Applied Aerodynamics

Independent Study Course Plan

John Yang

Dr. Mesut B. Çakir
South Brunswick High School
January 2020

Contents

This course plan is subject to change any time at the discretion of the instructor or student.

0 Course Overview

The independent study course in Applied Aeronautics serves as a practical and hands-on introduction to the fields of aerodynamics, aircraft design, and aircraft operations.

0.1 Overall Learning Objectives

By the end of the course, the student aims to:

- Gain an intuitive understanding of fluids, aerodynamics, aircraft design, and aircraft performance
- Be able to accurately and effectively analyze, simulate, and/or debrief a given situation
- Apply their knowledge in the subject using working physical models

0.2 Learning Methods

This is not a traditional course of study, thus traditional learning methods should not be expected. The student should be a self-motivated and self-driven learner who can work independently with or without direct supervision. For each topic, the student is expected to find appropriate resources to guide their learning. The student should then take notes on the topic until they have reached a self-determined level of understanding. The student will then apply their knowledge in one or multiple projects.

0.3 Methods of Assessment

Again, because this is not a traditional course, traditional assessments and tests will not be used.

- The student will self-reflect on their own progress and learning. Ask the following questions:
  - What are you trying to learn or gain from this topic?
  - Have you achieved that?
  - Could you explain this topic coherently to someone with no prior knowledge of the subject? Would they understand?

  The student may choose whether they would like to internalize, verbalize, or record their responses in writing.
- If the student passes their own test, they may move onto the next step. If not, they should return to the material, look over their notes again, and consider what they are missing or what they do not yet understand. They should then fill in any gaps in their knowledge and administer the self-assessment again.

- The student will engage in periodic discussions with the instructor regarding their progress. The student is expected to verbally summarize what they have learned and/or accomplished. The instructor may pose further questions to the student for consideration.
- Once the student deems that they have sufficiently mastered the theoretical knowledge for a certain topic, they may then move onto the planned project(s) for that topic as an exercise in applying their knowledge.
- The outcome of the project should reflect that the student has learned the material sufficiently well that they are able to apply their knowledge beyond memorization or a recitation of facts.

0.4 Resources and materials

Materials: Because this course involves hands-on projects, certain physical materials will be needed to complete them. The student is expected to provide any necessary materials at their own expense.
Resources: The student may use any reliable internet or library resources. Suggested resources are provided for each section of the course.

0.5 Course Prerequisites

- Successful completion of AP Physics C or equivalent knowledge
- Coenrollment in Multivariable Calculus and Linear Algebra or higher, or equivalent knowledge
- Basic knowledge of CAD and command line interfaces (CLI)

1 Fluids and Aerodynamics

This portion of the course somewhat follows the material of MIT 16.100 (OCW). The student will gain an understanding of the mathematical and physical basis of aerodynamics.

1.1 Review of basic fluid dynamics

1.2 Lift and drag equations

1.3 2-D Potential Flow

1.4 2-D Panel Methods

1.5 Thin Airfoil theory and Vortex Lattice Methods

1.6 Lifting line and high aspect ratio wings

1.7 Compressibility and Quasi-1D Flow

1.8 Oblique Shock Waves and Expansion Fans

1.9 Navier-Stokes equations

1.10 Boundary layers - Laminar, Separation, Transition, Turbulence

1.11 Airfoils

1.12 Computational Fluid Dynamics

1.13 Helpful Resources

- MIT OpenCourseWare
- OpenStax Textbooks
- NASA Glenn Research Center:
  - Aerodynamics Resources
  - CFD Programs
- OpenFOAM User Guide and Full Documentation

2 Flight Dynamics

The student will gain knowledge in how aerodynamics affects the flight characteristics of an aircraft, applicable to the person operating the aircraft.

2.1 Helpful Resources