**San José State University**

# College of Engineering / Aerospace EngineeringAE 160, Aerodynamic I, Section 01, Fall 2021

## Course and Contact Information

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| --- | --- |
| Instructor(s): | Brian Andrade |
| Office Location: | Online  |
| Email: | Brian.andrade@sjsu.edu |
| Office Hours: | Wednesday and Thursday, 1900-2000 & by appointment |
| Class Days/Time: | Monday and Wednesday, 1800-1850 |
| Classroom: | Online, Zoom, See Canvas for links. |
| Prerequisites: | Grade of C or better in MATH 31 (or MATH31X) and PHYS 50, or graduate standingCorequisite of ENGR 100W |

## Course Description

Introduction to incompressible, inviscid and viscous aerodynamics through problem solving, computer simulations, water and wind-tunnel experiments, films, and service learning. Topics include aerodynamic forces and moments, flow classification and similarity, conservation laws with applications in the calculation of lift and drag, and boundary layer theory with emphasis on calculation of skin friction and pressure drag.

## Course Format

**Online Course**

This course is an online course and all materials shall be conveyed via Canvas with the course lectures conducted via Zoom. Some materials may be provided by means of a free service outside of Canvas, in such case a link to the material shall be made available on Canvas along with notice of what the material is. This course will require internet connectivity to access these course materials on Canvas and elsewhere as well as to participate in the Zoom lectures. For participation in the zoom lecture a microphone connected to your computer is preferable but not required.

## Program Information

This class is administered in support the Bachelor of Science in Aerospace Engineering and Master of Science in Aerospace Engineering degree programs for the Aerospace Engineering Department. For any questions regarding the programs or department please refer to the Aerospace Engineering Department webpage ([www.sjsu.edu/ae](http://www.sjsu.edu/ae)) or office (Engineering building, room 272)

## Course Goals

Introduce students to:

 A. Modeling of low speed, viscous and inviscid flows.

 B. Calculation of aerodynamic forces on aerospace and ground vehicles.

C. Aerodynamic design for low drag.

 D. Water and wind tunnel testing.

## Course Learning Outcomes (CLO)

Upon successful completion of this course, students will be able to:

1. Explain the nature of aerodynamic forces.
2. Define the aerodynamic center and the center of pressure for an airfoil.
3. Calculate aerodynamic forces and moments on bodies by integrating surface

 pressure and shear stress distributions.

1. Use flow similarity to design wind tunnel tests.
2. Classify a flow as 1-D, 2-D or 3-D, uniform / non-uniform, viscous / inviscid,

 compressible / incompressible, steady / unsteady, subsonic, transonic,

 supersonic or hypersonic.

1. Design and perform flow visualization tests to study the characteristics of the

 flow around 2-D and 3-D aerodynamic bodies and analyze the results from

 such experiments.

1. Use the momentum equation to calculate (a) lift from given pressure

 distributions on the top and bottom of an aerodynamic body and (b) drag

 from given velocity profiles ahead and downstream of an aerodynamic body.

1. Describe qualitatively and quantitatively laminar and turbulent boundary

 layers in terms of thickness, velocity profiles, and shear stress variation.

1. Predict transition from laminar to turbulent flow on an aerodynamic surface.
2. Calculate the skin friction drag and estimate the pressure drag of

 aerodynamic bodies.

1. Predict location on an airfoil surface and inside a nozzle, where boundary

 layer separation is likely to occur.

1. Design and perform wind tunnel experiments to measure the drag of a 2-D

 aerodynamic body and analyze the results from such experiments.

1. Design and perform wind tunnel experiments to study boundary layer

 characteristics on an aerodynamic surface and analyze the results from such

 experiments.

1. Work effectively in teams to (a) define and solve open-ended aerodynamics problems, (b) design and perform water / wind tunnel experiments, and (c) analyze and present results from such experiments.

#### Course Relationship to BSAE Program Outcomes

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| *Learning Objectives* |  |  |  |  |  |  |  |
| 1 – 5, 7 – 11  | ++ |  |  |  |  |  |  |
| 6, 12, 13, 14 |  |  | +++ |  | +++ | +++ | +++ |

+: Skill level 1 or 2 in Bloom’s Taxonomy
++: Skill level 3 or 4 in Bloom’s Taxonomy
+++: Skill level 5 or 6 in Bloom’s Taxonomy

## Required Texts/Readings

### Textbook

John D. Anderson, Jr.’s Fundamentals of Aerodynamics (5th Edition) is RECOMMENDED but not mandatory

ISBN: 978-0-07-339810-5

Available from common online retailers.

NOTE: Any edition of the book is acceptable. Instructor shall be referring to the 5th edition but relevant material difference between editions is minimal

### Other Readings

Course slides (available on Canvas shortly after the respective lecture)

## Course Requirements and Assignments

Success in this course is based on the expectation that students will spend, for each unit of credit, a minimum of 45 hours over the length of the course (normally three hours per unit per week) for instruction, preparation/studying, or course related activities, including but not limited to internships, labs, and clinical practica. Other course structures will have equivalent workload expectations as described in the syllabus.

This course shall have quizzes , assignments , labs, and the final exam contribute to the final overall grade.

Quizzes shall be open book and open note, given synchronously during a normally schedule course time, and be submitted to Canvas by the specified time.

Assignments shall be completed individually (though collaboration is encouraged) and submitted per the schedule on Canvas.

Labs shall be completed in groups of not more than 4 and submitted per the schedule electronically on Canvas. Any issues regarding fair participation in the lab or completion of respective reports should be addressed as soon as feasible prior to the submission of the report. Provisionally labs shall be available in person however there shall be arrangements made for those who cannot feasibly attend an in-person lab.

### Final Examination or Evaluation

This course shall have a final cumulative exam which shall be given synchronously per the university final schedule on December 8th 2021 from 1715-1930.

## Grading Information

Grade Categories and contribution to total grade:

Homework 20%
Quizzes 30%
Final Exam 20%

Lab\* 30%

| *Grade*  | *Percentage* |
| --- | --- |
| *A plus* | *95 to 100%* |
| *A* | *90 to 95%* |
| *A minus* | *85 to 90%* |
| *B plus* | *80 to 85 %* |
| *B* | *75 to 80%* |
| *B minus* | *70 to 75%* |
| *C plus* | *67 to 70%* |
| *C* | *65 to 67%* |
| *D* | *60 to 65%* |
| *F* | *59.9% or lower* |

\*The lab is a separate section but is assessed into the letter grade for the course. The grading for the lab shall be covered in the lab syllabus and shall be factored into the overall grade with a 30% weight, per above, to determine the final overall letter grade.

Late work shall at the discretion of the instructor be penalized by up to 20%. No late work shall be accepted after two weeks from the original due date. Absence during a quiz or final shall result in a zero for the score unless a suitable makeup can be mutually determined between the instructor and student.

## Classroom Protocol

## Class shall be held via zoom meeting. It is encouraged to have a microphone for the purposes of asking questions, questions in text chat may go un-noticed accidentally. Microphones should be muted unless in active and deliberate use, to minimize background noise.

## University Policies

Per [University Policy S16-9](http://www.sjsu.edu/senate/docs/S16-9.pdf) *(http://www.sjsu.edu/senate/docs/S16-9.pdf)*, relevant university policy concerning all courses, such as student responsibilities, academic integrity, accommodations, dropping and adding, consent for recording of class, etc. and available student services (e.g. learning assistance, counseling, and other resources) are listed on [Syllabus Information web page](http://www.sjsu.edu/gup/syllabusinfo/) (http://www.sjsu.edu/gup/syllabusinfo), which is hosted by the Office of Undergraduate Education. Make sure to visit this page to review and be aware of these university policies and resources.

# AE160 / Aerodynamics I, Fall 2020, MW 1630-1745

## Course Schedule

| **Week** | **Date** | **Topics** |
| --- | --- | --- |
| 1 | 08/23 | Introduction to fluids, density, pressure, viscosity. |
| 1 | 08/25  | “ |
| 2 | 08/30 | Aerodynamic forces and moments |
| 2 | 09/01 | “ |
| 3 | 09/06 | Aerodynamic forces and moments. |
| 4 | 09/08 | Aerodynamic coefficients. Center of pressure. Aerodynamic center. |
| 4 | 09/113 | “ |
| 5 | 09/15 | Flow similarity. Application in wind tunnel testing. |
| 5 | 09/20 | “ |
| 6 | 09/22 | Flow description. Streamlines. Flow classification |
| 6 | 09/27 | ‘ |
| 7 | 09/29 | Continuity. Flow quality. Wind tunnel design. |
| 7 | 10/04 | ‘ |
| 8 | 10/06 | Bernoulli. Airspeed measurement. Airfoil pressure distributions. |
| 8 | 10/11 | “ |
| 9 | 10/13 | Momentum equation. |
| 9 | 10/18 | “ |
| 10 | 10/20 | Drag calculation for 2-D bodies |
| 10 | 10/25 | ‘ |
| 11 | 10/27 | Boundary layers: qualitative description |
| 11 | 11/01 | “ |
| 12 | 11/03 | Laminar boundary layers: thickness, velocity and shear stress distribution |
| 12 | 11/08 | ‘ |
| 13 | 11/10 | Turbulent boundary layers: thickness, velocity and shear stress distribution. |
| 13 | 11/15 | “ |
| 14 | 11/17 | Skin friction and pressure drag calculation |
| 14 | 11/22 | “ |
| 15 | 11/24 | Boundary layer transition and separation –Boundary layer control |
| 15 | 11/30 | “ |
| 16 | 12/01 | Final Review |
| 16 | 12/06 | “ |
| Final Exam |  | Online, December 10th 2020, 1445-1700 |

This schedule is subject to change as circumstances develop and notice of any change shall be delivered via Canvas announcement for quizzes and exams. Changes regarding the topic schedule or assignments will generally be made by canvas announcement but may be communicated during normally scheduled lecture for minor changes.