Hamiltonian Mechanics – MAT461HS

Spring 2025

Time: TU 10-12, TH 11-12

Instructor: Boris Khesin

Email: khesin@math.toronto.edu
Office: BA 6228
Office hours: TBA

Course description:

The course focuses on the key notions of classical mechanics: Newton equations, variational principles, Lagrangian formulation and Euler-Lagrange equations, the motion in a central force, the motion of a rigid body, small oscillations, Hamiltonian formulation, canonical transformations, Hamilton-Jacobi theory, action-angle variables, and integrable systems.

Textbooks:

1. Arnold: "Mathematical Methods of Classical Mechanics"
(can be downloaded from
`https://3lib.net/book/2297866/63d501`)

2. Goldstein, Poole, and Safko: "Classical Mechanics"
(can be downloaded from
`https://3lib.net/book/3355492/bc94a3`)

Course Website:

The website for the course is `http://www.math.toronto.edu/khesin/teaching/mechanics/mechanics25syl.html`

Homework Assignments:

There will be 3 assignments approximately weighting 20% each and a final individual project weighting 40% (which includes 2% of in-class participation), which together constitute the full course mark. No late assignments will be accepted.

Note: You must write your solutions yourself, in your own words. If your solution is aided by information from textbooks or online sources, you must properly quote these references.

Code of Behaviour / Plagiarism:

Students should become familiar with and are expected to adhere to the Code of Behaviour on Academic Matters which can be found at:
`http://www.governingcouncil.utoronto.ca/policies/behaveac.htm`

Course Syllabus:

1. Newton equations. Lagrangian Mechanics. Energy and Momentum.
2. The two-body problem. Motion in a central field. The Kepler problem.
3. The Calculus of Variations. Euler-Lagrange equations.
4. Liouville's theorem, Poincare's recurrence.
5. Symmetries and Conservation laws. Noether's theorem.
6. Rigid Bodies. Euler's equations.
7. Hamiltonian Mechanics. Phase space. Symplectic manifolds. Poisson Brackets.
8. Lagrangian submanifolds. Integrable systems. Action-angle variables.
9. Billiard ball maps. Integrability of billiards in and the geodesic flows on quadrics.
10. Introduction to the hydrodynamical Euler equation.

Prerequisites:

MAT235Y1/MAT237Y1/MAT257Y1 (multivariable calculus),
MAT244H1/MAT267H1 (differential equations),
MAT223 (linear algebra)

Program Area Section: Mathematics