Physics 236: Introduction to Computational Physics

Section 1, Spring 2026

Lecture: 12:30 PM–1:45 PM T in CS 311, 12:30 PM–1:45 PM R in CS 315

Lab: TBD in CS 425

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Textbook:	*Computational Physics* 2nd edition by Giordano and Nakanishi

Course description: Introduction to computational methods in physics, with an emphasis on developing tools for realistic computer simulations. Numerical methods for ordinary differential equations, nonlinear systems and chaos, Monte Carlo methods. Applications in the physical sciences including astronomy, statistical mechanics, and other scientific fields. *Prerequisites:* PHYC 122, MATH 166; and hopefully some prior programming experience.

Course Objectives: This course is deigned to introduce you to the basic techniques of numerical and computational physics. It is intended that when you have successfully completed this course, you will have acquired basic skills for solving problems using a computer, including algorithm development and code design, programming, testing and error analysis, and data analysis and interpretation. You will be exposed to basic algorithms for computational problem solving in a number of areas of physics that include but are not limited to mechanics, electricity and magnetism, statistical mechanics, and quantum mechanics. We will use the techniques developed in the laboratory exercises to gain a fresh perspective on concepts covered by the physics major, and thereby reinforce the conceptual understanding of the physical laws.

Laboratory: Lab exists to serve as a bridge between the mathematical and numerical concepts introduced in lecture and the effective realization of these concepts in computer programs. A first goal will be to get you familiarized with the computational tools available to you and how to use them to produce simple programs. A second will be the development and testing of numerical techniques used in projects, to enable you to make the transition between passive and educated use of numerical methods. A final component of lab is the use and manipulation of existing programs to obtain simulation data, and to learn how to interpret and use such data to make useful statements about physical phenomena involved. Most lab assignments will involve a good deal of homework but please make best use of scheduled lab time as possible.

Exams: One midterm exam will be given. This will mostly consist of quick problems but some discussion or multiple choice questions may be given. A *make up* exam will be given only for circumstances deemed valid by the instructor. Please give notice that you will miss an exam as soon as possible, preferably **before** the exam.

Programming Language: For this class, I will mostly use Python as a programming language. Python is a modern object-oriented language that is very easy to learn and easily translates between Windows, Linux and Mac environments. Labs will be written to work with Python, but you may work with whatever language you feel most comfortable with. Languages used in scientific programming include C, C++, Java, Fortran (90 or 95), Mathematica, Matlab, Maple, of which I am most familiar with C, Fortran and Mathematica. Please comment generously if you use Visual Basic or some other code I am not familiar with.

Semester Project: In place of your final exam, you will be asked to present a final project on a computational physics or engineering problem of your choice. The report should contain any background research you do to define your project and your own computational work. *Graduate students* will be expected to take on more challenging projects, possibly one related to your thesis research. Project topics need to be approved by Friday, March 13, 2026.

Attendance Policy: You are expected to attend all classes and laboratory activities, but I do not require you to attend. *Please note:* that your Attendance/Effort grade will reflect not only your attendance, but also the overall contribution to the academic environment of the of the classroom and laboratory activities.

Grading policy: The grades will be based on the total points acquired on the homework, exams and laboratory exercises. The uncertainty in the number of laboratory courses and homework assignments make it impossible to definitively determine the number of points accumulated over the semester. In the following table, I have summarized the tentative points available over the semester. In addition, for courses at this level it is difficult to determine overall performance on tests and class assignments. As a consequence, final grades will be determined by the overall grade distribution of the class, but will never be more strict than the following: 100-90 A, 90-80 B, 80-70 C, 70-60 D, and 60-0 F.

Item	Percentage of Total
Labs	50%
Mid-term Exam	10%
Attendance/Effort	10%
Final Project	30%
Total Points	100%

Academic Honesty: Cheating is prohibited at Ball State University. Copying other peoples work without attribution is not permitted and may be subject to disciplinary measures.

Students with Disabilities: If you need adaptions or accommodations because of a disability, or if you have emergency medical information to share with me, please contact me as soon as possible. Ball State's Disabled Student Development office coordinates services for students with disabilities; documentation of a disability needs to be filed in that office before any accommodations can be provided. Disabled Student Development can be contacted at 765-285-5293 or dsd@bsu.edu.

University Statement We are committed to ensuring that all members of the community are welcome, through valuing the various experiences and worldviews represented at Ball State and among those we serve. We promote a culture of respect and civil discourse.

Schedule: I have included a *tentative* schedule of the subjects to be covered in class on the following page. Please note the following schedule is *tentative* and subject to change.

Week	Reading (Giordano)	Topics/Projects
1, 2	Chap 1	Introduction to numerical methods
		Basics of scientific programming
	(Landau 2)	Numerical Error
	(Vpython)	**Lab/Project 1:** Orientation/Radiative Decay
	(Landau 3)	**Lab/Project 2:** Errors in Computing
3, 4	Chap 2	Introduction to numerical methods
		Newton's Laws
		Air drag
		Lab/Project 3: Cycling with realistic air drag
		Lab/Project 4: Physics of projectiles
5, 6	Chap 3	Nonlinear dynamics
	(Landau 9)	Programming ordinary differential equations
		Energy and motion
		Lab/Project 5: Simple harmonic oscillator
		Nonlinear dynamics and chaos
		Lab/Project 6: Nonlinear driven pendulum
7, 8, 9	Chap 4	Orbital Dynamics
		Universal gravitation
		Lab/Project 7A: Solar system orbits
		The three-body problem
		Lab/Project 7B: The sun, Jupiter and Mars
10, 11, 12	Chap 7	Random walks and statistical methods
	(Landau 5)	Monte Carlo Integration
		Lab/Project 8: Random numbers and Monte Carlo
		Random walks
		Lab/Project 9: Random walks and Diffusion
		Entropy / Relaxation methods
		Lab/Project 10: Choice A:
		Entropy of a cup of coffee
		Lab/Project 10: Choice B:
		Relaxation method for diffusion equation
13, 14, 15	Chap 9 and 10	Applied topics
		Laplace's Equation
		Methods for quantum mechanics
		Molecular Dynamics methods
		Lab/Project:TBA
		Final Presentation