Phys 370 (#06976, 3 credits) **Spring 2020**

Introduction to Computational Physics

Instructor: Dr. Alan R. Denton, South Engineering 214B
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Classes/Labs: TTh 12:30-13:45, South Engineering (SE) 221

Office Hours: drop in or make an appointment

Bulletin: Introduction to computational methods, with applications to planetary motion, numerical integration, chaotic oscillations, percolation, random walks, diffusion limited aggregation, molecular dynamics simulation, Monte Carlo methods, Fourier transforms.

Prereqs: PHYS 251, MATH 166, and CSCI 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. According to NDSU Policy 333 (`www.ndsu.edu/fileadmin/policy/333.pdf`), attendance in classes is expected. *More than three unexcused absences may result in failure.*

Muddiest Point: Each week, by Tues. 11:00 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.

Textbook: H. Gould, J. Tobochnik, and W. Christian,
An Introduction to Computer Simulation Methods, 3rd ed. (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 all computer codes and laboratory reports electronically (instructions TBA). 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 work will receive no points. Since solutions will be discussed on the due date, late assignments cannot be accepted. Partial credit may be given for incomplete work, however, so submit whatever you can finish by the deadline.

Project: Outlines are due **Friday, March 27**. Reports are due **Monday, May 11**. Oral presentations will be scheduled during the final week of semester (**May 4-8**).
Note: 5% 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: $< 60\%$

Topics

Week 1: Computers in Physics: role of computational modeling; numerical methods

Week 2: Finite-difference methods for solving ordinary differential equations (ODEs)

Week 3: Programming and the *Open Source Physics (OSP) Project*: model-view-control

Week 4: Particle Motion: modified Euler algorithms, solving ODEs, trajectories

Week 5: Oscillatory Systems: simple harmonic motion

Week 6: Planetary Motion: equations of motion, circular and elliptical orbits

Week 7: Chaos and Dynamical Systems: period doubling, universality

Week 8: Random Processes: random walks, nuclear decay, polymer conformations

Week 9: Dynamics of Many-Particle Systems: molecular dynamics

Week 10: Monte Carlo Methods: integration, importance sampling, thermal systems

Week 11: Normal Modes and Waves: coupled oscillators, Fourier series, wave motion

Week 12: Electrodynamics: electric charges, fields, and potentials

Week 13: Fractals and Kinetic Growth: fractal dimension

Week 14: Complex Systems: cellular automata, neural networks, genetic algorithms

Week 15: Projects

Week 16: Project presentations

Rules of the Road

- *No food or drinks are allowed in the computer lab (we love our computers)!*
- *All access to NDSU computers must respect NDSU Senate Policy, section 158: Acceptable use of Electronic Communication Devices*
  `https://www.ndsu.edu/fileadmin/policy/158.pdf`
- *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`.

  Any students with disabilities or other special needs, who need accommodations in this course, are invited to share concerns or requests with the instructor and to contact the Disability Services Office (`www.ndsu.edu/disabilityservices`*) as soon as possible.*
- *Plagiarism or inappropriate use of computers will result in failure of the course.*