

Physics 355 - Classical Mechanics

Session: Fall 2021

Instructor: Prof. John B. Buncher

Office: South Engineering 317 (Zoom this semester)

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Office Hours: MW 10:00 AM – Noon, TTh by appointment

Class Meetings: TTh 2:00 PM – 3:15 PM

Location: South Engineering 221, Zoom as needed (see Blackboard)

Final: Tuesday, December 14, 2021, 1:00 PM – 3:00 PM

Course Materials

- The primary text for the course will be “Classical Mechanics”, by John R. Taylor, published by University Science Books (ISBN: 1-891389-22-X).
- Although there are some integrals and formulas listed inside the front and back covers of the text, you will find an additional book of integral tables to be quite useful. A widely used one is the *Mathematical Handbook of Formulas and Physics* in the Schaum’s Outline Series. It will prove to be a valuable resource for the rest of your academic career.
- You are expected to have already taken Physics 2 (PHYS 252) and Calculus III (MATH 259), and either have taken or are currently enrolled in differential equations (MATH 266).

Course Description

From the NDSU Bulletin: Basic concepts, single and coupled oscillators, variational calculus, Lagrangian and Hamiltonian dynamics, central force motion, accelerated coordinate systems. Prereq: PHYS 252 and MATH 265. Co-req: MATH 266.

The course familiarizes students with the theoretical methods and techniques of classical mechanics at an intermediate level. This includes a variety of mathematical and computational techniques – especially the Lagrangian and Hamiltonian formalisms – for setting up and solving differential equations to determine the motion of individual particles and systems of particles. Students develop problem-solving skills needed to master the rigor of theoretical physics and understand the fundamental roles of symmetries and conservation relations in classical mechanics.

At the most basic level, this course can be thought of as a study in “What happens when things interact?” In other words: “Given a force acting on an object, what does it do?” Other areas of physics primarily consider *how* or *why* things interact (for example, electrodynamics is the study of how electric charges interact with one another, where general relativity is concerned with gravitational interactions), or what happens when *many* things interact (statistical and thermal physics), or what happens when *very small* things interact (quantum mechanics). In this course we will be concerned with cases where we have no more than a handful of objects of moderate size (larger than atoms) interacting. In doing so, we will develop the tools to talk about important concepts such as force, energy, and momentum that will be crucial in your future physics studies.

I will assume that you have taken the introductory physics sequence and are familiar with the topics covered

there, along with a basic understanding of differential and integral calculus. Additionally, you should have a basic knowledge of vectors and vector algebra. Any mathematical topics needed beyond these will be introduced/reviewed as necessary.

Learning Outcomes (General)

1. Develop the skills of a physicist: checking units, limiting cases, developing conceptual and mathematical skills
2. Comfortably apply advanced mathematical techniques to physical problems
3. Apply Lagrangian and Hamiltonian dynamics to physically interesting systems
4. Analyze and model the motion of objects on complex settings

Feedback

If you have any concerns about the course or suggestions on how it may improve, please let me know! I am happy to consider and implement student suggestions, and I have had success implementing such suggestions in previous courses.

Course Policies

Attendance & Participation

Attendance and participation in lecture is required. You are expected to come prepared each day and to participate in the discussion and problem-solving. If you miss a class, it is your responsibility to get the missed notes (from a classmate) and any assignments given (from a classmate or me). If you are absent on a day that homework is due, you will not have the opportunity to make up the assignment unless you discuss the absence with me and provide documentation of a University excused absence (in advance, if at all possible).

According to [NDSU Policy 333 www.ndsu.edu/fileadmin/policy/333.pdf](http://www.ndsu.edu/fileadmin/policy/333.pdf), attendance in classes is expected. Veterans and student service members with special circumstances or who are activated are encouraged to notify the instructor as soon as possible and are encouraged to provide Activation Orders.

Grades

Your final grade will be determined according to the following weights and cutoffs:

Participation & Preparation	5%
Homework	35%
Exams	40% (20% each)
Final	20%

A	90 %
B	80 %
C	70 %
D	60 %
F	< 60 %

Note that exams make up 60% of your final score! It is crucial that you prepare and study accordingly.

NOTE: You must satisfactorily complete 80% of the homework assignments in order to receive a passing grade in the course.

Homework

Homework will be given roughly once per week throughout the semester. Unless prior arrangements have been made, all homework is due at the **beginning** of class on the due date. If you are late to class on the due date your homework will **not** be accepted.

All of your assignments that you turn in must meet the following “formatting” requirements:

1. It should be neat and presentable.
2. It is to be written on loose-leaf, perforated, or plain paper (no notebook “frillies”).
3. Each problem should be started on a separate page.
4. Everything should be clearly legible. This means: no ink smears, no eraser smudges, etc.
5. The pages must be stapled. The staple **must** be positioned vertically in the upper-left corner of the page, less than half an inch from the left side of the page.
6. All pages must be numbered in the upper-right hand corner, and put in order.
7. You must re-state the problem which you are attempting to solve, at least briefly.
8. Answers should be clearly labeled (boxed, highlighted, bold, etc.).
9. If you worked with anyone else on your assignment (which you are encouraged to do!), you must indicated key contributions that your other group members made.
10. You may also typeset your assignments using any program that you prefer (\LaTeX , *Mathematica*, OpenOffice, Word, etc.), if you wish.

Your homework should not only contain equations and mathematical procedures, but also *sentences* which describe the *physics* of what is happening. Each solution should include the following “expert” problem solving steps:

1. Describe the physical system – particles, interactions, charges, fields, or whatever else is relevant.
2. Clarify geometrical relationships, usually with the aid of a coordinate system.
3. Identify relevant physical principles, such as Newton’s laws or conservation laws.
4. Identify simplifying assumptions, such as whether or not to use a particle or continuum model, whether or not to include air resistance, etc.
5. Adding details as needed, such as drawing a free-body diagram.
6. Insert the relevant quantities into the relevant equations and solve for the answer.

7. *Check* the answer to see that it makes sense by looking at units and *interpreting* the result.

Most of the *physics* is contained in the first five steps and step 7, yet many people think of step 6 as “doing physics”. This is what sets physics apart from “word problems” in a math course; you have to know the relevant physics to even write down the mathematical problem you need to solve! Don’t forget the last step either, you should never underestimate the usefulness of checking units and limiting cases to make sure that an answer makes sense. I know it has helped me catch a mistake more times than I can count.

Exams

Due to the nature of this semester and COVID-19, I will work out the best method for exams after the first few course meetings. *Normally* exams would be timed and in-class, but we’ll see how the semester progresses.

Office Hours

See the front page for office hours. If you need to meet outside of those times, email me and we should be able to work something out. During office hours, we can discuss anything that you wish (homework, grading, concepts, exams, topics of interest, etc.) If there is something of a personal nature, it would be best to make a separate appointment.

Accommodations

Any students with disabilities or other special needs, who need special accommodations in this course, are invited to share these concerns or requests with the instructor and contact the [Disability Services Office](http://www.ndsu.edu/disabilityservices/) <http://www.ndsu.edu/disabilityservices/> as soon as possible.

On Academic Dishonesty

The academic community is operated on the basis of honesty, integrity, and fair play. [NDSU Policy 335: Code of Academic Responsibility and Conduct](#) applies to cases in which cheating, plagiarism, or other academic misconduct have occurred in an instructional context. Students found guilty of academic misconduct are subject to penalties, up to and possibly including suspension and/or expulsion. Student academic misconduct records are maintained by the [Office of Registration and Records](#). Informational resources about academic honesty for students and instructional staff members can be found at www.ndsu.edu/academichonesty.

You are highly encouraged to work with your fellow students, and to seek out their assistance or the assistance of the instructor, in all of your studies. Working with another person is highly beneficial for both people when there is a healthy working relationship. However, whatever you turn in must be your own work and words. Copying someone else’s work and turning it in as your own is a case of academic dishonesty. You are not permitted to collaborate with anyone else on exams.

If you have any questions about what constitutes academic dishonesty it is your responsibility to ask before the assignment is due.

Course Schedule

We will not have a set course schedule. The pace and content of the course will be determined as it progresses. However, I intend to cover Chapters 1–7, 11, and 13 with time left over for a topic or two to be decided.

Week 1	Newton's Laws & Differential Equations
Week 2	Polar Coordinates, Projectile Motion, Drag
Week 3	Momentum, Center of Mass, & Angular Momentum
Week 4	Line Integrals, Work, Conservative Forces
Week 5	EXAM 1 & Curvilinear 1D systems, Central Forces, Elastic Collisions
Week 6	1D & 2D Oscillations (No Damping)
Week 7	Damped Oscillations, Driven Oscillations, Resonance
Week 8	Calculus of Variations & Euler-Lagrange Equation
Week 9	Fourier Series %
Week 10	EXAM 2 & Lagrange's Equations of Motion
Week 11	Lagrange's Equations & Constraints
Week 12	Generalized Momenta & Lagrange Multipliers
Week 13	Coupled Oscillators
Week 14	Central Force Motion
Week 15	Hamilton's Equations of Motion

Advice

Here are some helpful tips for success in the course, from my own personal experience and suggestions of other professors.

1. If you are having trouble, ask for help! Help is available through me via my office hours (or other appointment), other faculty in the department, and your fellow students.
2. Read the appropriate sections of the text *before* the relevant lecture session. That way, you're seeing the material for the second time, and are much better prepared to ask questions on things you're having trouble understanding.
3. When reading the text, be sure to read *critically*. That is, ask questions and take notes! If something is not clear, make a note of it so you can ask in class. You should also be working through steps done (or omitted) in class and the text. As a friend of mine once said "The exam will NOT ask if you agree with our solution, but will asked you to come up with your OWN solution."
4. This course will likely take a significantly greater amount of time than your previous courses, both in completing the homework and understanding the concepts. It is critical that you start your homework assignments as early as possible, as you may need a few days to solve the problem sets.
5. Don't work for more than a few hours on a problem if you're stuck! Switch to another problem (which may cause you to think about the troublesome one in a different way), and find assistance. That being said, do not despair if it is not obvious what to do after 5 minutes of thinking. These problems will require some extra thought.
6. Don't panic. Physics is hard. Like anything else worthwhile, it will take practice and perseverance to succeed, but the rewards are well worth it.

COVID-19 Specifics

This section of the syllabus contains information that is not part of my normal syllabus, pertaining to the circumstances around COVID-19.

Communication

- The primary method of communication will be through your official NDSU email address. This should be checked *frequently* (a few times per day).
- I will maintain a course web page via Blackboard. This is where any lecture recordings, PDFs of any lecture slides, assignments, etc., will be posted. Emails you receive will also show up here under “Announcements”.
- The *intended* mode of lecture delivery is in-person. Given the current reality of COVID, that may not be possible for the entire semester given local case and positivity rates. Additionally, masks are *required* in the classroom. If you do not have one (or it is not worn properly, or not properly fitting), you will be asked to leave. I may move lecture online if there is non-compliance.
- I will have scheduled office hours via Zoom, please feel free to drop by without an appointment, or to make an appointment if the regularly-scheduled hours conflict with your schedule!

Health and Safety Expectations

- NDSU *REQUIRES* students to wear face coverings in classrooms. Remember, wearing a face covering is intended primarily to protect others in case *you* are infected but to not show symptoms. Thus, it is *not* a “personal choice” to wear a mask.
- You must properly wear a face covering (covering both the mouth and nose) for the entirety of class.
- In accordance with this, food and drink are NOT allowed in the classroom.
- If you fail to properly wear a face covering, you will be asked to leave the classroom, and you will be referred to the Dean of Students Office for disciplinary action as needed.
- Students who cannot wear a face covering due to a medical condition or disability may seek accommodation through Disability Services (701)-231-8463; <https://www.ndsu.edu/disabilityservices/>.
- Disinfecting supplies are provided for you to disinfect your learning space. You may also use your own disinfecting supplies.
- Students should observe social distancing guidelines whenever possible. Students should avoid congregating around instructional space entrances before or after class. Students should exit the instructional space immediately after the end of class to ensure social distancing and allow for the persons attending the next scheduled class to enter the classroom.
- In accordance with **NDSU Policy 601**, failure to comply with instructions, including this syllabus, may be handled according to the Code of Student Conduct resolution process and may result in disciplinary sanctions.

Attendance Expectations

- Students are expected to attend every class and remain in class for the duration of the session when it is safe to do so in accordance with NDSU guidance regarding COVID-19.
- In this course students should participate in the course mostly synchronously, whether that is in the physical classroom or virtually through Zoom. Do NOT feel that you have to attend in the classroom. When needed, students are also able to participate virtually in asynchronous discussions and activities and submit assignments virtually.
- While the participation policy for this course is outlined in the main syllabus, please note that I will be flexible regarding deadlines for students who are experiencing illness or other challenges related to COVID-19. Please contact me as early as possible if you think you may not be able to complete an assignment or participate in the course due to illness.
- Do NOT come to class if you are sick (cold, flu, allergies, COVID). Even for something like “allergies”, other students will have heightened anxiety around you. You can view the lectures remotely and ask any questions you have on Zoom.

If you are ill,

- If you are unable to attend class at the regularly scheduled time due to illness, contact me for alternate arrangements, including recordings of class sessions and assignments as well as accommodations and extensions as needed.
- Do NOT come to class if you are sick. Please protect your health and the health of others by staying home and participate in class remotely. For information on COVID-19, symptoms, testing, and steps to stay healthy see https://www.ndsu.edu/studenthealthservice/covid_19/.
- Do not come to class if you have been exposed to individuals who tested positive for COVID-19 and/or you have been notified to self-quarantine due to exposure.
- If you are absent from class as a result of a COVID-19 diagnosis or quarantine, the decision for approval of all absences and missed work is determined by the course instructor. As instructor, I will do the following to help you make progress in the course:
 - You will be able to participate in class remotely.
 - You will be able to submit assignments and take exams remotely.
 - I will be flexible with deadlines.
 - Other remote learning options will be determined on a case-by-case basis.

Assignment Submission

- Your assignments and exams will largely be handwritten, but you will submit them electronically. I hope to get something set up in Blackboard so that you can upload a PDF directly there. I will also grade those PDFs and mark them up with feedback and send the PDFs back to you. Exams will likely work similarly.
- If you are sick, do NOT come to class or campus to turn in work! ALL work will be collected electronically! If you get sick, notify me as soon as possible, so I can make arrangements with you.

Additional Resources for Students

It is *normal* to feel overwhelmed at the best of times, but especially now. As a member of the NDSU community, resources are available for you should you need help in dealing with adverse reactions to things happening in the world today. A variety of resources are listed below:

For students on campus and remotely (telehealth):

Counseling Services: 701-231-7671; <https://www.ndsu.edu/counseling/>

Disability Services: 701-231-8463; <https://www.ndsu.edu/disabilityservices/>

Student Health Service: 701-231-7331; <https://www.ndsu.edu/studenthealthservice/>

Dean of Students Office: 701-231-7701; <https://www.ndsu.edu/deanofstudents/>

In a crisis or emergency situation: Call University Police: 701-231-8998

Call 9-1-1

Go to a Hospital Emergency Room Go to Prairie St. Johns for a Needs Assessment: 701-476-7216 (510 4th St. S.)

Call the FirstLink Help Line: 1-800-273- TALK (8255) or 2-1-1

Call Rape and Abuse Crisis Center: 701-293-7273