

Physics 621: Classical Mechanics

Syllabus - Fall 2025

CRN: 75395, F01

Lecture: MWF 10:30-11:30, REIC 203

Instructor: Ataur R. Chowdhury

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Office Hours: TR 10:00-11:30

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Prerequisites: Graduate standing or permission of instructor.

Text: **Classical Mechanics** by Goldstein, Poole & Safko, Third Edition, Addison Wesley (ISBN 0-201-65702-3).

Useful Resources:

1. J. Marion and S. Thornton, *Classical Dynamics of Systems and Particles* (Thomson-Brooks/Cole, 2004). An excellent undergraduate textbook on classical mechanics. If you find Goldstein a little difficult, this will be an excellent resource to bank on.
2. M. Boas, *Mathematical Methods in the Physical Sciences*, Second Edition (Wiley, 1983). A useful mathematical resource for most of the mathematical tools you need for this course. The math course (Phys 611) you have taken or will be taking concurrently with the course will also be very useful.
3. L. Landau and Lifshitz, *Mechanics* (Vol. 1, Course of Theoretical Physics). It is condensed but very insightful text that is the popular equivalent of Goldstein in Russia.

Description: Lagrange's equations, two-body problem, rigid body motion, special relativity, canonical equations, transformation theory, and Hamilton-Jacobi method.

Schedule: Materials covered in this course will be based on chapters 1-10 of Goldstein. Additional material will be provided in class as needed.

Course Objective:

1. To acquire a basic understanding of advanced concepts and formulation of classical mechanics.
2. To learn advanced mathematical methods that are useful through-out physics.
3. To develop and sharpen high-level problem-solving skills.

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4. To be able to apply the knowledge learned in this course to real-world problems in quantum mechanics and related fields.

Student Learning Outcomes:

1. Understand the basic formalism of classical mechanics.
2. Apply classical formalism to solving physical problems.
3. Learn the art of Lagrange equation, and its application to simple systems.
4. Apply Lagrange equations to solve problems in mechanics.
4. Exploit the symmetry in classical formalism.
5. Understand the rotational symmetry and its consequences.
6. Learn angular momentum based on symmetry.
7. Understand the physics of particle scattering.
9. Learn rudimentary theory of relativity.

Instructional methods: Interactive lecture-based instruction

Mode of Instruction: Face-to-face live lectures in class

Credits: 3 credits: 3 hr. of lecture per week.

Course Requirements/ Policies:

Class Attendance/Participation:

For a better understanding of the course material, attendance and participation in classroom activities are very important. For many of you this will be the first graduate physics course that deals with the fundamentals of advanced mechanics and many of you may find this course a little difficult and mathematically intense. However, if you attend classes and work out all the assignments, you will learn and possibly master the material. This is why it is highly expected that the students will commit themselves to attend the class regularly. There will be supplemental materials for this course and the students will be held responsible for all the materials that will be brought in from outside the text. The students will be expected to participate in class activities and take part in meaningful discussion and ask questions to better comprehend the subject material.

Homework:

Homework is the single most important aspect of this course. The best possible way to learn physics, and perhaps any science, is through working out problems. This is a graduate course and you may find homework challenging. However, if you find your homework difficult, please come and ask me for help. On average, 6-8 problems will be assigned on most Fridays.

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The homework will be due back at the beginning of class the following Friday. **NO LATE HOMEWORK WILL BE ACCEPTED. NO EXCEPTIONS** (barring emergencies and extreme situations). Group work is extremely effective in achieving a greater understanding of the subject material, and it is highly encouraged for solving problems. For additional help with the homework the students are most welcome to consult the instructor during office hours or any other time by prior appointment. Any homework you submit should reflect your own best effort. **Copying homework from your friend or any online sources including AI is not acceptable and will result in a grade of zero for the assignment.**

Paper:

For most graduate courses, it is customary that a paper is required to explore the field a little more than it is done in classroom setting. Classical mechanics is well established but it continuously evolves and is being employed in many other fields outside physics. To explore its contemporary development, you will be required to write a paper that adds something outside the scope of this course. You can delve into some exciting development of classical mechanics in space exploration, in non-linear dynamics, in chaotic motions, etc., and pick your topic. You could also choose an advanced topic in classical mechanics or any related field. This paper does not have to be an original piece of work but must be part of some work that is ongoing or some work that has been published in reputable scientific journals. The paper should be limited to 5-6 pages (not including references) pages, and the format of this paper should follow the format of any published article in a reputable journal. The paper will be graded mainly on the merit of its physics (70%), clarity of its concept (20%), and its style (10%) of presentation. An outline for this paper is due on September 27, 2025, and the written paper is due on November 24, 2025. The presentation of paper will take place on the 15th week of classes. The outline and paper need to be submitted on the blackboard.

Examinations:

There will be two midterm examinations (October 10, Friday 9:15-10:15, and one TBA) and a final comprehensive examination (December 12, Friday, 10:15 am-12:15 pm) for this course. Examinations will consist of, in most part, problems like those in the homework and those worked out in class. Midterms will cover the material covered in class and homework prior to the date of the test, and the final will be comprehensive and will include material covered during the entire semester.

Grading Policy:

Homework	30%
Participation	5%
Paper	10%
MidtermI	15%
MidtermII	15%
<u>Final</u>	<u>25%</u>
Total	100%

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The final grading for this course will be based on a curve. For a given score, your letter grade will not be lower than what it would be expected based on standard grading scale (90-100 = A, 80-90 = B, etc.). Allowed grades are limited to letter grades A, B, C, D, F, I, BN, and no plus-minus grades will be given for this course.

Incomplete Grade Policy: “The letter “I” (Incomplete) is a temporary grade used to indicate that the student has satisfactorily completed (C or better) most of the work in a course but for personal reasons beyond the student’s control, such as sickness, has not been able to complete the course during the regular semester. Negligence or indifference are not acceptable reasons for an “I” grade.”

University AI Policy:

UAF does not have a central university policy for AI to be abided by. Depending on how you use this, this could be a very useful tool for learning. But please make sure you are not using AI to cheat and copy things out of online sources of any kind. The university takes cheating seriously and it reserves the right to take lawful actions.

Academic Honesty

UAF expects and requires academic honesty from all members of the University community and takes any act of plagiarism and cheat seriously. It is expected that all assignments, including homework and reports, that are turned in for this course must be the original work of the individual student. Failure to comply with this policy will result in penalty as stipulated under UAF regulations.

Student Protections and Services:

COVID-19 Essentials: Because of COVID-19, the University has put in place some mandatory procedures to adhere to. All students are encouraged to observe these rules to ensure a safe environment for all of us for a successful fall semester. I request all of you to do the following:

- 1) Wear mask during class,
- 2) Maintain social distancing in class,
- 3) Use designated doors for entering and exiting,
- 4) Try to sit at the same place in class (for tracing),
- 5) Check updates about COVID-19 on the website listed below on a regular basis.

<https://sites.google.com/alaska.edu/coronavirus/uaf/uaf-students?authuser=0>

Further, students are expected to adhere to the university’s policies, practices, and mandates and are subject to disciplinary actions if they do not comply.

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Protection: Every qualified student is welcome in my classroom. Students at this university are protected against sexual harassment and discrimination (Title IX), and minors have additional protections. As required, if I notice or am informed of certain types of misconduct, then I am required to report it to the appropriate authorities. For more information on your rights as a student and the resources available to you to resolve problems, please go to the following site: www.uaf.edu/handboo

UA is an AA/EO employer and educational institution and prohibits illegal discrimination against any individual: alaska.edu/nondiscrimination.

Services: As needed, I am happy to work with you, disability services, veterans' services, rural student services, etc to find reasonable accommodations.

Effective communication: Students who have difficulties with oral presentations and/or writing are strongly encouraged to get help from the UAF Department of Communication's Speaking Center (907-474-5470, speak@uaf.edu) and the UAF English's Department's Writing Center (907-474-5314, Gruening 8th floor), and/or CTC's Learning Center (604 Barnette st, 907-455-2860).

Disabilities Services

The UAF Office of Disability Services implements the Americans with Disabilities Act (ADA), and insures that UAF students have equal access to the campus and course materials. Any student who may need assistance with disabilities, should feel free to contact the instructor or directly to the Office of Disabilities Services (208 WHIT) by calling 907- 474-5655, or through email: uaf-disability-service@alaska.edu.

General Remarks

"Physics is just the refinement of everyday thinking," A. Einstein

Physics is the subject that requires you to think and ponder. Physics is not mathematics, but it does require mathematics to make it useful. In order for you to succeed in this course you may pay heed to the following suggestions.

1. Read the chapter before it is discussed in class so that you know the material and know what questions to ask for clarification.
2. Start your homework on day one so that you have ample time to think about the questions and get the help you need.
3. Think about the problems through and follow the logical sequence to get the result.
4. Do not hesitate to ask for help. We wish all of you to excel and we are here to help.

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Tentative Schedule

Lecture, Reading, Paper and Exam

Week	Date	Topics	Reading Assignment
1	8/25-8/29	review of Newtonian mechanics Principle of virtual work	Goldstein chapter 1 Goldstein chapter 2
2	9/01-9/05	Lagrange's equations Goldstein chapter 2 and examples Labor Day (no classes)	
3	9/08-9/12	Lagrange approach in central force problems	Goldstein chapter 3
4	9/15-9/19	planetary motion	Goldstein chapter 3
5	9/22-9/26	rotating frames of motion Outline for paper due Monday	Goldstein chapter 4
6	9/29-10/03	kinematics of rotating bodies	Goldstein chapter 4
7	10/06-10/10	rotational motion of rigid bodies Midterm Friday (10/10)	Goldstein chapter 5
8	10/13-10/17	Euler's equations of motion	Goldstein chapter 5

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9	10/20-10/24	theory of small oscillations	Goldstein chapter 6
10	10/27-10/31	normal modes theory of special relativity	Goldstein chapter 6 Goldstein chapter 7
11	11/03-11/07	relativistic particle dynamics	Goldstein chapter 7
12	11/10-11/14	Hamilton's equations of motion	Goldstein chapter 8
13	11/17-11/21	canonical transformations	Goldstein chapter 9
14	11/24-11/28	Poisson's brackets	Goldstein chapter 9
	11/26-11/28	Fall Break (no classes) 11/24 Paper is due.	
15	12/01-12/05	Hamilton-Jacobi theory	Goldstein chapter 10
16	12/12	FINAL (comprehensive): Friday, 10:15-12:15 All the best...	