Sample Syllabus

ME 427: Aerodynamics for Mechanical Engineers

Spring 2023 · Section 001

Hammond 219 · MWF 12:20pm – 1:10pm

Instructor	Dr. Margaret Byron	**Email**	ME427@psu.edu
Office	301A Reber	**Office Hours**	10am – 12pm Wednesdays
Teaching Assistant	Abhi Vajjala	**Email**	akv5168@psu.edu
Course Website	All material (lecture notes, assignments, etc) will be distributed *via* Canvas.		

- To arrange a meeting outside of office hours, please email Dr. Byron or the TA.
- **Do not send homework questions by email unless they are very simple. Come to office hours instead.**

Text:

Fundamentals of Aerodynamics. 6^{th} *Ed.* Anderson, J. [required – previous editions acceptable]

Brief Course Description:

Overview of incompressible aerodynamics, including concepts such as lift, drag, aerodynamic moment, induced drag, viscous drag, pressure drag, separation, stall, circulation, downwash, camber, thickness ratio, and lift distribution. Short modules on aerodynamics applications in mechanical engineering (e.g. energy, automotive, et al) may also be included.

Prerequisites:

ME320 (Fluid Flow); heavy reliance on topics from MATH 230/231 (Multivariable Calculus)

Course Learning Objectives

By the end of this course, students will be able to…

1. Recognize the role of aerodynamics throughout the mechanical engineering discipline
2. Define and fluently communicate using terms and conventions specific to the field of aerodynamics
3. Use conservation principles (mass, momentum, and energy) to solve for flowfields in aerodynamic problems
4. Evaluate the aerodynamic *forces* and *moments* on bodies created by fluid flow
5. Analyze the role of *viscosity* in aerodynamic problems, and compare its role in different contexts
6. Use potential flow theory to evaluate quantities of interests, and recognize its advantages and limitations
7. Apply aerodynamic principles to real-world scenarios including but not limited to flight
8. Critically interpret contemporary research in various application areas of aerodynamics

Course Format

This course will provide an overview of incompressible aerodynamics, including a traditional aerospace engineering perspective as well as several detours into application areas commonly seen in mechanical engineering. The course will roughly follow the following sequence of topics: 1) introduction to aerodynamic nomenclature and modes of thinking, 2) review of basic fluid dynamic principles, 3) potential flow theory, 4) flow over 2D and 3D bodies, and 5) boundary layers. The final 5 weeks of the course will be dedicated to several application areas, including case studies and readings from current aerodynamics research. The course will also feature a variety of guest speakers and one field trip.

Assessment framework

The course grade is composed of the following categories: Homework, Engagement, Mini-Projects, Field Trip, Midterm Exam, and Final Project. The point value of an assignment (visible in Canvas) will dictate its relative importance within each category.

Homework: there will be 4 total homework assignments. Homework will be assigned every 2-3 weeks and concentrated in the first 2/3 of the semester. Homework is to be uploaded digitally to Canvas by the indicated day/time; no late homework will

be accepted except by prior arrangement with the instructor. At least one full day notice is required to request an extension. Homework may be completed in groups of up to 3 students, with one assignment submitted per group. Groups can change for each assignment; **group selection must be input on Canvas separately for each assignment.**

Engagement: students will complete a weekly individual check-in on Canvas reflecting on their understanding of course material. Various in-class activities (potentially including but not limited to Kahoot quizzes, surprise problems, et al) will also be counted in this category, as will a brief self-introduction at the start of the semester. Class discussions and individual reflections related to readings, guest speakers, etc will also count in this category.

Mini-projects: two mini projects will be assigned during the semester. They may require both experiment and computation. Grading will be based not only on technical detail but also on the communication of your results; further details including grading rubrics will be provided with the assignment.

Field trip: We will take a field trip during the first week of April (TBD but likely **April 3 from 12:20pm to 2:30pm – note extra time**) to the Penn State Aviation Center; students are expected to attend and complete a pre- and post-trip assignment. If any student cannot attend, they must complete a third mini-project (topic TBD). Absences must be discussed with Dr. Byron as early in the semester as possible. A note can be provided to excuse you from afternoon classes on the day of the trip.

Midterm Exam: There will be one midterm exam in this class, which will cover all material from weeks 1 – 10. This exam will take place in the evening, from **6:15 – 7:30pm on April 1** in 104 Thomas.

Final Project: There will be one final project in this class, a report on the topic of your choice (under the general umbrella of "Contemporary Aerodynamics"). The project will be due during Finals Week. It is an individual assignment.

Grading:

20%	Homework
14%	Engagement
8%	Mini-Project 1
8%	Mini-Project 2
10%	Field Trip
20%	Midterm Exam
20%	Final project

*For overall course grades, scores within 0.2 percentage points of the next tier up will be rounded (otherwise **no rounding**).*

Overall grading scale:

Final Course Average	Grade
<60.00	F
60.00≤ avg <70.00	D
70.00≤ avg <77.00	C
77.00≤ avg <80.00	C+
80.00≤ avg <83.00	B-
83.00≤ avg <87.00	B
87.00≤ avg <90.00	B+
90.00≤ avg <93.00	A-
93.00≤ avg	A

Course Schedule (approximate):

Wk	Topic	Textbook (approx.)
1	Pressure, shear stress, and the language of aerodynamics. No class Friday (instructor travel)	1.1 – 1.6, 1.9, 1.12
2	Review of basic fluid dynamics and vector calculus. No class Monday (MLK Jr. Day)	1.7 – 1.8, 1.10, 2.1 – 2.3, 2.9-2.13

3	Conservation principles (mass, momentum, energy) as applied to aerodynamics. Potential and streamfunctions. No class Friday (instructor travel)	2.4 – 2.8, 2.14-2.16
4	Bernoulli's equation, wind tunnel design, pitot tubes, pressure coefficient. Introduction to potential flow theory.	3.1 – 3.7
5	Potential flow theory: superposition, flow over cylinders & spheres, Magnus effect , D'Alembert's paradox	3.8 – 3.15, 3.18, selections from 6
6	Kutta-Joukowski theorem, source panel method. No class Friday (instructor travel)	3.16 – 3.17
7	Airfoil descriptions, vortex sheets, Kutta condition, Kelvin's Theorem; thin airfoil theory	4.1 – 4.9
8	Thin airfoil theory, vortex panel method.	4.10 – 4.13
SPRING BREAK: March 3 – 9		
9	Flow over finite wings. Vortex and vorticity dynamics. Lifting line theory.	~~5~~ 5.1 – 5.3, 6.7
10	Boundary layers	15.1 – 15.2, 15.4, 17, 18.1-2, 19.1-2 17, 18, 19
11	Leftover material and review *(Midterm exam on Monday of Week 12)*	
12	Exam: 6:15 – 7:30pm April 1, 104 Thomas Building Field Trip to University Park Aviation Center and Miller Fluids Lab: Wednesday, April 3 (depart from Reber parking lot promptly at 12:20pm!) April 5: Cancelled	TBD
13	April 8: Guest speaker (Paul Danehy, NASA) April 10: ENERGY 1 | April 12: ENERGY 2	TBD
14	April 15: SPACE | April 17: SPORTS April 19: Panel on sports aerodynamics	TBD
15	April 22: ROTORCRAFT April 24: Guest speaker (Steve Lynch, PSU) April 26: BIOLOGICAL FLIGHT	TBD

*Application areas will be selected from the following topics: Energy, Space, Sports, Automotive, Biolocomotion

Grading Policies

- **Open-book policy.** All assignments in this class are open-book and open-notes. While you may use external and web resources to complete homework and projects, you MUST appropriately cite these resources. Never copy and paste text from any external resource without explicit quotation marks and appropriate citation; this is plagiarism.
- **Projects.** Grading rubrics for both the mini-projects and the final project will be posted on Canvas.

- **Regrades and disputes.** If you feel that an assignment or exam was not graded correctly, please pursue one of the following two courses of action within 1 week of the return of the assignment/exam:
    - If the error was a simple arithmetic error (e.g. your points were added up incorrectly), please bring the assignment/exam to office hours and we will correct the error.
    - For all other regrade requests (e.g. you disagree with how partial credit was apportioned), please write out a clear justification for your proposed alternative score and email it to ME427@psu.edu.

Academic integrity

- **All work submitted in this class must be your own.** This course will follow the PSU academic integrity policies (https://studentaffairs.psu.edu/student-accountability/code-procedures/academic-misconduct-procedures). Violations of these policies will result in 0 grades for respective items and will be reported to the College.
- **Use of online solution manuals and help sites such as Chegg are cheating.** Using these sites, even as a homework aid, is not in your interest; numerous studies have shown that working through problems side-by-side with their solutions is not helpful to improving understanding compared to attempting the problem on your own.
- **Uploading any course material (lecture notes, homework, exams, solutions, etc) to ANY external website is STRICLY PROHIBITED.** If I find that you have uploaded material externally, you will receive a zero for any related assignments and you will be reported to the College of Engineering for a student conduct violation.
- Collaborating with other students on assignments, where permitted, is encouraged—teamwork is a big part of engineering. If you work in a group, make sure to register its members appropriately on Canvas. Maximum group size is 3 students. If you have trouble finding a group, please ask Dr. Byron for assistance.
- Using AI writing tools (e.g. ChatGPT) is prohibited except where explicitly authorized/requested. Uncredited use of AI in any part of the writing process **is plagiarism**. If you didn't write it, don't hand it in.
- If you plagiarize, we will find out. We have the internet too.

Make-up exams:

No make-up exams will be given except in accordance with University policy 44-30 (see below). If you know you will miss the midterm exam due to an unavoidable absence, contact Dr. Byron as soon as possible.

> A student is permitted to make up a missed exam without penalty if he/she has a conflict between an exam/quiz and a scheduled University-approved activity (as established in the Class Attendance policy, 42-27) or if he/she has more than one exam/quiz scheduled at the same time.

Other resources:

- **COVID. If you are experiencing symptoms of any respiratory virus (or other contagious illness), be considerate and stay home.** See also https://virusinfo.psu.edu/testing-support/.
- **Mental health.** Working toward a degree in engineering can be stressful. Make sure you take care of yourself both physically and mentally. Counseling and Psychological Services (CAPS) can help you resolve personal concerns that may interfere with your academic progress, social development, and satisfaction at Penn State. This might include (but isn't limited to) anxiety, depression, difficulties in relationships; sexual identity; lack of motivation or difficulty relaxing, concentrating or studying; eating disorders; sexual assault and sexual abuse recovery; and uncertainties about personal values and beliefs. Find CAPS at http://studentaffairs.psu.edu/counseling/.
- **Food insecurity.** The Lion's Pantry (https://thelionspantry.psu.edu/) provides food assistance to any student with a valid PSU ID. Please see the "Resources" tab of the Lion's Pantry website for links to several other resources. See also: https://www.psu.edu/news/campus-life/story/guide-student-food-and-housing-security-resources-penn-state/
- **Housing insecurity.** If you are experiencing a housing crisis, please reach out to the Center for Community Resources (https://ccrinfo.org/). If you are experiencing dating or relationship violence and feel unsafe in your home, the Gender Equity Center (https://studentaffairs.psu.edu/genderequity) can provide assistance. See also: https://studentaffairs.psu.edu/support-safety-conduct/basic-needs-support/housing-support
- **Students with disabilities.** Penn State welcomes students with disabilities into the University's educational programs. Every Penn State campus has an office for students with disabilities. The Student Disability Resources Web site provides contact information for every Penn State campus: http://equity.psu.edu/student-disability-resources/. **If you have an approved disability that requires class accommodations, please let Dr. Byron know ASAP.** We will be very happy to work with you to meet these accommodations.

- **Academic dishonesty.** The University and the College of Engineering consider academic dishonesty, including cheating and plagiarism, to be a serious offense. The University Policy 49-20 describes the general university policy on academic dishonesty. For Engineering, the academic integrity web site is at https://advising.engr.psu.edu/student-resources/academic-integrity.aspx. Dishonest incidents should be reported to the course instructor or to the Department Head who will refer it to the College Committee on Academic Dishonesty.