Course Syllabus

Course Title:	Introduction to Rocket Propulsion
Prerequisites:	CSCI 101, CSCI 150, or equivalent; PHYS 109 or equivalent; MATH 0121 or equivalent
Class Meetings:	Labs 9:30-11:30am EST MTW Discussions 10:30-11:30am EST F
Faculty:	Dr. Catherine Miller
Email:	cm2@middlebury.edu
Office Location:	75 Shannon St 221
Office Hours:	3-4pm EST TW; 9-10am EST ThF

Course Description

In this course, we will investigate the following questions: What is rocket propulsion? How do we send humans and robots to space? How do chemical and electrical rockets work and what applications are they suitable for? How do spacecraft travel to other planets? How can we use computers to design rockets and their trajectories? We will dive into topics including chemical combustion, energy conversion, ionized gases, launch vehicle design and trajectories, Kepler's Laws, orbit transfers, and much more. We will also read *Hidden Figures* and have weekly discussions about the text. Assignments will consist of readings, labs, quizzes, a short project, and a reflection paper on *Hidden Figures*.

Course Goals

1. Explain the fundamental principles of rocket propulsion using Newtonian mechanics.
2. Mathematically describe the shape and dynamics of circular and elliptical orbits.
   Quantify the change in velocity required for orbit transfers.
3. Describe how launch trajectories are numerically integrated using computer programs.
4. Explain how chemical rockets use chemical propellants to produce supersonic exhaust gases.
5. Describe how ions are created and accelerated in electric thrusters.
6. Analyze the performance of chemical rockets and electric thrusters.
   Compare and contrast the two technologies.
7. Read about the Black women computers, mathematicians, and engineers who worked at NACA, later NASA, from 1930-1970 in the book *Hidden Figures* by Margot Lee Shetterly.
8. Discuss how belonging and equity in STEM have evolved over the past half-century.

Grading

Your grade will be calculated according to the following distribution:

Labs	40%
Quizzes	30%
Final Project	10%
Final Paper	10%
Participation	10%

Labs

On Mondays, Tuesdays, and Wednesdays we will meet via Zoom for the lab sessions. **Read the lecture notes before the lab so you can be prepared to work on problems with your classmates.** During the lab, we will briefly review the material from the notes and spend most of the time working on the lab problems together. You will spend at least half of the class time working on the lab with your classmates in a small group. For some of the problems, we will come together as a class and solve them together.

You may need to spend some time outside of class finishing the lab assignment. We will work together to find a reasonable workload for the labs each week. Your lowest lab score will be dropped. The solutions to the lab will be made available to you as soon as you submit the assignment. *Please do not share or discuss the solutions with anyone who hasn't submitted the lab yet.*

Late policy for labs: For each day that the assignment is late, your score will drop by one letter grade. If it is more than three days late, you will receive a zero for the assignment. If you need an extension on the assignment, please contact me with 24 hours notice.

Quizzes

At the end of each week, there will be a Canvas quiz on the material for that week. You will be asked to explain concepts, solve analytical and quantitative problems, and reflect on what you learned that week. You will not be asked to write code for the quizzes. You may be asked to reflect upon the readings from *Hidden Figures*, but you won't be quizzed on specific details about the book. **Quizzes are independent assignments** and you should not discuss the quiz with your classmates unless both of you have already completed it. The quiz for the week will be made available on Friday morning and must be completed by Saturday evening. *As long as you complete all four quizzes, your lowest quiz score will be dropped. If you need an extension on the quiz, please contact me with 24 hours notice.*

Final Project

The final project builds upon the labs. For the project, you will write Python code to analyze the trajectory of a launch vehicle. You will be provided with a code template and step-by-step instructions to build up the code. This assignment will be similar in length to a lab. *It is expected that you work independently on this assignment, although you may discuss the assignment with your classmates.* The final project assignment description and rubric will be posted at the end of the second week of class. It is due the Sunday after the last class meeting, February 14th at 11:59 pm EST, which is a hard deadline.

Final Paper

The final paper is a 750-word reflection paper on *Hidden Figures*. This assignment will be graded on effort and ability to communicate ideas. The assignment description with a rubric will be posted by the

end of the first week of class. It is due the Sunday after the last class meeting, February 14th at 11:59 pm EST, which is a hard deadline.

Participation

This course meets *synchronously* on Mondays, Tuesdays, Wednesdays, and Fridays. You will need to attend class in order to participate in the discussions and collaborate with other students on the assignments. On Mondays, Tuesdays, and Wednesdays, you will work with your group on the lab assignment. On Fridays, we will discuss *Hidden Figures* as a class and in smaller groups.

It is expected that you arrive to class prepared and that you demonstrate effort in working on the lab assignment with your group or in discussing the readings from *Hidden Figures*. Before class on Friday, you will need to complete the *Hidden Figures* reading and bring a quote to share with the class.

Resources

Readings

The reading material for the technical component of this class will be provided to you in the form of typed lecture notes. Each lecture has a corresponding lab assignment, except for Lecture 0.

We will also read *Hidden Figures* by Margot Lee Shetterly. You can purchase a physical copy or a digital copy of the book. The reading schedule is as follows:

Week 1:	Prologue - Chapter 7
Week 2:	Chapter 8 - Chapter 13
Week 3:	Chapter 14 - Chapter 19
Week 4:	Chapter 20 - Epilogue

Python

In this course, we will be writing Python code to perform calculations and graphically represent the results of our analysis. You may use an Integrated Development Environment (IDE), such as **Thonny**, or you can use a text editor, such as TextMate or Atom, and the command line. Please reach out to me if you need assistance setting up your Python development environment.

Additional Resources

If you're interested in learning more about rocket propulsion, I encourage you to check out the following:

Rocket Propulsion Elements by George P. Sutton

Mechanics and Thermodynamics of Propulsion by Philip G. Hill and Carl. Peterson

Physics of Electric Propulsion by Robert G. Jahn

Fundamentals of Electric Propulsion by Dan M. Goebel and Ira Katz

Policies

What you can expect from me:

You can expect me to deliver the course content in a clear and organized manner. I will provide the information and guidance that you need to be successful in this course. I will engage with you during the class meetings to ensure that you understand the course content and have a path forwards with whatever problem you're working on. I will also be available outside of class during Zoom office hours as well as via email to assist you. I will grade fairly and return graded assignments in a timely manner. Most importantly, I will work to make this class interesting, engaging, and fun!

What I will expect from you:

You are expected to come to class prepared! This course is organized in a "flipped classroom" format, which means that the course content is delivered outside of the class meetings. We will use class meetings to engage with the material by solving problems and having discussions. This format will allow you to learn from your classmates, receive guidance and feedback on your problem-solving approach, and deepen your understanding of the course content. For this format to work, you need to come to class prepared and ready to solve problems or discuss the readings.

Honor Code

Do not work collaboratively unless indicated by the assignment. You can discuss the assignments, except for quizzes, but do not share your solutions. If someone does show you a partial solution or code (as an explanation or asking for debugging help), do not copy it. Retain ideas and go write your own version later. **Make sure that you understand the solution that you submit.** Attribute any ideas that you use (books, online resources, etc.) and include the names of any classmates that you collaborated with.

If you are uncertain how the **Honor Code** applies to a particular assignment, please ask me. For a refresher, review Middlebury's **Writing and Plagiarism Guides**.

Learning Community

It is important for me to create an inclusive learning environment where diversity and individual differences are respected and recognized as a source of strength. However, this must be a team effort so I expect you to join me in fostering such an environment. This class will represent a diversity of individual backgrounds and experiences, and every member is expected to show respect for every other member so that everyone can learn in this space. If you experience or witness any behavior that opposes this idea, it would be helpful for me to know so that I can address it. I recognize that this is additional work and may be difficult. If you are comfortable reporting such incidents, there are a few ways you can do so:

1. Talk to or email me
2. Report it to our anonymous CS departmental climate **feedback form**
3. Fill out a **Bias Incident Report** which goes to the Middlebury Community Bias Response Team

I will use the gender pronouns and name you go by, and I expect you to use the names and pronouns your classmates go by. (I understand that some students may be in the process of exploring their gender identity, may not feel comfortable sharing a gender pronoun, or may not go by gender pronouns; you can let me know if you do not want to share a gender pronoun.)

You belong in this class! Thank you for being here and for contributing to this course!

Disability Access/Accommodation

Students who have Letters of Accommodation in this class are encouraged to contact me as early as possible to ensure that such accommodations are implemented in a timely fashion. For those without Letters of Accommodation, assistance is available to eligible students through the Disability Resource Center. Please contact Jodi Litchfield, the ADA Coordinator, for more information: litchfie@middlebury.edu or 802-443-5936. All discussions will remain confidential.

Disclosing Personal Information

As a faculty member and member of the Middlebury community, I am committed to the safety of all students. If I learn of any potential violation of our Policy Against Sexual Misconduct, Domestic and Dating Violence and Misconduct, and Stalking (**SMDVS Policy**) or our **Anti-Harassment/Discrimination Policy**, I am required to notify a member of Middlebury's **Title IX team**. This ensures that the student receives timely care and information about their rights, their choices, and available resources for support. Students who would like to speak with a confidential resource who does not have an obligation to report can contact **MiddSafe**, the **Parton Center for Health and Wellness**, **WomenSafe** (serving individuals of all gender identities), or campus and local clergy and medical professionals. For more information, see **go/sexualviolenceinfo**.

Calendar

Date	Topic	Reading	Assignment	Due Today
1/19/21	Working Principles of Rocket Propulsion	Lecture 0 Lecture 1	Lab 1	
1/20/21	Rocket Performance	Lecture 2	Lab 2	
1/22/21	Hidden Figures #1	HF Part 1	Quiz 1	Labs 1-2
1/24/21				Quiz 1
1/25/21	Gravity and Orbits	Lecture 3	Lab 3	
1/26/21	Orbit Transfers and Solar System Exploration	Lecture 4	Lab 4	
1/27/21	Launch Trajectory Analysis	Lecture 5	Lab 5	
1/29/21	Hidden Figures #2	HF Part 2	Quiz 2	Labs 3-5
1/31/21				Quiz 2
2/1/21	Introduction to Chemical Rockets	Lecture 6	Lab 6	
2/2/21	Chemical Rocket Performance	Lecture 7	Lab 7	
2/3/21	Chemical Rocket Nozzles	Lecture 8	Lab 8	
2/5/21	Hidden Figures #3	HF Part 3	Quiz 3	Labs 6-8
2/7/21				Quiz 3
2/8/21	Introduction to Electric Propulsion	Lecture 9	Lab 9	
2/9/21	Introduction to Plasma Physics	Lecture 10	Lab 10	
2/10/21	Gridded Ion Thrusters	Lecture 11	Lab 11	
2/12/21	Hidden Figures #4	HF Part 4	Quiz 4	Labs 9-11
2/14/21				Quiz 4 Final Paper Final Project