Assignment 2: Basic Performance Calculations

Date Due: February 7, 2022 Instructor: Trani

Problem 1

Use the Eurocontrol interactive BADA database (https://contentzone.eurocontrol.int/aircraftperformance/default.aspx?) to answer the following questions.

a) Examine the performance characteristics of the Boeing 777-300ER (see Figure 1). Find the **typical cruise Mach number** for the aircraft according to the BADA database. The aircraft code name for the Boeing 777-300ER in the BADA database is B77W. The Mach number is the speed of the aircraft divided by the speed of sound at the cruise altitude.

From BADA the cruise Mach number is 0.84

b) Use the graphical flight profile (called details) of the BADA database for the B77W to estimate the **True Airspeed (TAS)** of the aircraft during the climb procedure at 5000 feet. The BADA database provides Indicated Airspeed (IAS) information for various phases of flight. Assume International Standard Atmospheric conditions (ISA). Figure 2 shows a graphic profile for the Airbus A320 (A320).

200 knots indicated airspeed at 5000 ft is 211 knots (true airspeed)

c) Use the graphical flight profile of the BADA database for the B77L to estimate the **True Airspeed** and the **Mach Number** of the aircraft during the climb procedure at 24000 feet (or FL 240 - called flight level). Assume International Standard Atmospheric conditions (ISA).

280 knots indicated airspeed at 24000 ft is 367 knots (true airspeed)

d) Find the European Union (EU) RECAT wake vortex category for the Boeing 777-300ER. If the Air France B77W lands ahead of a Boeing 737-800 (B738) at Atlanta (ATL), estimate the minimum wake vortex separation required in the United States between the two aircraft. Use the latest **Consolidated Wake Turbulence standards (on approach)** in FAA Order JO_7110.126A.

Boeing 777-300ER is class B (Upper Heavy). Boeing 737-800 is F (Upper Large). 5 nm is required on approach (and also directly behind)

e) Find the median landing (threshold crossing speed) for Boeing 737-800 (B738) in the Landing Events Database for landings on runway 26R at ATL. Use the threshold speed to estimate the **time separation** (i.e., equivalent to the headway) between the Boeing 777-300ER (as the Boeing 777-300ER crosses the runway threshold) and the Boeing 737-800 behind.

Figure 1. Boeing 777-300ER Landing on Runway 26R at Atlanta Airport (A. Trani).

Note: For this problem, you can use the Matlab scripts provided in class. However, for one of the problems, I would like you to show me a sample calculation using the equation to convert IAS to true Mach and then True Airspeed (TAS).

Problem 2

Use the Matlab computer programs such as **ISAM.m** (available in the Matlab files section of our web site - http://128.173.204.63/courses/cee5614/matlab_files_cee5614.html) to answer the following questions:

a) An Embraer 190 (see Figure 3) flies at Mach 0.78 and at 36,000 feet. Assuming ISA atmospheric conditions, find the true airspeed (in knots) of the aircraft and the typical outside atmospheric temperature at Flight Level 360.

Mach 0.78, speed of sound is 295.1 m/s. TAS is 447 knots

b) If the atmospheric temperature at FL 360 is 25 degrees Celsius above ISA, estimate the value of air density at FL 360 (you are allowed to use the **densityAltitudeOffISA Matlab** script supplied. Compare the density values with part (a) of the problem.

Density with ISA = 0.3652 kg/cu.meter, Density without ISA = 0.3275 kg/cu. meter

c) The same Embraer 190 performs a descent profile from FL360 and contacts the Terminal Radar Approach Control (TRACON) facility at Chicago O'Hare. The pilot reports the aircraft passing 10,000 feet and 250 knots (Indicated Airspeed). Estimate the value of true airspeed (TAS) assuming ISA conditions at 10,000 and at 5,000 feet (assume same IAS at 5,000 feet).

250 knots indicated = 279 knots true airspeed at 10,000 feet.

d) If the the Flight Management Computer (FMS) of aircraft in part (a) of this problem reports a 55 knot headwind while cruising at FL360. Find the ground speed of the aircraft in cruise at 36,000 feet.

Ground speed (GS) = 392 knots

Problem 3

The minimum flight speed in steady-flight (called stalling speed V_{stall}) can be estimated using the fundamental lift equation (assuming Lift is equal to aircraft weight - mg):

$$V_{stall} = \sqrt{\frac{2mg}{\rho S C_{l\max}}}$$

where: m is the aircraft mass (in kilograms), g is the gravity constant (9.81 m/s-s), S is the aircraft wing area (square meters), ρ is the air density (kg/cubic meter) and $C_{l\max}$ (dimensionless) is the maximum lift coefficient (a parameter determined during flight testing).

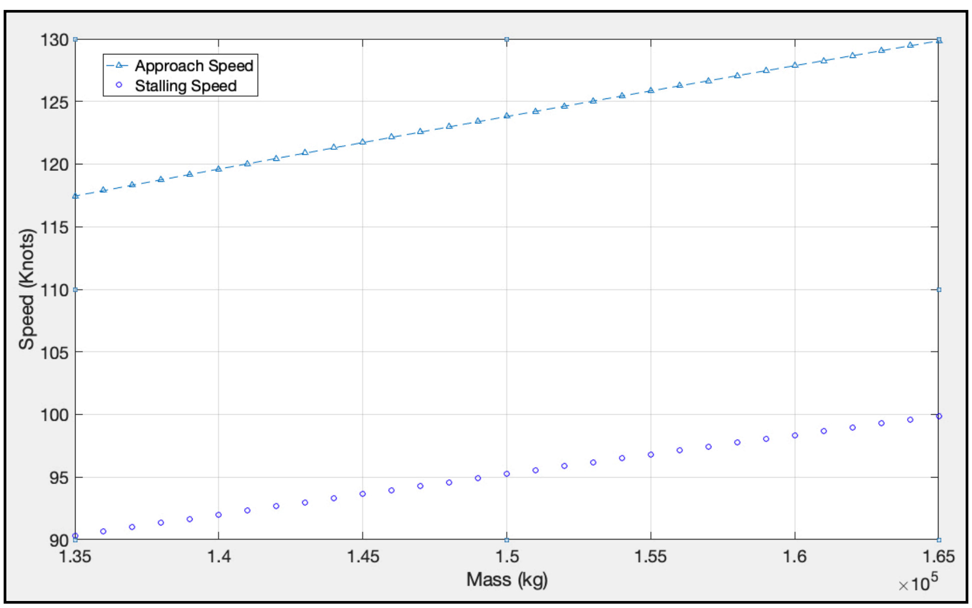
According to Federal Aviation Regulations (FAR Part 25):

i) T**he approach speed (over the runway threshold) of a commercial aircraft should be 1.3 times the stalling speed (30% safety margin) in the landing flap configuration.**

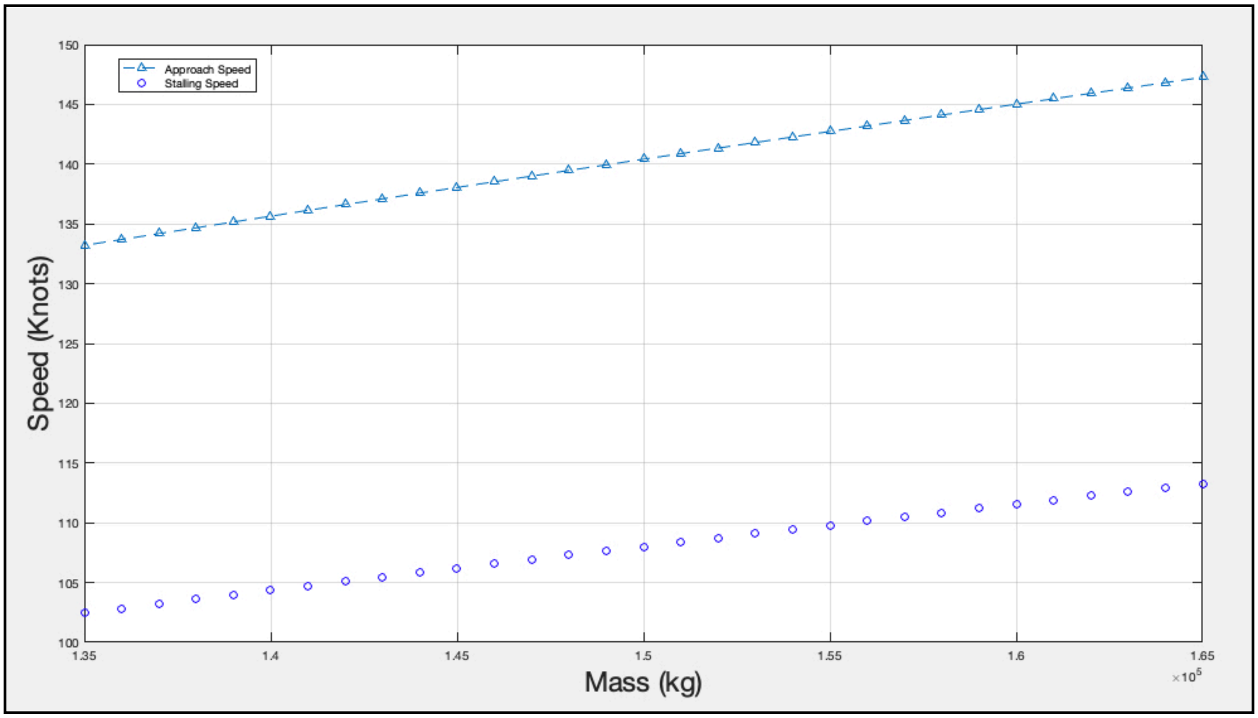
ii) **T**he initial safe climb speed (after takeoff) is **1.2 times the stalling speed in the takeoff flap configuration.**

a) Estimate both, t**he stalling and the approach speeds** for a large twin-engine jet aircraft (similar to the Boeing 787-8 - see Figure 4) with the following parameters: S= 385 square meters, $C_{l\max}$ = 2.60 (with flaps down 30 degrees in the **landing configuration - see Figure 5**), landing mass of 165,000 kg (the maximum allowable landing mass) and landing at sea level ISA atmospheric conditions. **Note that all speeds calculated using this method are true airspeeds (TAS).**

b) Repeat the analysis for a landing mass values of 135,000, 140,000, and 150,000 kilograms. Plot the trend of landing speeds as a function of landing mass. Comment on the different approach speeds estimated.



c) Find the **approach speed** for the twin-engine aircraft when the aircraft lands at Bogota International airport - Colombia - at 8360 feet above sea level conditions) at 165,000 kgs. Comment on the difference in the approach speeds at sea level and in Bogota.



d) The large twin-engine jet aircraft (similar to the Boeing 787-8 - see Figure 4) has a maximum lift coefficient $C_{l\,max}$ of 1.85 (with f**laps down 10 degrees** in the **takeoff configuration** - see Figure 4). Find the **initial safe climb speed** (1.2 times the stall speed in the takeoff flap configuration) at the maximum takeoff mass of 230,000 kilograms.

168 knots at sea level ISA

e) Repeat for values of takeoff mass of 200,000 and 215,000 kilograms. Comment on the changes to takeoff speed with changing mass.

At 200,000 kgs - 157 knots