PHY 303 – Mechanics

Fall 2020

General Course Information

Important Note: Every effort will be made to avoid changing the course schedule, but the possibility exists that unforeseen events will make syllabus changes necessary. It is your responsibility to check Blackboard for corrections or updates to the syllabus. Any changes will be clearly noted in course announcements or through Stony Brook email.

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Overview

Analytical Mechanics is the generic name of a set of theoretical approaches to Classical Mechanics in which Newton's concept of *force* takes a less prominent place. While Newton's formulation of Classical Mechanics proved tremendously successful and became the defining paradigm of our scientific age, its direct generalization potential turned out, from a historical perspective, to be rather limited. By contrast, the methods of Analytical Mechanics — the Lagrangian and the Hamiltonian formalisms, the Hamilton-Jacobi theory, the principle of least action, the idea of phase space, and the beautiful and deep relation between symmetries and conservation laws expressed by Noether's theorem — led to powerful and far-ranging generalizations. In some form or another their essential principles sit now at the heart of modern theoretical physics and play a central role in such varied fields as relativistic mechanics, general relativity, quantum mechanics, statistical mechanics and quantum field theory. Our aim in this course is to retrace this conceptual shift and walk the bridge between the Newtonian mind frame and the modern "analytical" one.

A more concrete goal of the course is for you to learn to solve classical mechanical problems using the methods and concepts of Analytical Mechanics. The mathematical level of the course should be considered as advanced, in accordance with the listed prerequisites. In particular, **you will be expected to have a solid working command of algebra and of single and multivariate calculus.** For a successful outcome, you should anticipate to spend a substantial amount of time every week preparing for the course and working on the homework.

Basic Info

Instructor

Radu Ionaş

Email: Radu.Ionas@stonybrook.edu

Office hours: online, MW from 5:45–6:45 pm, immediately after the lectures, on a dedicated Zoom link if privacy is required.

Teaching assistant

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Email: ⋆ ⋆ ⋆

Lectures

MW from 4:25–5:45 pm, live-streamed online via Blackboard-integrated Zoom. Video recordings of the lectures will be made available for subsequent viewing.

How We Will Communicate

The course administration will be done mainly via Blackboard. Course announcements, updates a.s.o. will be posted there or sent to you via class email. You will also have access to lecture slides, practice problems and various other course materials.

Course-related questions, whether about physics or organizational issues, whose answers may interest or benefit your colleagues should be posted in the General Questions Forum in the Discussions section of Blackboard. For personal/private issues, email me directly. Please allow between 24–48 hours for an email reply.

Required Materials

1. An electronic device with a video camera and microphone, capable of supporting Zoom, and a reliable internet connection capable of streaming video.
2. A means of submitting an easily readable copy of your homework assignment electronically (phone camera, scanner, tablet, etc. — anything that does a decent enough job and is hopefully as inexpensive to you as possible).

Textbook and Other References

The textbook for this course is

- L. N. Hand, J. D. Finch — *Analytical Mechanics*, Cambridge University Press, 1998 (1st ed.)

The "canonical" references in the field are

- L. D. Landau, E. M. Lifshitz — *Mechanics*, 1960 (the first volume in a magistral ten-volume *Course of Theoretical Physics*)
- H. Goldstein — *Classical Mechanics*, 1951 (with the latest, extended third edition from 2005 including also C. P. Poole and J. L. Safko as authors)

Many other books exist, covering a varied range of difficulty levels, mathematical tastes and pedagogical approaches. (Scientists have noticed that, alongside frustration, a common side effect of studying Analytical Mechanics consists of developing strong contrary opinions about these books.) Among the freely available resources which you might find useful to consult and to which I may refer from time to time are

- Professor Martin Roček's lecture notes (available in Blackboard)
- Professor Konstantin Likharev's book on *Classical Mechanics* (2013), part of his *Essential Graduate Physics* series.
- Professor Derek Teaney's notes for the corresponding graduate level course.
- D. Tong — *Lecture Notes on Classical Dynamics*.
- S. Golwala — *Lecture Notes on Classical Mechanics*.
- J. C. Baez, D. K. Wise — *Lectures on Classical Mechanics*.

If you need a refresher of the fundaments of Newtonian mechanics there are again many books that you could try, depending on your needs and taste. I will give here just one reference, freely available online, from a master of the trade:

- R. Feynman, *Lectures on Physics*, v.1.

Homework

Homework will be assigned weekly on Wednesdays and will be due on the next Wednesday at 7 am. It will consist of about five problems, some of which are going to be quite challenging. The penalty for missing the submission deadline will be of 10%/day. To account for unforeseen events, at the end of the semester the lowest two homework grades will be dropped. In exchange for this no deadline deferral requests will be granted, regardless of justification. Discussing the homework with your colleagues is not only allowed but in fact encouraged; however, the solutions you submit must be entirely your own work. Ten percent of each homework score will grade the quality of the presentation.

Exam and Grade Determination

There will be one single, final exam, which will be administered online on [final exam date and time]. Grades will be based on a combination of the total homework score (60%) and the exam score (40%). Letter grades for the course will then be assigned on a curve.

Important note: This grading scheme assumes that the final exam will be proctored in some way or another using an online proctoring platform recommended by SBU (which is expected to be announced at a later time). If that will turn out not be the case, I reserve the right to replace it with a different type of examination and adjust its percentual weight in the final grade accordingly.

Course outline

The lectures will follow, with some exceptions, the general chapter structure of Hand and Finch. The following is a tentative list of some of the topics that I plan to discuss throughout the semester:

- Mathematical preliminaries and a review of Newton's laws
- Lagrangian mechanics
- Variational calculus
- Simple and coupled linear oscillators
- Central forces and Kepler's problem
- Noether's theorem
- Hamiltonian mechanics
- Canonical transformations
- The Hamilton-Jacobi equation
- Mechanics in non-inertial frames
- Dynamics of rigid bodies

Student Accessibility Support Center Statement

If you have a physical, psychological, medical, or learning disability that may impact your course work, please contact the Student Accessibility Support Center, 128 ECC Building, (631) 632-6748, or at sasc@stonybrook.edu. They will determine with you what accommodations are necessary and appropriate. All information and documentation is confidential.

Academic Integrity Statement

Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty is required to report any suspected instances of academic dishonesty to the Academic Judiciary. Faculty in the Health Sciences Center (School of Health Technology & Management, Nursing, Social Welfare, Dental Medicine) and School of Medicine are required to follow their school-specific procedures. For more comprehensive information on academic integrity, including categories of academic dishonesty please refer to the academic judiciary website at

http://www.stonybrook.edu/commcms/academic_integrity/index.html

Critical Incident Management

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of University Community Standards any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Faculty in the HSC Schools and the School of Medicine are required to follow their school-specific procedures. Further information about most academic matters can be found in the Undergraduate Bulletin, the Undergraduate Class Schedule, and the Faculty-Employee Handbook.