PHYS 251
Introduction to Computer Techniques in Physics

Fall 2020
Lecture: Tuesdays and Thursdays 3:00 – 4:15 pm
Classroom: ZOOM VIRTUAL ROOM – You will access the virtual room from inside Black Board

Instructor:

- Dr. Fernando E. Camelli
- Phone: 703-993-4073 (Office)
- E-mail: fcamelli@gmu.edu

- Zoom Virtual Office Hours: Tuesday and Thursday 9:30 am – 10:30 am, and by appointment.

Course Description:

Introduction to using computers in physics based on examples from mechanics and astronomy. Fulfills Mason Core requirement in information technology (all except ethics).

Prerequisite(s): C or higher in PHYS 160. Prerequisite enforced by registration system.

About this Class:

PHYS 251 will be offered as a synchronous online class this semester. The class will meet in a virtual Zoom room Tuesdays and Thursdays from 3:00 pm to 4:15 pm. You can access the Zoom virtual room in the PHYS 251 Black Board webpage:

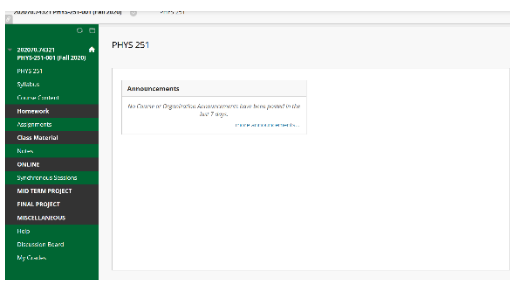

Figure 1: PHYS 251 Black Board web page.

Once you are in the PHYS 251 Black Board web page, you should click on “Synchronous Sessions”, on the left side of the page, and you will access the following page:

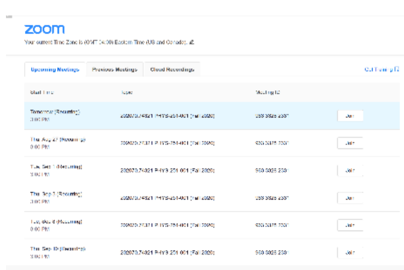

Figure 2: Access to Zoom from Black Board.

You should click on “Join” to access the virtual classroom.

Each class meeting (75 minutes each) will be split into two parts. In the first part, new information will be presented. In the second part, students will work on problems that will appear the homework assignment due at the start of the following class.

The material you need for this class is on Blackboard. You are expected to review the material before each class. All the topics and problems for this class are covered in the lectures available on Blackboard. The lecture notes contain example problems and activities.

You will need to have access to a computer for this class. Any kind of computer will be fine. It does not need to be new or last generation. Your computer can be Windows type, Linux type, or Mac.

The only require software for this class is Python and it is free. We will cover the steps to install it in your computer the first week of class.

This is an activity-driven class; I will not be giving extensive lectures on each topic. Instead, I will give a brief overview of the topic and then provide activities that you will work through in-class. The homework assignments are typically based in part on the activities that you worked on in class.

Attendance to this class is required. If you miss a class, you will likely find the homework assignments to be difficult.

Objectives:

- To develop proficiency with basic programming syntax in a high-level procedural programming language Python.
- To use a programming language to numerically solve basic physics and engineering problems encountered in first-year coursework.
- To be proficient in developing ideas for ways to predict expected features of a solution to a problem that can be only solved numerically.
- To be proficient in developing ideas for ways to determine if a numerical solution is physically reasonable or correct.
- To be proficient in developing ideas for ways to determine if a numerical solution is physically reasonable or correct.
- To use a programming language to analyze and visualize data.
- To have experience using packages for one or more programming languages to solve advanced programming and data analysis problems that will be encountered in the physics and engineering curriculum.
- To develop proficiency in troubleshooting, debugging, validation, and verification of computer programs.
- To develop and analyze the results of numerical experiments of physical systems.

Topics and Draft Outline:

The first four weeks of this course involve learning the programming features that are needed to solve physical problems. The remainder of the class involves writing programs to solve problems encountered in a first-year undergraduate physics course, i.e. classical mechanics. Some of the problems have analytic solutions while others do not, and a numerical method is needed to solve them. Only two numerical techniques are covered: numerical integration and numerical solutions to differential equations. The number of methods and the number of topics covered in this course is intentionally not large; an emphasis is placed on mastery and a deep understanding of fundamentals. A significant emphasis is placed on developing an intuition for how to develop a program for different problems, how to determine if the numerical solution is logical, and how to predict features of the expected solution to problems based on physical reasoning and theory.

- Week 1: Overview of Python. How to write a simple Python script.
- Week 2: Control statements and 1-D iteration.
- Week 3: Linear algebra.
- Week 4: Matrices and iteration in 2-D.
- Week 5: Data analysis. Plots.
- Week 6: Linear and nonlinear regression.
- Week 7: Numerical integration.
- Week 8: Newton's Laws and equation of motion.
- Week 9: Introduction to numerical solutions of Ordinary Differential Equations (ODE).
- Week 10: ODE's: Euler-Cromer. Coupled ODE's.
- Week 11: ODE's: Verlet, Position-Verlet, Velocity-Verlet.
- Week 12: Solving 1-D harmonic oscillator problems.
- Week 13: Solar system, solving the 2-body problem.
- Week 14: Using Python modules to solve ODE's.
- Week 15: Review.

Textbooks:

There is not a required textbook for this course. The following list is a sample of the books available in the University Library. Some of these books are available online through the University. The course will not follow any specific book.

- "Computational Physics", Mark Newman, 1st Edition revised and expanded, 2013. **RECOMMENDED**.
- "Computational Physics: Problem Solving with Python", Rubin H. Landau, Manuel J. Paez and Cristian C. Bordeianu, 3rd Edition, 2015.
- "Elementary Mechanics Using Python", Anders Malthe-Sørenssen, 2015.
- "A Primer on Scientific Programming with Python", Hans Petter Langtangen, 4th Edition, 2014.
- "Numerical Analysis", Tim Sauer, 2nd Edition, 2014.
- "Numerical Analysis", Richard L. Burden and J. Douglas Faires, 1993.
- "Python and Matplotlib Essentials for Scientists and Engineers", Matt A. Wood, 2015.
- "Mastering Matplotlib", Duncan M. McGreggor, 2015.
- "Introduction to Programming in Python: An Interdisciplinary Approach", Robert Sedgewick, Kevin Wayne and Robert Dondero, 2015.
- "Numerical Python: A Practical Techniques Approach for Industry", Robert Johansson, 2015.
- "NumPy: Beginner's Guide", Ivan Idris, 3rd Edition, 2015.
- "NumPy Essentials", Leo Chin and Tanmay Dutta, 2016.
- "SciPy and NumPy", Eli Bressert, 2012.
- "Python Data Analytics: Data Analysis and Science Using Pandas, matplotlib, and the Python Programming Language", Fabio Nelli, 2015,

References:

The following are additional references covering Computational Physics at the Junior/Senior undergraduate level.

- "Computational Physics", Nicholas Giordano and Hisao Nakanishi, 2nd Edition, 2006.

- “Computational Physics”, Mark Newman, 2012.
- “Basic Concepts in Computational Physics”, Benjamin A. Stickler and Ewald Schachinger, 2014.
- “A Course on Mathematical Methods for Physicists”, Russel L. Herman, 2013.
- “Introduction to Computational Science: Modeling and Simulation for the Sciences”, Angela B. Shiflet George W. Shiflet, 2006.

Other links:

- Finding E-Books at Mason: [1]
- A list of computational physics books: [2]
- Instructor resources for undergraduate computational physics: [3]

Grading:

- Projects: 60% - One midterm project and one final project, equally weighted.
- Homework: 40% - Usually one assignment per week. The lowest homework grade is dropped. I do not accept late homework assignments.

Letter Grades:

- > 97: A+
- 93 to 96.9: A
- 90 to 92.9: A-
- 87 to 89.9: B+
- 83 to 86.9: B
- 80 to 82.9: B-
- 77 to 79.9: C+
- 73 to 76.9: C
- 70 to 72.9: C-
- 60 to 69.9: D
- < 60: F

Projects:

You will work on the midterm and final projects individually. You can discuss ideas with other students, and you can ask me questions about the projects during office hours. You must not use someone else computer code in any of the projects. You must write an original computer code for the projects. You must explore a scientific question that may not be easily answer without the help of a computer.

The midterm project will require to write a computer code to answer a scientific question and present your results in a written paper. The written paper only requires presenting and explaining your results with tables or plots and a conclusion section. You should expect that the midterm project will like slightly more difficult than a homework.

The final project encompasses the analysis and interpretation of the data produced by your computer code. The deliverable of the final project is the computer code, and a full paper describing the project, the numerical methods used in your code and the analysis of the data produced by your code.

The paper final project paper will be organized with the following sections: (a) introduction, (b) description of the problem, (c) results, and (d) conclusions. Examples of scientific papers will be introduced in the class to help you to write your final paper. The possible final project topics will be announced by the end of September.

Email Communication:

Please send all your question to me via email. Here are a few thinks to remember to make email communication better.

- Please use your name in the salutation so that I do not have to look up your name given only your Mason email address. There is a way of setting up your email, consequently your full name appears in the header - see below.
- If you have a question about a program, copy it inline in the email body, or attach it.
- Always tell me what you tried and read and be very specific about your point of confusion. Otherwise, I may guess incorrectly why you are confused. For example, if you say "I don't know where to start" I may guess that you don't know how to use a keyboard or that you need to be told "at the beginning". You will oftentimes find that if you write out a question, in the process of trying to make yourself clear about your point of confusion, you will realize the answer to your question.

If you want to make any instructor happy, do all the above in all your email communications.

How to show your full name in MasonLive emails:

1. Log in to your MasonLive account.
2. Click on the 'Settings Gear' at the top right of your window, then select 'Options' from the drop-down list.
3. On the left-hand menu click 'General', then click on 'My Account'.
4. On the 'My Account' screen, type in your full name in the 'Display Name' area, then click 'Save'.

Collaboration Policy:

You may collaborate with other students on your homework. *However, the write-up and code that you turn in must be independent.* I suggest starting the homework prior to having any discussion with other students. Turning in a write-up or code that is similar to another student's will be treated as an honor code violation. The best way to avoid an honor code violation is to have someone look at your work when you are stuck and have them suggest modifications (rather than looking at someone else's work). ***Plagiarism will not be tolerated.*** If you collaborate with another student, you must indicate the name of the student on your write-up and/or code.

Referencing Policy:

It is quite unlikely that any homework problem will have a solution available on an external website, and you are encouraged to use other resources to help you with parts of a problem. If you used a website or a book while doing your homework, please reference it. This is a good habit to have when you do any programming or writing.

Software:

All software needed for this course is available to GMU students free of charge. Students will build on example code in Python; no prior experience with other languages is expected. We will also experiment with Python during the class.

Academic Calendar: GMU Academic Calendar

University Policy:

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.

Disability Accommodations:

If you have a learning disability or other condition that may affect academic performance, please: a) make sure documentation is on file with Office of Disability Services (SUB I, Rm. 4205; 993-2474; http://ods.gmu.edu) to determine the accommodations you need; and b) talk with me to discuss your accommodation needs.

Counseling and Student Support:

- Counseling and Psychological Services provides confidential psychological services, including 24/7 crisis intervention and consultation to faculty and staff: http://caps.gmu.edu/
- Student Support helps students negotiate life situations by connecting them with appropriate on- and off-campus resources http://studentsupport.gmu.edu/referral-form/

Celebrating our Diversity:

The College of Science, an intentionally inclusive community, promotes and maintains an equitable and just work and learning environment. We welcome and value individuals and their differences including race, economic status, gender expression and identity, sex, sexual orientation, ethnicity, national origin, first language, religion, age, and disability.

- We value our diverse student body and desire to increase the diversity of our faculty and staff.
- We commit to supporting students, faculty and staff who have been the victims of bias and discrimination.
- We promote continuous learning and improvement to create an environment that values diverse points of view and life experiences.
- We believe that faculty, staff, and students play a role in creating an environment that engages diverse points of view.
- We believe that by fostering their willingness to hear and learn from a variety of sources and viewpoints, our students will gain competence in communication, critical thinking and global understanding, aware of their biases and how they affect their interactions with others and the world.

Mason University Life religious holiday calendar:

https://ulife.gmu.edu/religious-holiday-calendar/

It is your responsibility, within the first two weeks of the semester, to let me know the dates of major religious holidays on which you will be absent or unavailable due to religious observances.

Student Privacy: https://registrar.gmu.edu/ferpa/

Student services:

- Keep Learning, Learning Services (learningservices.gmu.edu/keeplearning/)
- University Libraries (library.gmu.edu)
- Writing Center (writingcenter.gmu.edu)
- Counseling and Psychological Services (caps.gmu.edu)