# Flight Mechanics: Homework 1

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Due date: November 22, 2023

### Policy

You should write your own answer/code by yourself. Cheating is highly discouraged; it could mean a zero or negative grade from the homework. If a question is not clear, please let us know via email.

### Submission Instructions

Please submit your homework through the Ninova website. Please zip and upload all your files using filename $studentID.rar$. You must provide all functions you wrote with your zipped file. Functions you do not submit will cause you to lose a portion of your grade. Please make sure that you comment on your code. Make also sure that the plots you produce are readable and they have labels and legends.
You **MUST** include the *report.pdf* file with your homework. Include there:

1. answers to the questions,
2. outputs for each question,
3. how to call your functions for each question.

## Problems

In this homework, you are expected to implement a basic atmosphere model and functions for aerodynamic forces. You can find the required aircraft performance parameters in *aircraft.OPF* file. The equations and the structure of .OPF file are available in BADA 3.11 user manual.

## Atmosphere Model and Operating Speeds

Using BADA3.11 user manual, solve the problems given below.

(a) Compute your outputs for non-ISA conditions ($\Delta T = -15^oC$). Use expressions to calculate temperature $T$, pressure $p$, air density $\rho$ and speed of sound $a$ as a function of altitude H. Write a Matlab function ($f(H)$) that gives the temperature, pressure, air density and speed of sound. Plot the $H-T$, $H-p$, $H-\rho$ and $H-a$ graphs for altitudes below the troposphere.

(b) Write Matlab functions for CAS/TAS, TAS/CAS and Mach/TAS conversions. Use the conversion formulas defined at the manual. Plot the $V_{CAS}-V_{TAS}$ and $M-V_{TAS}$ graphs at 16000 ft.

## Drag Polar Model

Using BADA3.11 user manual and aircraft.OPF file, solve the problems given below. Write necessary Matlab functions.

(a) Calculate the lift coefficient for level flight at $H = 16000ft$ with $V_{CAS} = 90kt$.

(b) Plot the $C_L - C_D$ graph for level flight.

(c) Derive the expression between drag $D$ and speed $V$. Plot the $V-D$ graph for the given aircraft at $12,000ft$ and $17,000ft$ for level flight (assume $L = W$). Compare the minimum drag speeds at these flight conditions.

(d) Note that a specific drag polar model is not presented in *aircraft.OPF* file for take-off phase. Derive a drag polar model for the take-off phase by considering the impacts of the high-lift devices and using the approach described in the lecture and your textbook. Assume that the aircraft has plain flaps and no slats, $\delta_f = 20$ deg. As long as you explain clearly, you can make further assumptions for other quantities if it is required. Compare the obtained drag polar model for take-off with the model in (b), and discuss whether the obtained model is logical or not with proper explanations.