PHYS 613: Computational Physics II

Spring 2023

Lecture:	Mondays 4:30 pm – 7:10 pm
Course Modalities:	Online instruction via Zoom
Instructor:	Professor Chi Yang
Office:	Planetary Hall, Suite 103, #103B
Email:	cyang@gmu.edu
Office Phone:	703-993-4077
Office Hours:	Tuesdays 2:30pm – 4:00pm, and by appointment via Zoom

Required Textbook:
R. J. LeVeque, "Finite Difference Methods for Ordinary and Partial Differential Equations: Steady-State and Time-Dependent Problems," SIAM, 2007

The textbook can be downloaded from the following link using GMU VPN connection:
https://epubs.siam.org/doi/book/10.1137/1.9780898717839?mobileUi=0

Course Description:
This course focuses on elements of Computational Physics. The main goal of this course is to familiarize students with advanced concepts of computational sciences applied to physics and engineering. Students who complete this course should be able to develop their own code in MATLAB or Python, implement algorithms, manage the input and output of data, visualize the results. To take this class, students must be familiar with concepts of analytic geometry and calculus, matrix algebra, differential equations, partial differential equations, and MATLAB or Python programming.

Prerequisites:
PHYS 510 Computational Physics I: Errors & Uncertainties in Computations; Systems of Linear Equations; Linear Least Squares; Eigenvalue Problems; Nonlinear Equations; Optimization; Interpolation; Numerical Integration and Differentiation; Initial Value Problems for ODEs; Boundary Value Problems for ODEs; Fourier Analysis; and computer literacy including familiarity with MATLAB or Python programming.

About the Class:
Lectures will be given online by sharing lecture slides and Matlab screens. Lecture notes and homework assignments will be posted on the Blackboard. Announcement/email will be used to communicate with students after each class, which will include the summary of the materials covered in the class, homework instructions, and the topics to be covered in the next class.

Class URL:
Blackboard, https://mymasonportal.gmu.edu

Topics of Computational Physics II:

1. Introduction
2. Overview of Partial Differential Equations
    a. Classification of Differential Equations
    b. Derivation of Partial Differential Equations from Conservation Principles
3. Boundary Value Problems and Iterative Methods

    a. Finite Difference Approximations
    b. Steady States and Boundary Value Problems
    c. Elliptic Equations
    d. Iterative Methods for Sparse Linear Systems
    e. Applications
4. Initial Value Problems
    a. The Initial Value Problem for Ordinary Differential Equations
    b. Diffusion Equations and Parabolic Problems
    c. Advection Equations and Hyperbolic Systems
    d. Applications
5. Visualization
    a. 2D plots: Python, gnuplot, etc.
    b. 3D plots: Python, Paraview, etc.

Tentative Course Schedule:

Week	Date	Contents
1	01/23	Introduction
2	01/30	Overview of Partial Differential Equations
3	02/06	Finite Difference Approximations
4	02/13	Steady States and Boundary Value Problems (I)
5	02/20	Steady States and Boundary Value Problems (II)
6	02/27	Elliptic Equations (I)
7	03/06	Elliptic Equations (II)
8	03/13	Spring recess (no classes from Monday March 13 to Sunday March 19)
9	03/20	Iterative Methods for Sparse Linear Systems
10	03/27	Diffusion Equations and Parabolic Problems (I)
11	04/03	Diffusion Equations and Parabolic Problems (II)
12	04/10	Advection Equations and Hyperbolic Systems
13	04/17	Visualization
14	04/24	Project Presentation
15	05/01	Review

Grading:

Homework:	40%
Project:	30%
Final Exam:	30%

Homework:

The homework includes developing codes to solve common scientific problems in computational physics and engineering. The homework and project are expected to be done with MATLAB or Python.

MATLAB Computing Environment:
MATLAB is a computing environment with programming capability, good graphics, and powerful library functions. Matlab is available to faculty, staff, and enrolled students on Mason-owned or personally-owned computers. For students, the software can only be used for academic coursework and non-commercial research use. You can also access MATLAB through Mason Citrix Virtual Lab (https://its.gmu.edu/service/citrix-virtual-lab/). Alternatively, a PC or Macintosh version can be purchased.

References:

1. R. H. Landau, M. J. Paez and C. C. Bordeianu, "Computational Physics: Problem Solving with Python," 3rd edition, Wiley, 2015.
2. R. H. Landau and M. J. Paez, "Computational Problems for Physics: With Guided Solutions Using Python," CRC Press, 2018.
3. F. J. Vesely, "Computational Physics: An Introduction," 2nd edition, Springer 2001.
4. A. Iserles, "A First Course in the Numerical Analysis of Differential Equations," 2nd edition, Cambridge University Press, 2009.
5. R. M. M. Mattheij, S. W. Rienstra, and J. H. M. ten Thije Boonkkamp, "Partial Differential Equations: Modeling, Analysis, Computation," SIAM, 2005.
6. H. P. Langtangen, "A Primer on Scientific Programing with Python," 5th edition, Springer, 2016.

Online Resources:

1. MIT: 18.085 - Computational Science and Engineering I
   - http://math.mit.edu/classes/18.085/2015FA/index.html
2. MIT: 18.086 - Computational Science and Engineering II
   - http://math.mit.edu/~stoopn/18.086/index.html
3. MIT: Numerical Methods for Partial Differential Equations
   - https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-920j-numerical-methods-for-partial-differential-equations-sma-5212-spring-2003/lecture-notes/
4. University of Washington: Numerical Methods for Time-Dependent Differential Equations
   - http://staff.washington.edu/rjl/classes/am586s2016/
5. Washington State University: Understanding the FDTD Method
   - http://www.eecs.wsu.edu/~schneidj/ufdtd/
6. University of Minnesota: MATH 8445 - Numerical Analysis of Differential Equations
   - http://www.ima.umn.edu/~arnold//8445.f11/
7. The Python Tutorial
   - https://docs.python.org/3/tutorial/
8. Download Anaconda Distribution: Python 3.7 version
   - https://www.anaconda.com/download/

Email Communications:
Students must use their Mason email account to receive important University information, including communications related to this class. I will not respond to messages sent from or send messages to a non-Mason email address. Please see https://its.gmu.edu/service/office365-email/ for more information.

Student and Faculty Names and Pronouns:
Name and pronoun use: If you wish, please share your name and gender pronouns with me and indicate how best to address you in class and via email. I use she/her/hers for myself and you may address me as Chi, or Dr./Prof. Yang in email and verbally.

Academic Integrity:
It is expected that students adhere to the George Mason University Honor Code as it relates to integrity regarding coursework and grades. The Honor Code reads as follows: "To promote a stronger sense of mutual responsibility, respect, trust, and fairness among all members of the George Mason University Community and with the desire for greater academic and personal achievement, we, the student members of the university community, have set forth this Honor Code: Student Members of the George Mason University community pledge not to cheat, plagiarize, steal, or lie in matters related to academic work." More information about the Honor Code, including definitions of cheating, lying, and plagiarism, can be found at the Office of Academic Integrity website at http://oai.gmu.edu.

Office of Disability Services:
If you are a student with a disability and you need academic accommodation, please see me and contact the Office of Disability Services (ODS) at 993-2474. All academic accommodation must be arranged through the ODS. https://ds.gmu.edu

Mason Diversity Statement:
https://stearnscenter.gmu.edu/purpose-and-mission/mason-diversity-statement/

Other Useful Resources:

Academic Calendar: https://registrar.gmu.edu/calendars/spring_2023

Writing Center: A114 Robinson Hall; (703) 993-1200; http://writingcenter.gmu.edu

University Libraries: "Ask a Librarian" https://library.gmu.edu/

University Policies: The University Catalog, http://catalog.gmu.edu , is the central resource for university policies affecting student, faculty, and staff conduct in university academic affairs. Other policies are available at http://universitypolicy.gmu.edu . All members of the university community are responsible for knowing and following established policies.