Department of Computational and Data Sciences

4400 University Drive, MS 6A12, Fairfax, Virginia 22030
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CDS 230

Modeling and Simulation I

1. General Information

Instructor:	Dr. Hamdi Kavak (hkavak@gmu.edu)
Backup Instructor:	Dr. Jason Kinser (jkinser@gmu.edu)
Teaching assistant (STAR):	Ms. Gowri Prathap (gprathap@gmu.edu)
Where:	Online via Blackboard Collaborate Ultra
When:	Monday 10:30 am - 1:10 pm
Course website:	The GMU Blackboard Website
Code repository:	https://github.com/hamdikavak/cds230
Video repository:	https://www.youtube.com/channel/UCBijHAVQUO2c9uqCXX3t8Tg
Credits:	3
Recommended Prereq.:	CDS 130
Office Hours:	Fridays from 1:30-5:00 pm (email hkavak@gmu.edu with your preferred meeting time)

2. Course Description

Modeling and simulation is an emerging engineering discipline that leverages techniques and tools from various other disciplines (e.g., computer science, systems engineering, mathematics) to develop computational models. Such models enable us to create cost-effective, safe, and large scale experimentation capabilities of real-world systems. Modeling and simulation is heavily used in areas such as biology, healthcare, military training and operations planning, transportation, manufacturing, logistics, and aerospace, among others.

This course teaches the fundamentals of modeling and simulation and helps gain the necessary skills for developing computational models of real-world systems. Programming languages are commonly used in computational model development. In this respect, the first half of the course covers the basic concepts of the Python programming language, which will be used in the second half of the course to develop computational models. Specific modeling techniques to be covered in the second half of the course are dynamical systems, Monte Carlo simulation, and discrete-event simulation.

3. Learning Outcomes

By the end of the course, students will

- have a fundamental knowledge of modeling and simulation,
- be able to write basic Python code,
- be able to create and run basic computational models,
- have experience with model development software.

4. Format and Course Recordings

The course will be taught as synchronous online lectures supported with additional material disseminated through the course website, code repository, and video repository. All of our synchronous meetings in this class will be recorded automatically for offline access. Recordings will be stored on Blackboard and will only be accessible to students taking this course during this semester.

5. Student Privacy

All course materials posted to Blackboard or other course site are private; by federal law, any materials that identify specific students (via their name, voice, or image) must not be shared with anyone not enrolled in this class.

- Video recordings of class meetings that include audio or visual information from other students are private and must not be shared
- Live Video Conference Meetings (e.g. Collaborate or Zoom) that include audio or visual information from other students must be viewed privately and not shared with others in your household

6. Textbooks and Slides

There are no required textbooks for the class because it is difficult to find a single comprehensive book that covers all the topics we will learn throughout the course. Thanks to Dr. Carlos Cruz, we have lecture notes that are helpful for this class. Make sure to download the latest copy before using it. The following is a list of books that you may find helpful:

- Lecture Notes by Carlos Cruz.
  https://github.com/hamdikavak/cds230/blob/spring-2020/lecture_notes.pdf
- Modeling and Simulation in Python by Allen B. Downey. Publisher: Green Tea Press. Free e-book: http://greenteapress.com/modsimpy/ModSimPy3.pdf.
- Learning Scientific Programming with Python (1st edition) by Christian Hill. Publisher: Cambridge.
- Modeling and Simulation Fundamentals: Theoretical Underpinnings and Practical Domains by John A. Sokolowski and Catherine M. Banks. Publisher: Wiley.

Course slides will be provided via the Blackboard website. When needed, additional information sources will be listed in the references section of lectures.

7. Technology Requirements

Activities and assignments in this course will regularly use the Blackboard learning system, available at https://mymason.gmu.edu. Students are required to have regular, reliable access to a computer with an updated operating system (recommended: Windows 10 or Mac OSX 10.13 or higher) and a stable broadband Internet connection (cable modem, DSL, satellite broadband, etc., with a consistent 1.5 Mbps [megabits per second] download speed or higher. You can check your speed settings using the speed test software websites.)

8. Course outline (Tentative)

In this course we will cover the following topics (please note that the topics and their order are subject to change at the discretion of the instructor, any changes will be announced in class or via Blackboard):

Week of	Lecture notes chapter	Topic	Assignment
Aug 24	-	**MODULE 1 - Introduction** ● Welcome and Course Overview ● An Introduction to Modeling and Simulation	Homework 0

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Aug 31	1, 2	**MODULE 2 - Getting Started with Python** ● Setting Up Your Python Environment ● Variables and Basic Data Types in Python ● Simple Physics Models	Homework 1
Sep 7		**LABOR DAY (No class)**	
Sep 14	3	**MODULE 3 - Control Flow** ● Comparisons, Logic, and Conditional Statements **MODULE 4 - Strings** ● Strings	Homework 2
Sep 21	3, 4, 5	**MODULE 5 - Collections and Iteration** ● Lists, Tuples, Dictionaries, and Sets ● Loops	Homework 3
Sep 28	6, 11	**MODULE 6 - Making Your Code Organized** ● Functions ● Classes and Object Oriented Programming	
Oct 5	9, 10	**MODULE 7 - Using Third Party Packages** ● NumPy ● Matplotlib	Homework 4
Oct 12		**MIDTERM EXAM** ● Oct 12-15 (take home)	Mid-semester survey
Oct 19		**MODULE 8 - Dynamical Systems** ● Overview of Dynamical Systems ● Ordinary Differential Equations	
Oct 26		● Dynamical Systems Examples **MODULE 9 - Representing Uncertainty in Models** ● Modeling Equal Chances and Pseudo Random Number Generation	Homework 5
Nov 2		● Modeling Unequal Chances ● Example problems	Homework 6
Nov 9		● Fundamentals of Monte Carlo Simulation	
Nov 16		● Monte Carlo Simulation Examples	Homework 7
Nov 23		**MODULE 10 - Discrete Event Simulation** ● Queuing Systems ● Introduction to CLOUDES	
Nov 30		● Developing CLOUDES Models ● Example Problems for Final Exam	Homework 8
Dec 7		**READING DAYS** ● No class meeting **FINAL EXAM** ● Dec 9-12 (take home)	

9. Grades

Each homework and written exam will be given a numerical grade on a 0-100 scale. Some homework assignments may include bonus tasks which can increase the total score over 100. At the end of the term, the final mark will be totaled as a weighted average according to the following weights:

Average Homework Score	**40%**
Midterm Exam Score	**30%**
Final Exam Score	**30%**

Please note that the average homework score is calculated by dividing the total scores of all homework by the total number of homework assignments. Final grades at the end of the course will be assigned based on the following table, independent of the relative standing in the class.

Final Mark	Corresponding Grade
>96.7	A+
93.3 – 96.6	A
90.0 – 93.2	A-
86.7 – 89.9	B+
83.3 – 86.6	B
80.0 – 83.2	B-
76.7 – 79.9	C+
73.3 – 76.6	C
70.0 – 73.2	C-
60.0 – 69.9	D
<60.0	F

10. Exams

The course includes mandatory midterm and final exams. You are responsible for all the content covered before the exam. Both the midterm and final exam will be take-home using your own computer. There will be no group work in the exam and you're only allowed to communicate with your instructor about the exam. The honor code will be in effect in ensuring that all work turned in will be your own.

A student who cannot write a course examination or complete a course homework because of an incapacitating illness, severe domestic affliction, or other compelling reasons can apply for an extension of time. Note that such extensions will be evaluated case by case. There is no guarantee that the instructor will grant the extension.

11. General guidelines for homework preparation and submission

- All homework assignments are mandatory unless otherwise noted. A single homework may involve a combination of questions requiring you to write Python code and textual answers. Homework assignments are always due Sunday midnight (usually 7 days after the lecture).

- Grades of assignments will be based on conciseness and completeness of your answers. Please write to the point and explicitly address the question or task. Avoid using unnecessary graphics (figures, tables, graphs) unless they serve a specific purpose.
- Programming assignments:
  - should be submitted as a single Python (.py or .ipynb) file per homework named according to the format: firstname_last_name_HW_X.py or firstname_last_name_HW_X.ipynb. For instance, if I am turning in Homework 4, then my file name should be "hamdi_kavak_HW_4.py" or "hamdi_kavak_HW_4.ipynb".
  - should start with comment lines that show (1) student's full name, (2) assignment number, and (3) question number. See below for an example:

```
####################################
## Name: First M. Last
## Assignment: 4
####################################
## Question 1
####################################
```

- In case more than one file needs to be submitted, you should submit a single ZIP file containing all the assignment files.
- Please make sure you have a backup of all the materials you submit.
- Assignments should be submitted **through the Blackboard course website**. Every assignment should allow you to submit the work multiple times up until the deadline. The last version of the assignment will be graded. If you turn in a newer version of your homework, you must include ALL files associated with that homework.

Please note: Assignments should be submitted only through the Assignment submission section of the Blackboard system - DO NOT email assignments directly to the instructor.

12. Make-up Work

Assignments submitted **within 48 hours after the due date will get -10 pts**. Assignments submitted more than **48 hours after the due date will get 0.** If a student is ill or quarantined, make-up opportunities may be given.

13. Attendance

Attendance is not part of the grade but highly recommended.

14. Course website

The course has a Blackboard website. This website will provide you a portal through which you may obtain lecture notes, retrieve assignment data and review links to additional materials, and receive special announcements. You are required to visit the course website regularly and follow all announcements. Please notify ITS (and, if necessary, the instructor) if you encounter any problems accessing the Blackboard website.

15. Electronic communication, office hours and support

All course-related submission of assignments should be made through the course Blackboard website. Please **DO NOT** email your assignment submissions to the instructor or STARs unless the Blackboard website is down for an extended period.

Students are encouraged to contact the STARs and the instructor for any questions regarding the course content. The ideal time to contact the instructor for such inquiries is the office hours which is provided under General Information. The instructor will notify the students via GMU email if there are any temporary changes in office hours. For other times, students must contact the instructor via email to schedule an online appointment. Ideally, the instructor will respond to course-related student emails within 2 business days. If you include "[CDS 230]" in the email subject, it will help to accelerate the response time.

16. Students with disabilities

Disability Services at George Mason University is committed to providing equitable access to learning opportunities for all students by upholding the laws that ensure equal treatment of people with disabilities. If you are seeking accommodations for this class, please first visit http://ds.gmu.edu/ for detailed information about the Disability Services registration process. Then please discuss your approved accommodations with me. Disability Services is located in the Student Union Building I (SUB I), Suite 2500. Email: ods@gmu.edu | Phone: (703) 993-2474

17. Expectations from students

- *Academic Integrity:* Students must be responsible for their own work, and students and faculty must take on the responsibility of dealing explicitly with violations. The tenet must be a foundation of our university culture. [See http://academicintegrity.gmu.edu].
- *Honor code:* Students must adhere to the guidelines of the George Mason University Honor Code. [See https://oai.gmu.edu/mason-honor-code/].
- *MasonLive/Email (GMU Email):* Students are responsible for the content of university communications sent to their George Mason University email account and are required to activate their account and check it regularly. All communication from the university, college, school, and the program will be sent to students solely through their Mason email account.
- *University Policies:* Students must follow the university policies (See http://universitypolicy.gmu.edu) including the Responsible Use of Computing [See https://universitypolicy.gmu.edu/policies/responsible-use-of-computing/).
- *Class behavior:* Cell phone usage is not allowed in class. In urgent cases, the student can leave and use the phone outside of the class. Eating any sort of food should be avoided.

18. Frequently asked questions

- *What software do we need?*
  This course will use Python version 3.7 (or later) distributed via Anaconda (https://www.anaconda.com/distribution/). Students are welcome to install other python distributions of their choice as long as the version number matches.

- *What are the required knowledge and skills to be successful in this course?*
  This course has a recommended prerequisite of CDS 130 which touches upon some programming concepts. So, you are expected to have some basic computing skills like running a program and doing some basic calculations. However, you are not required to master in any programming languages, including Python. It is to your advantage in this class and in your career if you acquire computing skills. Additionally, you will be asked to **transcribe** some mathematical equations (i.e., models) of real world systems to Python code in assignments and exams. This does **not** require you to solve or memorize equations.

- *Have another question?*
  Ask the instructor via email. If your question applies to all students, it will be shared here as well.

Disclaimer: Any typographical errors in this Course Outline are subject to change and will be announced in class. The date of the final examination is set by the Registrar and takes precedence over the final examination date reported by the instructor.

Notes: (1) Recording is permitted only with the prior written consent of the professor or if recording is part of an approved accommodation plan. (2) The format and template of this syllabus is prepared based on the syllabus of Dr. Andreas Zufle's GGS 787 - Scientific Data Mining for Geo-informatics 2018 course. A partial content of this syllabus is adopted from the syllabus of Dr. Jason Kinser's CDS 230 - Modeling and Simulation 1 - Summer 2017 course.