Problem 1 Vocabulary

Explain the following terms; making sure to use sufficient detail, including any math or helpful figures. In some cases, these terms are simple one sentence definitions, in others, you should include several paragraphs to explain them fully.

Wing Geometry Terms

- Wing Area
- Chord
  - Mean Geometric Chord
  - Mean Aerodynamic Chord
- Taper Ratio
- Span
- Aspect Ratio
- Sweep
- Dihedral
- Twist
- Washout

Forces and Moments

- Lift
- Drag
  - Induced Drag
  - Parasitic Drag
    - Skin Friction Drag
    - Pressure Drag
  - Compressibility Drag
- Pitching Moment
- Lift and Drag Polars
  - Angle of Attack
  - Zero Lift angle of attack
  - Lift Curve Slope
  - Stall

Non-dimensional Numbers

- Reynolds Number
- Mach Number
- Coefficients
  - Lift Coefficient
  - Drag Coefficient
  - Moment Coefficient

Airframe Analysis

- Vortex Lattice Method
- Strip Theory
- Critical Section Theory

Airframe Performance

- Lift Distribution
- Stall Speed

Stability

- Static Stability
  - Aerodyanmic Center
  - Center of Gravity
  - Static Margin
  - Stability Derivatives
  - Roll
  - Pitch
  - Yaw
  - Side Slip Angle
- Dynamic Stability
  - Stability Modes
  - Eigen Values
- Tails
  - Tail Volume Ratios

Optimization

- Design Variables
- Objective
- Constraints

Problem 2 Studies

Complete the following studies.

2.a Prerequisites

i. Install VortexLattice.jl and complete the Getting Started Guide as well as the Steady State Wing and Tail Example.

ii. Obtain, and become familiar with, the various tools auxiliary to VortexLattice.jl including:

- The airfoil analysis code
- The strip theory and far-field drag codes
- The critical section theory code
- The eigen value code
- The wing efficiency code

2.b Forces, Moments, and Polars

i. Create the following plots using the example wing from the previous problem:

- Lift vs Angle of Attack
- Induced Drag (near and far field) vs Angle of Attack
- Moment vs Angle of Attack
- Lift vs Drag
- Lift/Drag vs Angle of Attack

ii. Explain why an external drag model is required to capture stall.

iii. Identify the lift curve slope in your lift vs angle of attack plot, and compare it to the lift curve slope from thin airfoil theory (2π).

2.c Lift Distributions and Wing Efficiency

i. Create a plot comparing the lift distributions of a constant chord, tapered chord, and elliptic wing with no twist and with the same wing area. Also plot the ideal elliptic distribution for comparison.

ii. Discuss the differences you see in your plot. Which planform design is the most efficient? Why?

2.d Stability

i. Explore how the Vertical and Horizontal Tail Volume Ratios affect the static and dynamic stability of an airframe.

ii. Explore how wing sweep and dihedral affect the static and dynamic stability of an airframe.

iii. In preparation for you next assignments, use what you found in the previous to steps to create an airframe (wing + tail) design that is stable.