AE429 - Aircraft Performance and Flight Mechanics

INSTRUCTOR: **Pier Marzocca**
OFFICE: **234 CAMP, MAE Dept**
CLASS SCHEDULE: **RL244 MW 3:00 - 4:15**
OFFICE HOURS: **MW 12:30 - 3:00, CAMP 234 or by appointment**
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Corequisites

ME425, AE 425 Aerodynamics

Brief Course Outline

Fundamentals of propeller and jet aircraft performance. Steady and accelerated flight. Equations of motion. Level flight. Gliding, climbing, driftdown. Takeoff and landing. FAR requirements. Range and endurance. Payload-range diagram. Maneuvering. V-n diagram. Turning and pull-ups. Stall and spin behavior. Energy methods.

Textbook

Aircraft Performance and Design, John D. Anderson, McGraw-Hill, 1999

References

Airplane Aerodynamics and Performance, Roskam, J. and Lan, C.-T., DARcorporation, 1997.
Fundamentals of Flight, Shevell, R.D., Second Edition, Prentice Hall, 1989.

Learning Objectives

- To introduce students to the fundamental concepts of airplane aerodynamics, propulsion, and the equations of motion.
- To enable students to analytically estimate airplane performance for all phases of flight.
- To enhance the students' written, oral, and graphical communication skills.

Course Goals

- Demonstrate competence in evaluating lift and drag of airplanes, and installed thrust of their engines.
- Be able to formulate a mathematical model of an airplane for performance analysis.
- Be able to calculate airplane performance for steady and accelerated flights
- Present good oral and written reports on airplane performance.

Grades

The evaluation tools used for this course include homeworks, tests/exam, and a project. The homework assignments are selected to reinforce class lectures. The tests are variations on homework and class material with both analytic and numerical components. All tests will be closed book, closed notes, a formula sheet is allowed.
[1] Homework 10%
[2] Test 1 20% (Middle of February, tentative date: Feb 13)
[3] Test 2 20% (End of March, tentative date: March 14)
[4] Test 3 25% (End of April, tentative date: April 18)
[5] Project 25% (Project report and oral presentation ~ finals)

Project

Select one of the two projects illustrated next:

1) To enhance learning, the student teams (up to three students) are required to estimate the performance characteristics of actual airplanes. Each team selects an airplane, obtains its geometric, mass, and thrust data, and computes performance. Students submit a work-in-progress reports and final reports at the end and make oral presentations.

2) To enhance learning, the students are required to find one or more literature article (from a journal, book, etc.) where the problem of performance and flight mechanics of airplanes has been treated. Each team (up to three students) should choose any of the topics under the general category of performance and flight mechanics of airplanes. However, aside from this constraint, the primary driving force in the selection of the paper topic should be your interest. You should review the literature in order to become familiar with your topic and the issues surrounding it. Students submit work-in-progress reports and final reports at the end and make oral presentations.

3) To enhance learning, the students are required to use of flight simulators to demonstrate flight characteristics of an existing aircraft. For example x-plane is a software that does have many build in features that enable such study. Flight-gear is also capable of such study. There might be many other flight simulators available for free (e.g. orbiter, etc). Each team (up to three students) should prepare a report discuss typical performance issues related to aircraft that can be verified with x-plane, for example take off speed and distance, landing, rate of climb, etc. Students submit a work-in-progress reports and final reports at the end and make oral presentations.

Note: Start this assignment early! ALL topics must be approved by the instructor.

Computer Usage:

The students are encouraged to use mathematical software packages and spreadsheets for homework and project. Oral presentation and project report require the use of word processing and graphics software.

Detailed Outline

- **Introduction**
- **Standard Atmosphere**
- **Basic Aerodynamic Concepts (Chapter 2)**
  - Airfoil Theory
  - Wing Theory
  - Aircraft Drag Estimation
- **Aircraft Propulsion (Chapter 3)**
  - Thrust, Power and SFC
  - Turboprop Engines
  - Turbofan Engines
- **Equations of Motion (Chapter 4)**
- **Steady Flight (Chapter 5)**
  - Steady, level flight
  - Climb and Drift-down
  - Range
  - Endurance
- **Accelerated Flight (Chapter 6)**
  - Maneuvering
  - V-n Diagram
  - Take-off
  - Landing

Course Rules

Reading Assignments

The student should read ahead one or two sections before each class. Topics will be presented in the syllabus order. This will greatly facilitate understanding the lectures and will save time in the long run.

Problem Assignments

The instructor-assigned problems are not necessarily those suggested on the book. Late problems will generally not be accepted (except for reasons of illness, etc). The first few minutes of the due date class will be devoted to the problems due that day.

Homework papers should be orderly and logical, with a straightedge/circle template used for all diagrams. Use 8-1/2"x11" paper (no legal sizes or pages tom from composition books), pencils (no pens), and staples in the upper left-hand comer. Submit your paper unfolded, with name, course, and due date in the upper right-hand comer. Use of only the front sides of the pages is recommended, but if you have strong ecological feelings to the contrary, use the backs as well.

If **computer-oriented problems** will be assigned, the submission of only a computer program listing and output is unacceptable. Begin as with any mechanics problem: With pencil and paper, apply the fundamental principles to the problem at hand. Bring the development to a critical point at which the computer is utilized to manipulate numbers, produce a plot, etc. Cite any program used; if you write the program, attach it to your solution as an appendix. As with any engineering problem, delay the introduction of numbers as long as possible.

The **three tests** will cover all material up to and including the last lecture before the test, but will stress the material since the last test. All tests will be closed book, closed notes, and held during the class period (1 hr 15 min). Each test and the exam may include short-answer questions and will include at least one problem similar to homework assignments. Make-up tests only for reasons of illness, etc. For the **final project** see the guideline of the course.

Honor Policies

The tests and the exam are closed book, closed notes, no personal aid tests. One 8.5x11-inch piece of paper with whatever you wish written on both sides is allowed for each test and the exam. Electronic calculators are allowed, but arithmetic will count very little toward your grade, whereas the demonstration of understanding the basic concepts will be weighed heavily. The pledge to be written out and signed on tests is as follows: "I pledge that I have neither given nor received aid on this test."

You may consult other students in your section if you have difficulties with the homework problems - in fact, discussion is encouraged. However, direct copying of the homework problems from solutions of any kind will be deemed an honor violation.

Grade Weighting

Homework:10%; 3 Tests: 65%; Project: 25%;

Letter Grade Standards: A (90-100), B (80-89.9), C (70-79.9), D (60-69.9), F (0-59.9)

The interpretation here is that a numerical grade of 90 or better is guaranteed to be an A, 80 or better a B, etc. It may be, for example, that an 89+ is judged to be an A in a particular class, but the pattern cannot emerge until after the examination. So there can be no discussion of letter grades until the end of all the work of the semester; until then, use the above scale as your guideline.

Classroom Policies

Although attendance is not considered in determining the final grade, you are highly encouraged to attend every class. Doing so will make life easier and help ensure that you obtain the best return for your educational expenditures. You should be in the classroom promptly on the hour, ready to begin work. In consideration of your fellow students, please do not talk in class. But feel free to ask any question at any time. A good question can really enliven a class!!

All parties MUST arrive for class on time. Seats near the door will be reserved for students who have a previous class more than ten minutes away. The goal here is to have NO distractions during class.

General Comments

- Although many of you do not realize this now, being a student is probably the best job you will ever have. I would like to challenge you to take pride in your status. Realize that there is much satisfaction in working hard to be superior student. Recognize, too, that being a good student is actually easier than being a poor student - certainly it is much more pleasant! With these thoughts in mind, let me wish you the best in all your courses.