sets. However, please write up your problem sets yourselves, and make sure that every step you write down you understand.

Exams

There will be a midterm exam and a final exam for the course. The midterm will be in class on Oct. 9. The final will be comprehensive of the entire semester and will be on Dec. 13, 11am. All exams will be closed books and closed notes. However, we will provide a formula sheet.

Faculty Liaison

All courses in the Department of Physics and Astronomy have an assigned Faculty Liaison to serve students as a confidential, neutral, informal, and independent resource when they wish to discuss issues concerning their course without directly confronting their instructor. The Faculty Liaison for this course is Prof. Jack Feinberg (feinberg@usc.edu, 213-740-1134, SSC 327).

Academic Integrity

The University of Southern California is foremost a learning community committed to fostering successful scholars and researchers dedicated to the pursuit of knowledge and the transmission of ideas. Academic misconduct is in contrast to the university's mission to educate students through a broad array of first-rank academic, professional, and extracurricular programs and includes any act of dishonesty in the submission of academic work (either in draft or final form).

This course will follow the expectations for academic integrity as stated in the [USC Student Handbook](#). All students are expected to submit assignments that are original work and prepared specifically for the course/section in this academic term. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s). Students suspected of engaging in academic misconduct will be reported to the Office of Academic Integrity.

Other violations of academic misconduct include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

Academic dishonesty has a far-reaching impact and is considered a serious offense against the university. Violations will result in a grade penalty, such as a failing grade on the assignment or in the course, and disciplinary action from the university itself, such as suspension or even expulsion.

For more information about academic integrity see the [student handbook](#) or the [Office of Academic Integrity's website](#), and university policies on [Research and Scholarship Misconduct](#).

Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment or what information requires citation and/or attribution.

Course Content Distribution and Synchronous Session Recording Policies

USC has policies that prohibit recording and distribution of any synchronous and asynchronous course content outside of the learning environment.

Recording a university class without the express permission of the instructor and announcement to the class, or unless conducted pursuant to an Office of Student Accessibility Services (OSAS) accommodation, is prohibited. Recording can inhibit free discussion in the future, and thus infringe on the academic freedom of other students as well as the instructor. ([Living our Unifying Values: The USC Student Handbook](#), page 13).

Distribution or use of notes, recordings, exams, or other intellectual property, based on university classes or lectures without the express permission of the instructor for purposes other than individual or group study. This includes but is not limited to providing materials for distribution by services publishing course materials. This restriction on unauthorized use also applies to all information, which had been distributed to students or in any way had been displayed for use in relation to the class, whether obtained in class, via email, on the internet, or via any other media. Distributing course material without the instructor's permission will be presumed to be an intentional act to facilitate or enable academic dishonesty and is strictly prohibited. ([Living our Unifying Values: The USC Student Handbook](#), page 13).

Students and Disability Accommodations

USC welcomes students with disabilities into all of the University's educational programs. [The Office of Student Accessibility Services](#) (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at <https://osas.usc.edu>. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Student Financial Aid and Satisfactory Academic Progress

To be eligible for certain kinds of financial aid, students are required to maintain Satisfactory Academic Progress (SAP) toward their degree objectives. Visit the [Financial Aid Office webpage](#) for [undergraduate](#)- and [graduate-level](#) SAP eligibility requirements and the appeals process.

University Support Systems

Counseling and Mental Health: (213) 740-9355 – 24/7 on call

<https://studenthealth.usc.edu/counseling>

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

988 Suicide and Crisis Lifeline: 988 for both calls and text messages - 24/7 on call

<https://988lifeline.org/>

The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress

24 hours a day, 7 days a week, across the United States. The Lifeline consists of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services (though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

Relationship and Sexual Violence Prevention Services (RSVP) – (213) 740-9355(WELL) – 24/7 on call
<https://sites.usc.edu/clientservices/>

Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

Office for Equity, Equal Opportunity, and Title IX (EEO-TIX) - (213) 740-5086
<https://eetix.usc.edu/>

Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment – (213) 740-2500
<https://report.usc.edu/>

Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

Office of Student Accessibility Services – (213) 740-0776
<https://osas.usc.edu>

OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

USC Campus Support and Intervention – (213) 740-0411
<https://campussupport.usc.edu>

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC – (213) 740-2101
<https://diversity.usc.edu>

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency – UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
<https://emergency.usc.edu>

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety – UPC: (213) 740-6000, HSC: (323) 442-1200 – 24/7 on call
<https://dps.usc.edu>

Non-emergency assistance or information.

Office of the Ombuds - (213) 821-9556 (UPC) / (323-442-0382 (HSC)
<https://ombuds.usc.edu/>

A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

Occupational Therapy Faculty Practice - (323) 442-2850 or otfp@med.usc.edu

<https://chan.usc.edu/patient-care/faculty-practice>

Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.