PHYS 613:   Computational Physics II

Spring 2022

Lecture: Mondays 4:30 pm – 7:10 pm
Classroom: 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

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

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.

Grades:

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. George Mason University offers temporary free access to MATLAB. 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/

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: Student members of the George Mason University community pledge not to cheat, plagiarize, steal and/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.

GMU e-mail Accounts:
Students must use their Mason email accounts to receive important University information, including messages related to this class. See https://its.gmu.edu/service/office365-email/ for more information.

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

Other Useful Campus Resources:

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.