Mechanics: From Oscillations to Chaos
PHYB54H3S
Winter 2019

Professor Hanno Rein

Prerequisites The prerequisites (PHYA21H3, MATB41H3, MATB44H3) as well as the co-requisite (MATB42H3) for this course will be strictly enforced.

Contact You can reach me via e-mail at hanno.rein@utoronto.ca. I typically check my work e-mails once every two days. For urgent issues, see me in my office, SW504C, or call me on my office phone at (416) 287-7206. Regular office hours are posted on my door. I do in general not provide appointments for meetings outside of the regular office hours. However, you can try and find me in my office during other times. As a basic rule: whenever my office door is open, I am available to answer your questions.

Website All course material will be posted online at rein.utsc.utoronto.ca. Note that I will not post any material on Quercus.

Textbooks The lectures will closely follow the textbook Classical Mechanics by John R. Taylor. I encourage you to either get a physical or electronic copy of the book. Alternatively, the UTSC library has copies on course reserve.

Lecture Thursdays, 12:00 - 14:00, AA 205

This course will make heavy use of a pedagogical technique called classroom inversion. In most weeks, you will be assigned a part of the textbook to read before the lecture. During the lecture, we will then only go over some parts of the material and work on problems. If you do not do the required reading before the lecture, then you will not be able to follow the in-class activities.

Lecture Etiquette The lectures will start at 10 minutes past the hour. There will be a break after 50 minutes. Please be on time. Please do not use electronic devices such as laptops and phones in class unless specifically instructed to do so. If you are registered with Accessibility Services and need to use an electronic device, please contact me before the start of the term to find an acceptable arrangement. Note that although this lecture will take place around lunchtime, eating lunch during the lecture is not acceptable. You will be asked to leave the lecture if you do not follow these rules.

Attendance Attendance is mandatory in both the lectures and the tutorials. If you have a scheduling conflict with another course, then you cannot take both courses. Attendance will be taken at the beginning of each lecture and tutorial. If you are late, you will not be able to sign the attendance list. Attendance is worth 5% of your final mark.

Journal For this course, you need to buy a small bound journal. For example, the UofT bookstore offers journals such as this one, but even smaller ones will be adequate. But whatever journal you buy, note that it needs to be a bound book, i.e. not a folder with loose paper. The journal is not intended for writing your lecture notes. You need the journal to complete tasks I'm giving you both in class and while you are doing the assigned reading at home. You need to bring the journal to every tutorial and lecture. I will collect the journal at random times during the course. You will get a mark for the journal which, combined with a participation mark, is worth 12.5% of your final mark.

Tutorial Wednesdays, 12:00 - 13:00, AC 334

In the tutorials, we will focus on numerical topics related to classical dynamics. If you have taken PSCB57, you will already have encountered some of these. In particular, we will work with python, numpy, and scipy. At the end of the course you will be comfortable deriving numerical solutions of differential equations that appear in dynamics.

Assignments There will only be three assignments for this course. Note that if you submit a solution to an assignment question, you need to understand it. Be prepare to present and defend your submission.

Final Exam The final exam will take place during the exam period. The exam may include, but is not restricted to, material from all lectures and all tutorials. You can use a non-programmable calculator but no other aides.

Grading Scheme The final grade will be calculated as follows:

Attendance	5 %
Journal & Participation	12.5 %
Assignments	12.5 %
Midterm	20 %
Final exam	50 %

In addition to achieving a final grade of $\geq$ 50%, you also need to pass the final exam to pass the course.

Absences In the case of an event that supports an absence to a lecture or tutorial, or an inability to hand in an assignment, you need to hand in valid and official supporting documentation must be submitted **in paper form within five business days** of the missed lecture or tutorial. Documentation cannot be submitted by e-mail. You may slide the documentation under the door to my office if I'm not in.

Accessibility Students with diverse learning styles and needs are welcome in this course. In particular, if you have a disability/health consideration that may require accommodations, please feel free to approach me and/or the AccessAbility Services Office as soon as possible. I will work with you and AccessAbility Services to ensure you can achieve your learning goals in this course. Enquiries are confidential. The UTSC AccessAbility Services staff (located in SW302) are available by appointment to assess specific needs, provide referrals and arrange appropriate accommodations (416) 287-7560 or `ability@utsc.utoronto.ca`.

Academic Integrity

Academic integrity is one of the cornerstones of the University of Toronto. It is critically important both to maintain our community which honours the values of honesty, trust, respect, fairness and responsibility and to protect you, the students within this community, and the value of the degree towards which you are all working so diligently. Detailed information about how to act with academic integrity, the Code of Behaviour on Academic Matters, and the processes by which allegations of academic misconduct are resolved can be found online: `http://www.artsci.utoronto.ca/osai/students`.

According to Section B of the University of Toronto's Code of Behaviour on Academic Matters (`http://www.governingcouncil.utoronto.ca/policies/behaveac.htm`) which all students are expected to know and respect, it is an offence for students to:

- To use someone else's ideas or words in their own work without acknowledging that those ideas/words are not their own with a citation and quotation marks, i.e. to commit plagiarism.
- To include false, misleading or concocted citations in their work.
- To obtain unauthorized assistance on any assignment.
- To provide unauthorized assistance to another student. This includes showing another student completed work.
- To submit their own work for credit in more than one course without the permission of he instructor.
- To falsify or alter any documentation required by the University. This includes, but is not limited to, doctor's notes.
- To use or possess an unauthorized aid in any quiz or exam.

Specifically to this course, please be reminded that you need to understand every solution that you submit. If you work together on an assignment, you still have to be able to present your submission.

There are other offences covered under the Code, but these are by far the most common. Please respect these rules and the values which they protect. Offences against academic integrity will be dealt with according to the procedures outlined in the Code of Behaviour on Academic Matters.

Course Objectives

At the end of this course, you will be able to construct idealized dynamical models and predict model response to applied forces using Newtonian mechanics. Specific learning objectives are

- Understand the basic principles of 2D rigid body motion
- Understand central force motion
- Formulate the equations of motion of 2D and 3D rigid bodies
- Understand linear theory of harmonic oscillators
- Understand basic concepts of Chaos and Chaotic systems

Measurable outcomes are

- Provide a definition for basic concepts such as force and mass in Newtonian mechanics
- Select and use an appropriate coordinate system to describe particle motion

- Describe particle motion using intermediate reference frames, which can be in relative motion (including rotation) with respect to each other
- Identify and exploit situations in which integrated forms of the equations of motion, yielding conservation of momentum and/or energy, can be used
- Use the Lagrange equation to solve the motion of constrained systems
- Utilize 2-body orbital mechanics to analyze space trajectories
- Model and analyze simple problems involving vibration with and without damping
- Explore, model and analyze simple problems involving Chaotic system
- Solve differential equation on a computer
- Visualize trajectories on a computer
- Integrate the equations of motion for a planetary system on a computer

Tentative Class Schedule

Week	Date	Topic
1	Jan 9	Introduction to course and overview of topics
	Jan 10	Newton's Laws of motion (Chapter 1)
2	Jan 16	Getting started with python and jupyter notebooks
	Jan 17	Projectiles and Charged Particles (Chapter 2)
3	Jan 23	Plotting tools
	Jan 24	Momentum and Angular Momentum (Chapter 3)
4	Jan 20	Differential equation solvers
	Jan 31	Energy (Chapter 4)
5	Feb 6	Using the scipy ODE solver
	Feb 7	Oscillations (Chapter 5)
6	Feb 13	Assignment 1 discussion
	Feb 14	Oscillations (Chapter 5)
7	Feb 20	No tutorial (Reading Week)
	Feb 21	No lecture (Reading Week)
8	Feb 27	Midterm
	Feb 28	Lagrange Equation (Chapter 7)
9	Mar 6	Midterm discussion
	Mar 7	Central Force Problems (Chapter 8)
10	Mar 13	Assignment 2 discussion
	Mar 14	Coupled Oscillators (Chapter 11)
11	Mar 20	Geometric integration methods
	Mar 21	Chaos (Chapter 12)
12	Mar 27	Orbital mechanics with REBOUND
	Mar 28	Chaos (Chapter 12)
13	Apr 3	Assignment 3 discussion
	Apr 4	TBD