MAE 335 – Incompressible Aerodynamics
Mechanical and Aerospace Engineering Department – West Virginia University
Fall 2021, MWF 11:00 – 11:50 AM, G39 ESB

Instructor: Dr. Christopher Griffin, Teaching Assistant Professor, MAE Dept.
Office Hours: MW, 2:00 – 3:00 PM; Th, 1:00 PM – 2:00 PM; or by appointment (open door policy)
Contact Info: Office – 939 ESB, Phone – 304.293.3386, Email – cgriffin@mail.wvu.edu

Course Prerequisites: MATH 251 and either MAE 215 or MAE 331

Course Textbook: Fundamentals of Aerodynamics, 5th or 6th Edition by John Anderson

General Topics to be covered

- Fluid Properties
- Conservation of Mass and Momentum Principles
- Flow Similarity
- Circulation and Vorticity
- Superposition of Potential Flow Elements
- Velocity Potential
- Stream Function
- Airfoil Nomenclature
- Thin Airfoil Theory
- Lifting Line Theory
- Laminar Boundary Layers

***NOTE:** This course relies heavily on mathematics to analyze incompressible flow around aerodynamic bodies, in particular vector calculus. Therefore, this course is not nearly as applied as other courses in the Aerospace Engineering Curriculum. However, the mathematical fundamentals are critical to a true physical understanding of not only this course, but also other courses in aerodynamics. Simply put, there is no way around this course being math intensive in order to properly cover the required topics. Students will be expected to use MATLAB in this course.

Grading

The final grade in the course will be assigned on the following basis:

Homework/Quizzes	10%
Project	10%
Exam 1	25%
Exam 2	25%
Final Exam	30%

Final course grade will be submitted as: A (≥89.5%), B (≥79.5%), C (≥69.5%), D (≥59.5%), F (<59.5%)
NOTE: A final course score of 59.4% and below is a letter grade of "F", whether you are graduating or not, have a job lined up or not. No exceptions.

Course Objectives

The objectives of this course are to examine the fundamentals of flowing fluids that can be treated as incompressible and to use this foundation to analyze and predict the dynamics of fluid flow fields. To this end, we will come to understand what it means to be an incompressible fluid, analyze and develop potential flow field expressions, and make use of airfoil theory and finite-wing theory.

Key Course Learning Outcomes

Through satisfactory completion of homework, quiz and exam problems, as well as through classroom discussion, successful students will understand the fundamentals of incompressible aerodynamic theory and be able to calculate lift forces, drag forces, and pitching moments of aerodynamic shapes. Students will also have an introductory knowledge of viscous boundary layers. This outcome supports ABET Outcome 1, shown below.

This course is a Key Course for the following ABET Outcomes:

Outcome 1. *An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.*

Fall 2021 General Academic Calendar Key Dates

AUG 18	First Day of Classes	NOV 16	Last Day to Drop/Withdraw
AUG 24	Last Day to Modify Courses	NOV 20-28	Fall Recess (No Classes)
SEP 06	Labor Day (No Classes)	DEC 09	Last Day of Classes
OCT 07	Mid-Check Grades Due	DEC 10	Prep Day
OCT 07-08	Fall Break (No Classes)	DEC 16, 11AM	Final Exam*

***If a student has more than three final examinations in one day, the student may make arrangements to reschedule the last examination of the day on a different day.**

Engagement Policy

There is no doubt we are in very unusual times. I appreciate all of you continuing your education despite the obstacles that we all are facing. I hope none of us gets sick, I also hope no one close to us gets sick, but I am prepared to work with anyone that may need to miss lecture or assignments due to COVID-19 or any other serious issue. I encourage you to reach out to me as soon as any issue arises so we can work out a plan to keep you up to speed and allow you to finish the course.

To this end, I will make use of TopHat to encourage engagement during virtual lecture, as well as to provide a space for you to collaborate with each other. **The join code is 849926**.

Assignment Policy

Make-up exams, quizzes, late homework, or late projects will **NOT** be accepted without **prior approval granted at least 2 days before the due date** from the instructor, consistent with WVU policies. Neat work is expected on all material submitted for grading (i.e. have to be able to read it to grade it). **All written assignments will be scanned and submitted via eCampus.**

Additional Exam Policy:

The following guidelines are imposed during every exam in MAE 335:

1. Absolutely **NO WIRELESS COMMUNICATION DEVICES** can be used during testing.
2. Exams are “open book and notes”.
3. Students must maintain one empty seat between themselves and their neighbors (exceptions may be made if space is unavailable).
4. All midterm exams must be returned to the instructor and/or proctor by 11:55 am; all final exams must be returned within the allotted two-hour exam period (exceptions will of course be made for students with documentation of additional requirements).

Teaching Philosophy

As the instructor, I will do everything possible to help you learn and understand the material, but you must do your part. The student is ultimately responsible for learning the material. It is not a trivial matter to earn an “A” in my course, but in the same respect, it is also difficult to receive an “F”.

As always, it is best if you can read the book material prior to lecture. But, equally important is to ask questions during lecture. If there are no questions, then I have to assume the material is easily understood and I can move on to the next topic. ASK QUESTIONS…

If you have a question on material, the textbook, homework, how I graded, or life in general, please come and see me as soon as possible. The earlier we can address a deficiency, the better. I am always open to meeting to discuss any questions and concerns.

Finally, I cannot stress enough the importance of doing all assigned work yourself. This includes reading, homework, projects, and self-study. I believe this approach is the only way to learn to address the following questions when solving a problem: a) what is the problem asking, b) what relevant theory do I need to apply, c) what is a representative system drawing for this problem, d) what assumptions and simplifications can I make, e) what local, initial or boundary condition information do I need, and f) what are the steps to solve this problem? **In other words, do not confuse copying solutions with asking your peers for help.**

COVID-19 Statement

WVU is committed to maintaining a safe learning environment for all students, faculty, and staff. Should campus operations change because of health concerns related to the COVID-19 pandemic, it is possible that this course will move to a fully online delivery format. If that occurs, students will be advised of technical and/or equipment requirements, including remote proctoring software.

In a face-to-face environment, our commitment to safety requires students, staff, and instructors to observe the social distancing and personal protective equipment (PPE) guidelines set by the University at all times. While in class, students will sit in assigned seats when applicable and wear the required PPE. Should a student forget to bring the required PPE, PPE will be available in the building for students to acquire. Students who fail to comply will be dismissed from the classroom for the class period and may be referred to the Office of Student Conduct for further sanctions.

If a student becomes sick or is required to quarantine during the semester, they should notify the instructor. The student should work with the instructor to develop a plan to receive the necessary course content, activities, and assessments to complete the course learning outcomes.

Inclusivity Statement

The West Virginia University community is committed to creating and fostering a positive learning and working environment based on open communication, mutual respect, and inclusion.

If you are a person with a disability and anticipate needing any type of accommodation in order to participate in your classes, please advise your instructors and make appropriate arrangements with the Office of Accessibility Services. (https://accessibilityservices.wvu.edu/)

More information is available at the Division of Diversity, Equity, and Inclusion (https://diversity.wvu.edu/) as well.

Sexual Misconduct Statement

West Virginia University does not tolerate sexual misconduct, including harassment, stalking, sexual assault, sexual exploitation, or relationship violence [BOG Rule 1.6] (https://policies.wvu.edu/finalized-bog-rules/bog-governance-rule-1-6-rule). It is important for you to know that there are resources available if you or someone you know needs assistance. You may speak to a member of university administration, faculty, or staff; keep in mind that they have an obligation to report the incident to the Title IX Coordinator. (https://titleix.wvu.edu/staff)

If you want to speak to someone who is permitted to keep your disclosure confidential, please seek assistance from the **Carruth Center, 304-293-9355** or **304-293-4431** (24-hour hotline), and locally within the

community at the **Rape and Domestic Violence Information Center** (RDVIC), **304- 292-5100** or **304-292-4431** (24-hour hotline).

For more information, please consult WVU's Title IX Office (https://titleix.wvu.edu/confidential-resources).

Academic Integrity

The integrity of the classes offered by any academic institution solidifies the foundation of its mission and cannot be sacrificed to expediency, ignorance, or blatant fraud. Therefore, instructors will enforce rigorous standards of academic integrity in all aspects and assignments of their courses. For the detailed policy of West Virginia University regarding the definitions of acts considered to fall under academic dishonesty and possible ensuing sanctions, please see the West Virginia University Academic Standards Policy (http://catalog.wvu.edu/undergraduate/coursecreditstermsclassification). Should you have any questions about possibly improper research citations or references, or any other activity that may be interpreted as an attempt at academic dishonesty, please see your instructor before the assignment is due to discuss the matter.

Statler College Policy of Academic Integrity
(Approved by the Statler College Academic Standards Committee, 28 March 2019)

Case	Violation	Penalty
1	Cheating or plagiarism on minor course element (e.g., quiz, weekly lab report, homework as specified in the syllabus)	Report of academic dishonesty Grade of zero on the entire minor course element Possible one-letter reduction in final grade
2	Cheating or plagiarism on a major course element (e.g., exam, project)	Report of academic dishonesty Grade of zero on the entire major course element Possible additional one-letter reduction in final grade Possible UF† recommendation Possible exclusion from further participation in class
3	Collusion on major course element	Report of academic dishonesty Exclusion from further participation in class Failure in the course Recommendation for UF†
4	Other (document alteration, tampering with records, etc.)	Report of academic dishonesty Grade of zero on the entire major course element Possible additional one-letter reduction in final grade Possible failure in the course Possible exclusion from further participation in class Possible UF† recommendation
* Dismissal from Statler College is permanent for Academic Integrity violations. Student conduct violations can be considered in dismissal. † UF - Unforgivable F Grade; cannot be replaced under D-F repeat policy. π Separable sanctions (e.g., dismissal from Statler College, suspension, or expulsion from WVU) will be recommended for aggravated or second AI offenses. § Warning letters may be issued from the Statler College or the WVU Office of Student Conduct.		
Sanctions will be assessed at the instructor and at the college/university levels. Additional sanctions may be assigned at the level of the instructor, college, and/or university.		
FORBIDDEN on Exams and Quizzes: The use of programmable calculators or smart devices (including smart-phones, smart watches, tablets, cameras, wearable devices, etc.) is prohibited unless specifically indicated by the instructor.		

Disclaimer

The instructor reserves the right to deviate from the syllabus when a change is in the best interests of the class, as determined by the instructor.

Planned Lecture Schedule

Lecture	Date	Topic	Text Section
1	8/18	Course Introduction/Procedures	-
2	8/20	Forces and Moments	1.1 – 1.5
3	8/23	Moments; Center of Pressure	1.5 – 1.6
4	8/25	Dimensional Analysis	1.6 – 1.8
5	8/27	Intro to Ch. 2; Vector Calculus	2.1 – 2.2
6	8/30	Continuity Eq.; "Del"	2.3 – 2.4
7	9/01	Momentum Eq.; Control Volume	2.5 – 2.6
8	9/03	Wake Drag Technique; Energy	2.6 – 2.7
N/A	**9/06**	**Labor Day (No classes)**	**N/A**
9	9/08	Energy Eq.; Substantial Derivative	2.7 – 2.10
10	9/10	Streamlines; Alternative forms of PDEs	2.10 – 2.11
11	9/13	Vorticity; Strain; Circulation	2.12 – 2.13
12	9/15	Velocity Potential; Stream Function	2.14 – 2.16
13,14	9/17 – 9/20	Bernoulli Equation, Applications of Bernoulli	3.1 – 3.5
15	9/22	Problem Solving	3.6 – 3.8
16	9/24	Uniform Flow, Line Source	3.9 – 3.10
17	9/27	Doublet; Source; Sink	3.11 – 3.12
18	9/29	Doublet; Rankin Body	3.12
19	10/01	Circular Cylinder	3.13
20	10/04	Line Vortex	3.14
21	10/06	Lifting Cylinder Flow	3.15 – 3.16
N/A	**10/08**	**Fall Break (No classes)**	**N/A**
22	**10/11**	**Exam 1 Review**	
23	**10/13**	**Exam 1**	**Ch. 1 – Ch. 3.16**
24, 25	10/15, 10/18	Source Panel; Non-lifting Airfoil	3.17
26	10/20	Intro to Airfoil Theory	4.1 – 4.3
27	10/22	Vortex Sheet; Kutta Cond.; Kelvin Theorem	4.4 – 4.6
28, 29	10/25, 10/27	Thin Airfoil: Symmetric	4.7
30, 31	10/29, 11/01	Thin Airfoil: Cambered	4.8
32	11/03	Vortex Sheet Theory	4.9 – 4.10
33	11/05	Real Airfoils	4.11
34	**11/08**	**Exam 2 Review**	
35	**11/10**	**Exam 2**	**Ch. 3.17 – Ch. 4**
36	11/12	Intro to Finite Wing Theory	5.1
37	11/15	XFLR5	(5.5)
38	11/17	Biot-Savart; Lifting Line Theory	5.2 – 5.3
39	11/19	Example of Lifting Line Theory	5.3
N/A	**11/22 – 11/26**	**Fall Recess (No classes)**	**N/A**
40	11/29	Elliptic Loading	5.2-5.3
41	12/01	General Loading	5.3
42	12/03	Vortex Lattice	5.5
43	12/06	Nonlinear Lifting Line; Delta Wing	5.4, 5.6
44	**12/08**	**Final Exam Review**	
	12/16, 11am	**Final Exam**	**Ch. 1 – Ch. 6**

Note: Dates and topics covered are subject to change, but I will do my best to adhere to this schedule.