MAE 335 – Incompressible Aerodynamics
Mechanical and Aerospace Engineering Department – West Virginia University
Fall 2018, MWF 1:00 – 1:50 PM, ESB G-39

Instructor: Dr. Christopher Griffin, MAE Dept.
Office Hours: MWF, 10:30 – 11:30 AM or by appointment (open door policy)
Contact Info: Office – 939 ESB, Phone – 304.293.3386, Email – cgriffin@mail.wvu.edu

Course Description

MAE 335 covers the fundamentals of flowing fluids that can be treated as incompressible. Topics include what it means to be incompressible, analyzing the dynamics of fluid flow fields, ideal fluid flow, and viscous boundary layers. In this course, we will also cover airfoil theory as well as finite-wing theory. Students will be expected to use MATLAB in this course

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.

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.

Key Course Learning Outcomes

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

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

Outcome a. *An ability to apply knowledge of mathematics, science, and engineering;*
Goal 1: Graduates will have an ability to apply knowledge of Mathematics effectively.
Goal 2: Graduates will have an ability to apply knowledge of Chemistry and Physics effectively.
Goal 3: Graduates will have an ability to apply knowledge of Engineering effectively.

Outcome i. *A recognition of the need for, and an ability to engage in life-long learning;*

Goal 1: Graduates will recognize the need for continuing education, throughout their professional careers.

Goal 2: Graduates will recognize and be able to access available opportunities for continuing education, either through formal frameworks, or through personal initiatives.

Outcome j. *A knowledge of contemporary issues;*

Goal 1: Graduates will know and understand contemporary issues pertaining to the environment and society.

Goal 2: Graduates will know and comprehend the importance of cost factors in engineering design.

Goal 3: Graduates will understand and appreciate the importance of international standards and units.

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

Outcome e. *An ability to identify, formulate and solve engineering problems;*

Goal 1: Graduates will be able to translate a set of given objectives and constraints into one or more designs or solution approaches that can be analyzed by using engineering reasoning and problem-solving techniques.

Goal 2: Given an engineering problem, graduates will be able to draw an appropriate system diagram in which they identify and label all forces, flows, constraints, boundary conditions or other parameters pertinent to the solution of the problem.

Goal 3: Graduates will be able to choose and formulate appropriate governing equations for analysis of a given problem.

Goal 4: Given a set of governing equations, graduates will be able to choose and execute an appropriate method of solution for the given equations.

Outcome k. *An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice:*

Goal 1: Graduates will have the ability to use modern laboratory equipment for a broad range of typical engineering applications in the field of mechanical engineering, including, but not limited to, advanced instrumentation, data acquisition, and control systems.

Goal 2: Graduates will have the ability to utilize commercial software for engineering analysis, simulations, data management, computer-aided design and manufacturing.

Fall 2018 General Academic Calendar Key Dates

AUG 15	First Day of Classes	NOV 6	General Election (No Classes)
AUG 21	Last Day to Modify Classes	NOV 17 – NOV 25	Fall Recess (No Classes)
SEP 3	Labor Day (No Classes)	DEC 5	Last Day to Withdraw
OCT 4	Mid-Semester Grades Due	DEC 6	Last Day of Classes
OCT 12	Fall Break (No Classes)	DEC 7	Prep Day for Finals
OCT 23	Last Day to Drop a Class	DEC 11, 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.

Attendance Policy

Attendance will not be taken during class, but is expected! Students cannot reasonably expect to master the course material without regular attendance in class. You are all adults, and I want to treat you as such. Therefore, it is up to you to decide how important learning the material presented in class is. Make no mistake; if you do not come to class, you will not succeed. Students are responsible for all material covered in class regardless of their attendance.

Assignment Policy

Make-up exams, 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). **Multiple sheets must be stapled and problems in the order assigned**. You may use engineering problem paper or standard notebook paper, but NOT scratch paper or paper torn from a spiral notebook and write on only one side of each page.

Additional Exam Policy:

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

1. Absolutely **NO WIRELESS COMMUNICATION DEVICES** are to be used during testing.
2. Students must maintain one empty seat between themselves and their neighbors (exceptions may be made if space is unavailable).
3. All midterm exams must be returned to the instructor and/or proctor by 1:55 pm; 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 actually 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 I get 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 an 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 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.**

Class Etiquette

1. Please make sure all cell phones are turned off, or at a minimum set to vibrate, during lectures and exams.
2. If you have a habit of falling asleep in class, please stay home.
3. Please do not engage in idle chat with classmates during lecture. It is distracting to me and there may be students around you that are also distracted.
4. Please do not send text messages, play games on your phone, read the newspaper, or browse the internet on your laptop, etc… Again, it is a distraction and disrespectful.

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.

Policy of Zero Tolerance in Academic Dishonesty. It is an MAE Departmental Policy, that cheating of any kind or form in exams, quizzes, projects or assignments will result in formal disciplinary action that may include unforgivable F (UF), suspension or dismissal from the Program.

Adverse Weather Statement

In the event of inclement or threatening weather, everyone should use his or her best judgment regarding travel to and from campus. Safety should be the main concern. If you cannot get to class because of adverse weather conditions, you should contact your instructor as soon as possible. Similarly, if your instructor(s) are unable to reach the class location, they will notify you of any cancellation or change as soon as possible, using WVU MIX email to prevent students from embarking on any unnecessary travel. If you cannot get to class because of weather conditions, instructors will make allowances relative to required attendance policies, as well as any scheduled tests, quizzes, or other assessments.

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).

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	8/15	Course Introduction/Procedures	-
2	8/17	Forces and Moments	1.1 – 1.5
3	8/20	Moments; Center of Pressure	1.5 – 1.6
4	8/22	Dimensional Analysis	1.6 – 1.8
5	8/24	Intro to Ch. 2; Vector Calculus	2.1 – 2.2
6	8/27	Continuity Eq.; "Del"	2.3 – 2.4
7	8/29	Momentum Eq.; Control Volume	2.5 – 2.6
8	8/31	Wake Drag Technique; Energy	2.6 – 2.7
9	9/5	Energy Eq.; Substantial Derivative	2.7 – 2.10
10	9/7	Streamlines; Alternative forms of PDEs	2.10 – 2.11
11	9/10	Vorticity; Strain; Circulation	2.12 – 2.13
12	9/12	Velocity Potential; Stream Function	2.14 – 2.16
13	9/14	Bernoulli Equation	3.1 – 3.2
14	9/17	Applications of Bernoulli	3.3 – 3.5
15	9/19	Problem Solving	3.6 – 3.8
16	9/21	Uniform Flow, Line Source	3.9 – 3.10
17	9/24	Doublet; Source; Sink	3.11 – 3.12
18	9/26	Doublet; Rankin Body	3.12
19	9/28	Circular Cylinder	3.13
20	10/1	Line Vortex	3.14
21	10/3	Lifting Cylinder Flow	3.15 – 3.16
22	**10/5**	**Exam 1**	**Ch. 1 – Ch. 3.16**
23, 24	10/8, 10/10	Source Panel; Non-lifting Airfoil	3.17
25	10/15	Intro to Airfoil Theory	4.1 – 4.3
26	10/17	Vortex Sheet; Kutta Cond.; Kelvin Theorem	4.4 – 4.6
27, 28	10/19, 10/22	Thin Airfoil: Symmetric	4.7
29, 30	10/24, 10/26	Thin Airfoil: Cambered	4.8
31	10/29	Vortex Sheet Theory	4.9 – 4.10
32	10/31	Real Airfoils	4.11
33	**11/2**	**Exam 2**	**Ch. 3.17 – Ch. 4**
34	11/5	Intro to Finite Wing Theory	5.1
35	11/7	XFLR5	(5.5)
36	11/9	Biot-Savart; Lifting Line Theory	5.2 – 5.3
37	11/12	Example of Lifting Line Theory	5.3
38	11/14	Elliptic Loading	5.2-5.3
39	11/16	General Loading	5.3
40	11/26	Vortex Lattice	5.5
41	11/28	Nonlinear Lifting Line; Delta Wing	5.4, 5.6
42, 43	11/30, 12/3	Axisymmetric Flows	6.1 – 6.6
44	12/5	Review	
	12/11, 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.