

AE 162 – Aerodynamics II**Instructor Info**

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Credit

3 units

Class Time

TR 3:00 – 4:15 pm

Final Exam

Monday, 23 May 2016, 14:45 – 17:00

Classroom

Engr164

Prerequisites

“C-” or better in Math133A, AE160, and Engr100W

Textbook

Instructor Notes

Course Website

< <http://ae.sjsu.edu/node/233> >

Description

Airfoil and wing theory. Modeling of inviscid flows around aerodynamic bodies using 2-D and 3-D potential flow theory. Problem solving, computer simulations, wind tunnel experiments and team project.

Goals

Introduce students to:

- A. Low speed airfoil theory.
- B. Low speed wing theory.
- D. Aerodynamic simulations.
- E. Aerodynamic design of airfoils and wings.

AE 162 – Aerodynamics II**Learning Objectives**

Students completing AE162 should be able to:

1. Define the vorticity of a flow field and distinguish between rotational and irrotational flows.
2. Define circulation and calculate it around various paths.
3. Define the stream function and the potential function for a flow and calculate each, if they exist.
4. Analyze the elementary flows (uniform, source / sink, doublet, vortex, corner) as well as combinations of them.
5. Explain Kelvin's theorem and its implications for the vortex system of an airfoil.
6. Use and interpret airfoil nomenclature.
7. Describe the aerodynamic characteristics of an airfoil and their importance in airplane design.
8. Explain the design and the performance improvements of modern airfoils (LS, MS, and supercritical).
9. Use experimental data, thin airfoil theory results, and computer programs to predict aerodynamic characteristics of airfoils (e.g. lift and drag at various angles of attack, pitching moment about various points, ac location, etc.)
10. Design and perform an experiment to study the performance of an airfoil, analyze and interpret the results from this experiment, compare with analytical / computational predictions and other published experimental data, and explain any discrepancies.
11. Use the Biot-Savart law to calculate induced velocities in the vicinity of line vortices.
12. Explain how rectangular, swept, and delta wings differ in terms of maximum lift, lift slope, stall angle of attack, induced drag, skin friction drag, L/D at low speeds, and L/D at high speeds.
13. Describe the horseshoe vortex model for a wing and its limitations.
14. Apply Prandtl's lifting-line theory to calculate the aerodynamic characteristics of airplane wings.
15. Use the method of images to discuss and calculate aerodynamic interference for (a) wings flying in the vicinity of each other (i.e., wing/tail/canard combination, biplanes, etc.), (b) wind-tunnel boundaries, and (c) ground effects.
16. Work effectively in a team to (a) define and solve open-ended problems that combine aerodynamics and flight performance, (b) design and perform wind tunnel experiments, and (c) analyze and interpret experimental data.

AE 162 – Aerodynamics II**Approximate Weekly Schedule**

<u>Week</u>	<u>Lecture Topic(s)</u>
01	Introduction to potential flow theory.
02	Vorticity. Rotational and irrotational flows.
03	Velocity potential and stream function. Quiz 1
04	Elementary flows: uniform, source / sink, doublet, vortex. Wind tunnel experiment 1: Cylinder pressure distributions.
05	Circulation and lift. Kutta – Jukowski theorem. Quiz 2
06	Airfoils: Kutta condition, nomenclature, characteristics, design and performance. Wind tunnel experiment 2: Airfoil pressure distributions.
07	Modern airfoils for low and high speed. Quiz 3
08	High lift devices. Wind tunnel experiment 3: Airfoil lift & drag.
09	Wings: Induced drag, Biot-Savart law. Quiz 4 Spring Break
10	Wings: twist, horseshoe vortex model. Wind tunnel experiment 4: Airfoil high-lift devices.
11	Prandtl's lifting-line theory; elliptical lift distribution.
12	General lift distribution.
13	Wings for high speeds.
14	Aerodynamic interference; method of images.
15	Wind tunnel corrections; ground effect.
16	Review.

Grading		
	Workouts	100 points
	Open-Ended Problems	100 points
	Quizzes	200 points
	Final Exam	200 points
	Project	200 points
	Lab Reports	200 points

950 points < A+

900 points < A

850 points < A-

800 points < B+

750 points < B

700 points < B-

670 points < C+

650 points < C

600 points < D**Below 600 points = F****Teamwork**

Instructor will form all teams. Under no circumstances should you work in a team with more than 4 members! No credit will be given for any assignment performed in a team with more than 4 members.

AE 162 – Aerodynamics II**Workouts**

- Workout problems are a great opportunity for developing problem solving skills during class, when I am available to coach you. However, you need to come to class prepared by reading the relevant material beforehand to benefit from these problems.
- Workout problems are solved in teams during class. Teams may change in composition from class meeting to class meeting.
- You must come to class, solve each problem correctly, and present the solution following any guidelines given in class, to receive workout points.
- In some cases, you may be allowed to finish these problems outside of class. In such cases you must turn them in at the beginning of the following class meeting.
- If your name appears on a workout solution sheet you should be able to come up to the board and present this solution to the rest of the class.
- It is everyone's responsibility to ensure that everyone else in their team understands the solution of the problem. If a student is asked to present the solution to a problem and he/she is not able to do so, the team will not receive any points for this problem, even if their written solution is correct.
- No workout solutions will be accepted after a workout problem is solved on the board.

Exams

- You must average **at least 60%** on your tests (quizzes and final) **to receive a passing grade in the course ("C-", "C" or "C+"). If you average 60% - 69% on your tests you can only earn a "C-", "C" or "C+"** in the course, regardless of the total number of points you may have earned.
- You must average **at least 70%** on your tests (quizzes and final) **to receive an A or a B in the course.**

Laboratory

You will design and perform in teams 4 wind tunnel experiments in the aerodynamics lab (Engr. 107). Each experiment takes approximately 2 hours. A lab report is due for each experiment, following the posted guidelines, two weeks after you complete the experiment. **You must average a minimum of 70% in your lab reports to receive a passing grade in the course.**

Project

You will work in teams – no more than 4 people – to define a project that integrates theory and applications from AE165 and possibly other courses (e.g. AE114, AE157). A proposal is due no later than the 3rd week of the semester following the posted guidelines. A final report is due at the end of the semester. Guidelines are included below.

1. *Select an airplane with a high AR wing.*

AE 162 – Aerodynamics II*2. Potential Flow Simulation*

Use Potential Flow Theory to simulate the flow around the fuselage. Plot the streamlines around your fuselage and write the stream function and the velocity potential function.

3. Airfoil Study

- a. Define criteria for selecting an airfoil for your airplane.
- b. Based on these criteria, find at least 10 potential airfoils and compare them using published data and software such as XFLR5.
- c. Based on your criteria select the best airfoil for your airplane wing.
- d. Use thin airfoil theory to estimate the aerodynamic characteristics of your selected airfoil; compare with actual data.

4. Wing Study

- a. Perform a parametric study to determine the best combination of sweep angle, thickness ratio and taper ratio. Use wing weight as your Figure-of-Merit. Use the WingDesign software of Desktop Aeronautics or any other piece of software you see fit.
- b. Calculate the lift and drag characteristics of your wing using the monoplane equation.
- c. Estimate the maximum lift coefficient of the wing.

5. Drag Polars

Calculate the low and high-speed (if appropriate) drag of your entire vehicle. Derive and plot the drag polars for the cruise, takeoff, and landing configurations.

AE165 Project Requirements

6. Estimate the takeoff and the landing performance of your airplane; compare your results with actual performance data.
7. Estimate the climb performance of your airplane; compare your results with actual performance data.
8. Estimate the cruise performance of your airplane; compare your results with actual performance data.
9. Estimate the range / endurance of your airplane; compare your results with actual performance data.
10. Estimate the glide performance of your airplane; compare your results with actual performance data.
11. From planform geometry and aerodynamic data, calculate the stability derivatives C_{M_α} and $C_{M_{\delta_e}}$ of the aircraft.

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