



Course Information

Course Title: Aircraft Propulsion, Power, and Thermal Systems Design and Simulation

Course Number: ENME489W

Term: Fall 2022 **Section:** 0101

Credits: 3

Course Times: MW 11:00 AM – 12:15 PM

Instructor: Dr. Anthony Malatesta

Email: antonino@umd.edu

Office Hours: Virtual via Zoom ~~F-1330-1430~~

Classroom: JMP 2116 / USMSM ~~Bldg. 3-1308~~

Course Description

Principles of aircraft energy systems including design and analysis of propulsion, power, and thermal management systems. Students will become familiar with designs and challenges of common jet engines, thermal fluid transport systems, and electrical power systems. Applied fundamentals of thermodynamics, fluids, heat transfer, electrical power, and numerical analysis will be used to construct and optimize integrated transient mission level models.

Relationship of course to program objectives

This course serves as a foundation in the design and simulation of principle aircraft energy systems. The course will be an application and expansion of topics learned in the core mechanical engineering curriculum and will provide practical experience and tools that students can use in continuing education and in post-graduation employment.

Course Objectives

The main objective of this course is to familiarize the students with aircraft energy systems, components, theory, history, and design through the lens of one-dimensional transient simulation.

- Students will become familiar with common design and components of relevant aircraft energy systems, including jet engines (multi-stage compressors/turbines, nozzles etc.), thermal management systems (heat exchangers, working fluids, air cycle machines), and electrical power systems (generators, distribution, power conversion, payloads), their associated design challenges, and their interfaces.
- Students will apply fundamentals of thermodynamics, fluids, heat transfer, and electrical power to represent physical systems.
- Students will understand principles and limitations of numerical analysis including common approaches to simultaneous solution of non-linear equations and basic optimization using Newton-Raphson based techniques.
- Students will develop skills with commercially available software (matlab/Simulink) for physical system modeling and analysis.

- Students will understand the principles of validation, verification and uncertainty in modeling.
- Students will understand the importance of source control in software applications.

Required Resources

- Course Website: elms.umd.edu
- Books: (All texts are available as ebooks via the University Library: lib.umd.edu)
 - M. Ahlers, "An Introduction to Aircraft Thermal Management," SAE International, Warrendale, PA, 2020.
 - P. M. Sforza, Theory of Aerospace Propulsion, Waltham, MA: Academic Press, 2012.
 - S. Farokhi, Aircraft Propulsion, West Sussex, UK: John Wiley & Sons Ltd., 2014.
 - S. Abood, Fundamentals of Electrical Power Systems: A Primer with MATLAB, Hauppauge, NY: Nova, 2020.
 - There will be several journal articles and reports as recommended reading as well

Course Structure

- This course has 2 sessions per week of 75 minutes each. Homework will be posted every Friday and will be due at 11:59 PM the following Friday unless otherwise noted. There will be a midterm exam, a final exam, and a group project.

Tips for Success

1. **Participate.** Ask questions; attend the available resources such as office hours and exam review sessions; form a study group with your classmates or students in the other sections. You can learn a great deal from discussing ideas and perspectives with your peers and the professor. Participation can also help you articulate your thoughts and develop critical thinking skills.
2. **Manage your time.** Give yourself plenty of time to complete assignments including extra time to handle any technology related problems or to ask questions regarding concepts or homework. Note that you will be given at least 1 full week to complete each homework assignment – having a conflict the night before the due date is not grounds for an extension (except in special circumstances).
3. **Login regularly.** Log in to the ELMS-Canvas site several times a week to view announcements, discussion posts and replies to your posts. You may need to log in multiple times a day when group submissions are due.
4. **Do not fall behind.** This class moves at a fast pace and each week builds on previous material. It will be hard to keep up with the course content if you fall behind.
5. **Use ELMS-Canvas notification settings.** Canvas ELMS-Canvas can ensure you receive timely notifications in your email or via text. Enable announcements to be sent instantly or daily.
6. **Ask for help if needed.** If you need help with ELMS-Canvas or other technology, contact IT Support. If you are struggling with a course concept, reach out to me, your

classmates, or the TFs and TAs for support.

Campus Policies

It is our shared responsibility to know and abide by the University of Maryland's policies that relate to all courses, which include topics like:

- Academic integrity
- Student and instructor conduct
- Accessibility and accommodations
- Attendance and excused absences
- Grades and appeals
- Copyright and intellectual property
- COVID-19 and mask mandate policies

Please visit www.ugst.umd.edu/courserelatedpolicies.html for the Office of Undergraduate Studies' full list of campus-wide policies and follow up with me if you have questions.

Course-Specific Policies

Communication with Instructor:

- Email: If you need to communicate with me, please email me at antonino@umd.edu, message me through ELMS or attend instructor office hours. Please feel free to reach out about personal, academic, and intellectual concerns/questions in addition to normal class-related questions. If you wish to meet with me and my office hours do not fit your schedule, please email me to set up office hours by appointment.
- ELMS: I will send IMPORTANT announcements via ELMS messaging. You must make sure that your e-mail & announcement notifications (including changes in assignments and/or due dates) are enabled in ELMS so you do not miss any messages. You are responsible for checking your email and Canvas/ELMS inbox with regular frequency.

Communication with Peers:

With a diversity of perspectives and experience, we may find ourselves in disagreement and/or debate with one another. As such, it is important that we agree to conduct ourselves in a professional manner and that we work together to foster and preserve a classroom environment in which we can respectfully discuss and deliberate controversial questions.

I encourage you to confidently exercise your right to free speech—bearing in mind, of course, that you will be expected to craft and defend arguments that support your position. Keep in mind, that free speech has its limits and this course is NOT the space for hate speech, harassment, and derogatory language. I will make every reasonable attempt to create an atmosphere in which each student feels comfortable voicing their argument without fear of being personally attacked, mocked, demeaned, or devalued.

Any behavior (including harassment, sexual harassment, and racially and/or culturally derogatory language) that threatens this atmosphere will not be tolerated. Please alert me immediately if you feel threatened, dismissed, or silenced at any point during our semester together and/or if your engagement in discussion has been in some way hindered by the learning environment.

COVID-19 and Mask Mandate Policies

As members of the UMD community, we care about keeping each other safe and healthy—which includes reducing unintended spread of COVID19 among ourselves and those we encounter. Toward this end, the university has developed, implemented, and communicated policies based on the current threat levels. As we approach the start of the fall semester, these are as follows:

Masks: COVID-19 community levels are currently low in Prince George's County. Effective Monday, August 29, wearing a mask will not be required while indoors in most situations, including classrooms. As a reminder, masks are a significant defense against the spread of COVID-19 and other respiratory viruses. Therefore, wearing a KN95 mask while indoors is still recommended for added protection.

Testing: Students, faculty, and staff are strongly encouraged to take a rapid antigen COVID-19 test within 24 hours before returning to campus from time away. If you test positive, you should not return to campus, and you should isolate per CDC guidelines.

Vaccination: UMD continues to require vaccination against COVID-19 for all on-campus faculty, staff and students, including the first booster, depending on the vaccine received. Please review our COVID-19 website for additional guidance for individuals over 50, those with special health conditions, international students, and individuals seeking medical and religious exemptions.

Major Assignments

Weekly Homework Assignments

- Each homework assignment will be posted on ELMS and will require use of MATLAB/Simulink, a github account, and word processing software. MATLAB/Simulink resources are available through the virtual computer lab.
- Homework is intended to give students the opportunity to practice problem-solving, reflect on concepts, and apply critical thinking. Students who complete homework have improved performance on exams and understanding of course material. Not all assigned problems will necessarily be graded, and problems will not be equally weighted. Detailed solutions will be available.
- While general concepts may and should be, discussed with classmates, homework is an individual assignment. Submitted work must be your own, and by putting your name on it you are certifying that it is yours. Consultation of prior years' solutions is not permitted.
- Expect about 10-11 assignments. Homework must be submitted online and will typically be due by **Friday at 11:59pm**. The website will remain open until 6:59 AM on Saturday morning at which point homework can no longer be submitted.
- Homework will be submitted electronically and will generally require a short typed word document or pdf along with a MATLAB/Simulink file(s). Instructions will be provided on the assignments. It is the student's responsibility to hand in organized,

neat, readable, fully completed homework. The teaching team is not obliged to grade unorganized or illegible work, and full points should not be expected for less than complete answers. Homework submitted later than the extended due date (Saturday at 6:59 AM) will not be accepted without an excused absence by the instructor.

Midterm and Final Exam

- There will be a midterm and a comprehensive final exam.
 - **Midterm: Wednesday, March 15 during the scheduled class time. (Tentative date)**
 - **Final: TBD – consult final exam table**
- The exams will be concept based. You should expect questions that require you to apply concepts covered in lectures and the homework. Some questions will be calculation based, some questions will require you to do calculations and then apply the answers, and some questions will focus entirely on concepts.
- Exams will be closed book with no note sheets. Fundamental knowledge will be expected to be demonstrated.
- One make-up exam will be provided for each exam for students with a valid excused absence for the regular exam date. Students with prior knowledge that they will be absent (excused) on the exam date must notify the instructor by email prior to the regular exam date. Documentation needs to be provided to validate the excused absence.

Team Project

- The team project will build on assignments completed throughout the semester.
- Deliverables will include a model repository, concise report, and a short in-class presentation.
- The purpose of the team project is for students to assemble all of the core concepts and physical systems studied during the course of the semester
- Detailed information of the team project will be posted on ELMS.
- The final report will be due on Monday, May 15, 2023.

Grading Structure

Assignment	Percentage %
Homework and Quizzes	50%
Midterm Exam (50 minutes) Tentative date March 15, 2023 during the scheduled class time.	10%
Team Project/Paper/Presentation	25%
Final Exam (120 minutes)	15%

Consult Final table	
Total	100%

Grades

- Final grades will include +/- descriptors.
- All assessment scores will be posted on the course ELMS page. If you would like to review any of your grades (including the exams), or have questions about how something was scored, please email me to schedule a time for us to meet and discuss. You may submit regrade requests through Gradescope for assignments graded by Gradescope.
- Work submitted after the due date will not be accepted for course credit so please plan to have it submitted well before the scheduled deadline. I am happy to discuss any of your grades with you, and if I have made a mistake, I will immediately correct it. Any formal grade disputes must be submitted in writing and **within one week of receiving the grade**.
- Final letter grades are assigned based on the weighted percentages. There will be no curve for an individual assignment or exam. Final grades will be curved based on the class section's final grade distribution. To be fair to everyone I have to establish clear standards and apply them consistently, so please understand that being close to a cutoff is not the same as making the cut (89.9 $\neq$ 90.0). It would be unethical to make exceptions for some and not others.

Academic Integrity

The University's **Code of Academic Integrity**, [see https://www.studentconduct.umd.edu/current-students](https://www.studentconduct.umd.edu/current-students), is designed to ensure that the principles of academic honesty and integrity are upheld. In accordance with this code, the University of Maryland does not tolerate academic dishonesty. Please ensure that you fully understand this code and its implications because all acts of academic dishonesty will be dealt with in accordance with the provisions of this code. All students are expected to adhere to this Code. It is your responsibility to read it and know what it says, so you can start your professional life on the right path. **As future professionals, your commitment to high ethical standards and honesty begins with your time at the Clark School.**

It is important to note that course assistance websites, such as CourseHero, are not permitted sources, unless the instructor explicitly gives permission for you to use one of these sites. Material taken or copied from these sites can be deemed unauthorized material and a violation of academic integrity. These sites offer information that might not be accurate and that shortcut the learning process, particularly the critical thinking steps necessary for college-level assignments.

Additionally, it is understandable that students may use a variety of online or virtual forums for course-wide discussion (e.g., GroupME or Hangouts). Collaboration in this way regarding concepts discussed in this course is permissible. However, collaboration on graded assignments is strictly prohibited unless otherwise stated. Examples of prohibited collaboration include: asking classmates for answers on homework, quizzes or exams, etc.

Finally, on each exam or assignment you must write out and sign the following pledge:

"I pledge on my honor that I have not given or received any unauthorized assistance on this exam/assignment."

Please visit the Office of Undergraduate Studies' full list of campus-wide policies and follow up with me if you have questions.

To help you avoid unintentional violations, **the following table** lists levels of collaboration that are acceptable for each type of assignment. If you ever feel pressured to comply with someone else's

academic integrity violation, please reach out to me straight away. Also, *if you are ever unclear* about acceptable levels of collaboration, *please ask!* See the course CANVAS-ELMS page for academic integrity expectations for each individual assignment. If you are ever unsure about acceptable levels of collaboration, please ask!

	 OPEN NOTES	 USE BOOK	 SEARCH ONLINE	 ASK FRIENDS	 WORK IN GROUPS
Homework Assignments	✓	✓	✓	.	.
Midterm Exams	.	.	.	.	.
Team Project	✓	✓	✓	✓	✓

Course Outline

Week	Dates	Topic		Deliverables
1	Jan 25 - 27	Module 1: Course Fundamentals	Lecture 1: Course Motivation, Outline, and Class Expectations	N/A
2	Jan 30 – Feb 3		Lecture 2: Model Based Design and Basics of Simulink Lecture 3: Introduction to Source Control	HW1 Due Feb 3
3	Feb 6 – 10	Module 2: Aircraft Thermal Fluid Systems	Lecture 4: Aircraft Thermal Management Systems Lecture 5: Liquid Cooling Systems	HW2 Due Feb 10
4	Feb 13 - 17		Lecture 6: Fuel Systems 1 Lecture 7: Fuel Systems 2	HW3 Due Feb 17
5	Feb 20 -24	Module 3: Numerical Techniques	Lecture 8: Newton Raphson 1 Lecture 9: Newton Raphson 2	HW 3 Due Feb 24
6	Feb 27 – Mar 3		Lecture 10: Sizing Lecture 11: Dynamic Boundary Conditions	HW4 Due Mar 3

7	Mar 6 - 10		Lecture 12: Validation 1 Lecture 13: Validation 2 (Uncertainty, Sensitivity, etc.)	HW 5 Due Mar 10
8	Mar 13 - 17		Lecture 14: Review EXAM 1	
9	Mar 20 - 24		SPRING BREAK	
10	Mar 27 - 31	Module 4: Aircraft Propulsion Systems	Lecture 15: Brayton Cycle, Engine Components Lecture 17: Engine Configurations	
11	Apr 3 - 7		Lecture 18: Engine Modeling 1 Lecture 19: Engine Modeling 2	
12	Apr 10 - 14		Lecture 20: Bleed Air/Air Cycle Systems Lecture 21: Secondary Power	
13	Apr 17 - 21	Module 5: Aircraft Electrical Power Systems	Lecture 22: Aircraft Power Introduction/ Power Electronics Fundamentals Lecture 23: Aircraft AC Power Systems	
14	Apr 24 - 28		Lecture 24: Power Conversion Lecture 25: Power System Modeling	
15	May 1 - 5	Module 6: Integrated Aircraft Energy Systems		
16	May 8 - 12			
17	May 15 - 19		Final	

Note: This is a tentative schedule, and subject to change as necessary – monitor the course ELMS page for current deadlines. In the unlikely event of a prolonged university closing, or an extended absence from the university, adjustments to the course schedule, deadlines, and assignments will be made based on the duration of the closing and the specific dates missed.

Resources & Accommodations

Accessibility and Disability Services

The [Accessibility & Disability Service \(ADS\)](#) provides reasonable accommodations to qualified individuals to provide equal access to services, programs and activities. **ADS cannot assist retroactively**, so it is generally best to request accommodations several weeks before the semester begins or as soon as a disability becomes known. Any student who needs accommodations should contact me as soon as possible so that I have sufficient time to make arrangements. **ADS requires that all requests for exams to be proctored at ADS be made no later than 1 week in advance of the test date.**

For assistance in obtaining an accommodation, contact Accessibility and Disability Service at 301-314- 7682, or email them at adsfrontdesk@umd.edu. Information about [sharing your accommodations with instructors, note taking assistance](#) and more is available from the [Counseling Center](#).

Student Resources and Services

Taking personal responsibility for your own learning means acknowledging when your performance does not match your goals and doing something about it. I hope you will come talk to me so that I can help you find the right approach to success in this course, and I encourage you to visit [UMD's Student Academic Support Services website](#) to learn more about the wide range of campus resources available to you.

In particular, everyone can use some help sharpening their communication skills (and improving their grade) by visiting [UMD's Writing Center](#) and scheduling an appointment with the campus Writing Center. You should also know there are a wide range of resources to support you with whatever you might need ([UMD's Student Resources and Services website](#) may help). If you feel it would be helpful to have someone to talk to, visit [UMD's Counseling Center](#) or [one of the many other mental health resources on campus](#).

Basic Needs Security

If you have difficulty affording groceries or accessing sufficient food to eat every day, or lack a safe and stable place to live, please visit [UMD's Division of Student Affairs website](#) for information about resources the campus offers you.

Course Evaluation

Please submit a course evaluation through CourseEvalUM in order to help faculty and administrators improve teaching and learning at Maryland. All information submitted to CourseEvalUM is confidential. Campus will notify you when CourseEvalUM is open for you to complete your evaluations for fall semester courses. Please go directly to the [Course Eval UM website](#) to complete your evaluations. By completing all of your evaluations each semester, you will have the privilege of accessing through Testudo, the evaluation reports for the thousands of courses for which 70% or more students submitted their evaluations.

Copyright Notice

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Anthony Malatesta, January 25, 2023