Physics 355: Classical Mechanics

3 credits
Fall 2019
Pre-req: PHYS 252 and MATH 265; Co-req: MATH 266.

Lectures: T, Th 2:00 pm – 3:15 pm, SE 221
Instructor: Prof. Mila Kryjevskaia
Office: South Engineering, 212C
Office hours: Monday 1-2 pm, Wednesday 12-1 pm, or by appointment.
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Website: On Blackboard. Access to this site is important. In-class worksheets, homework assignments and solutions, and exam solutions will be posted here.
Text: "Classical Mechanics" by John Taylor

Course Description

Basic concepts, single and coupled oscillators, variational calculus, Lagrangian and Hamiltonian dynamics, central force motion, accelerated coordinate systems.

Classical mechanics is a great subject! It allows us to build roller coasters, explain the Coriolis effect, and travel to the moon. It is fascinating in its own right, but also provides a mathematical and conceptual foundation for topics in modern physics such as quantum mechanics. I am quite excited about this topic, and about working with you in this class.

Now that your background includes introductory mechanics and some differential equations, we will ramp things up a bit. That is, this course is intended to deepen and expand your understanding of mechanics and equip you with powerful mathematical tools that you will need to solve more advanced and more complicated physics problems. Some of the topics discussed in this class (*e.g.*, oscillations and normal modes) will be quite valuable as you continue on with other physics courses. And the mathematical techniques that we develop to understand these topics will be valuable for just about all future physics that you do. These techniques include gradient and curl, Fourier series, and the calculus of variations.

Content Listing:

- Basic concepts: Newton's laws, energy, momentum, angular momentum, rockets
- Single Oscillators: harmonic oscillations, damped oscillations, driven oscillations, resonance
- Variational calculus: functional minimization, Euler-Lagrange equations, constraints
- Lagrangian dynamics: generalized coordinates and momenta, holonomic constraints, action integral, Hamilton's principle, conservation laws
- Central force motion: relative coordinates, reduced mass, bounded versus unbounded motion, Kepler equation, Virial theorem
- Accelerated coordinate systems: pseudo-forces in rotating frames, Coriolis effect
- Coupled oscillators: normal modes, eigenvalues, principal axis transformation, normal coordinates
- Hamiltonian dynamics: Hamilton equations, principle of least action, conservation theorems

If time permits special topics can be included. Examples include: collision theory, nonlinear dynamics and chaos, rigid body motion, transition to continuum mechanics, phase space and Liouville's theorem.

Course Objectives:

Student will develop proficiency 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.

Course format

The course will emphasize both conceptual understanding and quantitative analysis. Class meetings will include standard lectures as well as small-group activities.

I *will* attempt to break things up and keep you engaged in a variety of different ways. For example, sometimes we will do structured derivations in which students are asked to fill in missing steps. In other cases, brief challenge questions posed during the lecture will ask students to explain their ideas to a neighbor or to the entire class. The purpose is to encourage you to stay active in thinking through the ideas that are being covered, rather than tuning out or simply copying down what is said without thinking. The goal is for students to be comfortable expressing their ideas and trying to figure things out, and not be worried about giving an incorrect answer. (In this situation, incorrect answers are an opportunity to learn.)

Attendance

Attendance and active participation are expected.

In-class work credit will be given based on effort and correctness. Specifically, regular "check-points" will be given at the beginning of a class. Students will receive 2.5% credit toward their final grades based on the effort in attempting to answer the check-point questions. If ~50% of all answers are correct, students will receive additional 2.5%, thus obtaining 5% total toward their final grades.

Homework. Homework will be assigned roughly every week. The assigned HW will be collected, graded and returned. Detailed solutions to all written HW problems will be posted.

Examinations. There will be two mid-term exams and a final.

- Midterm 1: October 1
- Midterm 2: November 12
- Final exam (comprehensive): Tuesday, December 17, 1.00 pm – 3.00 pm.

Assignment of grades

Grades will be computed as follows:

- in-class work (5%)
- homework (30%),
- midterms (20% each),
- final exam (25%).

Letter Grading:

89.5 to 100% = A
79.5 to 89.4% = B
69.5 to 79.4% = C
59.5 to 69.4% = D

Special Considerations

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 (www.ndsu.edu/disabilityservices) as soon as possible. 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.

Academic Responsibility

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.