

Introduction to Computational Physics

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Classes/Labs: TTh 11:00-12:50, SE 221 (optional free lab time TBA)

Office Hours: TTh 10:00-10:50 or by arrangement

Bulletin Description: Introduction to computational methods, with applications involving planetary motion, numerical integration, chaotic oscillations, percolation, random walks, diffusion limited aggregation, and Fourier transforms.

Prereqs: PHYS 251, MATH 166, and CS 160 / ECE 173 **Coreq:** PHYS 252

Goals: Master basic concepts and practical methods of computational physics; develop scientific programming skills through numerically solving a variety of physics problems. By course end, students will be able to code, run, analyze, and interpret the results of Monte Carlo and molecular dynamics simulations of interacting many-particle systems.

Philosophy: physical concepts → numerical algorithms → coding implementation

Student Responsibilities: Attend all classes/labs. Read assigned material in advance. Come prepared for discussion. Be curious; ask questions. Complete assignments on time.

Muddiest Point: Each week, by Tues. 10:00 a.m., send me an e-mail to let me know the one concept that you *least* understand. I will address questions (anonymously) in class.

Text: H. Gould, J. Tobochnik, and W. Christian,
An Introduction to Computer Simulation Methods, 3rd edition (Pearson, 2007).

Evaluation: homework (60%); project (30%); quizzes, notebooks, participation (10%).

Homework: Assignments will be posted on Blackboard (<https://bb.ndsu.nodak.edu>). Assignments distributed on Tuesday will be due on the following Tuesday before class. Keep a **lab notebook**, documenting your “computer experiments” for each assignment. Submit code electronically (instructions TBA) and reports in hard copy for comments. In preparing **laboratory reports**, follow the format in the **Appendix of Chapter 1**.

Teamwork is encouraged, but *write your own report and code* and list any collaborators. Identical or near-identical programs will receive no points. As part of each assignment, you will be asked to present your work during the lab session. Since solutions will be discussed on the due date, late assignments cannot be accepted. Partial credit may be given to incomplete work, however, so submit whatever you can finish by the deadline.

Project: outlines due **Friday, March 26**. Final project reports due **Friday, April 30**. Oral presentations will be scheduled during the final two weeks of semester (**May 3-14**).

Note: 10% of the project grade will be based on attending and evaluating presentations.

Grading: A: 90-100%, B: 80-89.9%, C: 70-79.9%, D: 60-69.9%, F: < 60%

Tentative List of Topics

- Computers in Physics: role and importance of computational modeling
- Programming and the *Open Source Physics (OSP) Project*: model-view-control
- Finite-difference methods for solving differential equations
- Particle Motion: modified Euler algorithms, solving ODEs, trajectories
- Oscillatory Systems: simple harmonic motion
- Planetary Motion: equations of motion, circular and elliptical orbits
- Chaos and Dynamical Systems: period doubling, universality
- Random Processes: random walks, nuclear decay, polymer conformations
- Dynamics of Many-Particle Systems: molecular dynamics
- Normal Modes and Waves: coupled oscillators, Fourier series, wave motion
- Electrodynamics: electric charges, fields, and potentials
- Monte Carlo Methods: integration, importance sampling, “Metropolis” algorithm
- Fractals and Kinetic Growth: fractal dimension
- Complex Systems: cellular automata, neural networks, genetic algorithms

Rules of the Road

- *No food or drinks are allowed in the computer lab (we love our computers)!*
- *If a program hangs the computer, do not reboot. Rather, contact an instructor.*
- *All access to NDSU computers must respect NDSU Senate Policy, section 158: Acceptable use of Electronic Communication Devices*
<http://www.ndsu.nodak.edu/policy/158.htm>
- *All work done in this course must be completed in a manner consistent with NDSU Senate Policy, section 355: Code of Academic Responsibility and Conduct*
<http://www.ndsu.nodak.edu/policy/355.htm>
- *Plagiarism or inappropriate use of computers will result in failure of the course.*
- *Any students with disabilities who need accommodation in this course are encouraged to speak with the instructor as soon as possible to make appropriate arrangements.*