Performance Task: Your Own Computer Simulation

Background: The last weeks of this unit are designed for you to bring together all of the skills that you've learned to produce and experiment with your own computer simulation. Now is your chance to do something creative and unique!

Note: This project must be done independently.

Objectives: You must choose a system and then create a computer simulation of your system using VPython. Once you have developed the simulation, you will use it to conduct a controlled investigation.

Complexity Requirement: The system you choose to simulate must be too complicated for you to model analytically. In other words: your controlled investigation should *NOT* be something you could answer with pencil and paper methods. To ensure that your system is sufficiently complex I encourage you to select a system: in which objects undergo non-constant force and/or there are multiple interacting objects.

About the Controlled Investigation: For your controlled investigation, I suggest taking an approach similar to what you did in the labs we conducted throughout this unit. This means choosing an independent variable, a dependent variable, and constant variables. Then, manipulating the independent variable and see how the dependent variable is affected. I suggest graphing your data in Logger Pro and potentially even fitting functions onto your data.

> *Note that you don't *need* to conduct an experiment in this manner if you have a different type of interesting/relevant question worth investigating. For example, let's say you created a simulation of an airplane wing. Rather than looking at the relationship between two variables, it could be interesting to instead try to look more qualitatively at a few different types of wings.

Ongoing Feedback: Although this is an independent project, I will be checking in with you each day in class. There will also be class days where there will be opportunities built in to our schedule to give/receive feedback on each other's projects.

Sample Ideas: *I don't know what system to choose? Where should I start?*

If you don't know what to simulate, I suggest taking a system that you've studied before, but making it more complex or adding in factors that we usually ignore (like air drag). Some examples of systems could be:

- An object falling towards the Earth, accounting non-uniform gravitational force and/or air drag.
- Multiple objects connected by springs.
- Objects undergoing diffusion as can be modeled by a random walk. (For example, the investigative question could be: How does the number of steps taken in a random walk relate to the displacement of that walk.)

Project Completion Requirements: *What do you need to turn in?*

- **Presentation:** You must present your code to the class. In your presentation you are expected to:
  - Explain the system your simulation models and (briefly) the mathematical relationships between relevant variables.
  - Walk the class through your program step by step, summarizing how your code works.
  - State the question you sought to answer with your controlled investigation and your results/conclusions. You will most likely want to include a graph (or graphs).
  - Explain why your question is unanswerable by analytical methods (and why a simulation was necessary to answer it.)
  - *Note: you may simply show your code and walk us through it. You do *NOT* need to put together a Powerpoint presentation for this.

- **Program Code:** You must share your program with me. To do this, follow these steps:
  - Click the "edit" link under your program.
  - Once you're in the editor click the "share or export this program" link.
  - Copy the link and email it to me. Write your full name in the subject line of your email.

- **Methods/Results/Claim:** Submit a printed document (one side of a page max) including the following:
  - Your investigative question and explain how you used your code to conduct this investigation (methods).
  - Your results and any relevant graphs.
  - A claim regarding your investigative question, using evidence gathered from your simulation results.

- **Troubleshooting Reflection:** Submit a printed document (one side of a page max) explaining the major challenges you encountered and how you overcame them (one side of a page max). Consider some of the following:
    - What attributes of VPython did you learn about in the process of writing this code?
    - What online resources did you find particularly valuable? What did you learn from them and how did you find them?
    - What conversations did you have that helped you make major progress? What were they about?
    - When did you get stuck? How did you get unstuck?
    - Were there any moments that you felt gave you major breakthroughs? What were they?

Performance Task Rubric: The following criteria will be evaluated through a combination of all your submitted work.

	No Evidence of Student Learning	*Approaching*	*Proficient*	*Exemplary*
Understanding of Program Code	-Your presentation and annotations are not sufficient evidence for the instructor to infer even a basic understanding of your program code. -Annotations are either missing or inaccurately describe functioning of your code. -You provide no evidence to show that you understand why a simulation is needed to answer your investigative question.	-You demonstrate some understanding of your program, as evidenced by your presentation and annotations, but there are some instances where it is clear you misunderstand the function of your own program -Annotations are written in a manner that allows your instructor to understand your code, however, a peer would struggle to understand your code from reading them. -It is clear that you have some notion of why a simulation is needed to answer your investigative question, however most peers would struggle to follow your explanation.	-You demonstrate near to complete understanding of your program, as evidenced by your presentation and annotations, but in some instances, you are not explicit enough for complete understanding to be inferred. -Annotations are mostly written in a manner that would allow a peer to understand your program, but there are some instances where a peer reader would be lost or confused. -You explain why a simulation is necessary to answer your investigative question, but your explanation lacks clarity such that some peers would likely struggle to understand it.	-You explicitly demonstrate a complete understanding of your program as evidenced by your oral presentation and annotations made in your code. -Annotations are written in a manner that would allow a peer to understand your program. -You clearly explain why a simulation is necessary to answer your investigative question (as opposed to analytical methods). Your explanation is given at a level such that your peers can understand it.
Simulation Functionality and Accuracy	-Your program fails to animate objects. -Iterative looping is not used. -Mathematical models	-Your program animates objects, but there are flaws in your program that cause the behavior to inaccurately reflect the behavior of your system. - Iterative looping is used to update variables over each time step, but there are instances where these updates do not align with your intentions. -Mathematical models employed do	-Program animates objects in a manner that accurately reflects the behavior of your system, but animations are not fluid and lack refinement (too fast, too jumpy, etc…). -Iterative looping is used to successfully update all relevant variables over each time step in a manner that aligns with your intentions. -Mathematical models employed come	-Program fluidly animates objects in a refined manner that provides a realistic simulation of your system. -Iterative looping is used to successfully update all relevant variables over each time step in a manner that aligns with your intentions. -Mathematical models

	employed do not accurately reflect the properties of the system you chose to simulate. These errors lead to failure of your controlled investigation and may or may not lead to complete failure of the simulation.	not accurately reflect the properties of the system you chose to simulate. These errors lead to failure of your controlled investigation and may or may not lead to complete failure of the simulation.	close to accurately reflecting the properties of the system you chose to simulate. There may be one or two errors, but those errors do not lead to complete failure of the simulation or your controlled investigation.	employed accurately reflect the properties of the system you chose to simulate.
Independence and Troubleshooting	-No attempts were made to independently troubleshoot challenges encountered throughout this project.	-There is at least one major instance where inadequate troubleshooting led to problems with your simulation or controlled investigation.	-Some relevant resources were found and used to overcome challenges, but there are one or more instances where a minor problem was not properly addressed and was instead circumvented in a manner that led to a simulation that was less robust than it could have otherwise been.	-Relevant resources were found and utilized to overcome challenges encountered throughout the course of this project, leading to a robust program that suits your experimental needs.
Scientific Reasoning	-Methodology of your controlled investigation does not align with the question you sought to answer. -No claim is made regarding your investigative question *OR* a claim is made, but is not connected to evidence from your simulation.	-Methodology of your controlled investigation does not align with the question you sought to answer. -An attempt is made to support a claim regarding your investigative question using evidence from your simulation, but reasoning utilized is flawed.	-Methodology of your controlled investigation aligns with the question you sought to answer. -Evidence gathered from your simulation and logical reasoning are used to support claims regarding your investigative question, although at times reasoning is implied (not explicit).	-Methodology of your controlled investigation aligns with the question you sought to answer. -Evidence gathered from your simulation and logical reasoning are used explicitly to support claims made regarding your investigative question.