Assignment 2: Basic Performance Calculations

Date Due: January 30, 2018 Instructor: Trani

Problem 1

Use the Matlab computer program 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 Airbus A380 of Singapore Airlines (Flight SIA 25) flew on January 22, 2018 from JFK to Frankfurt at Mach 0.845 and at 39,000 feet over the North Atlantic. Assuming ISA conditions, find the true airspeed (in knots) of the aircraft and the typical outside temperature at the cruise altitude (Flight Level 390).

b) An Air Canada Express Bombardier CRJ-200 pilot reads 245 knots indicated airspeed while descending through 12,000 feet near Montreal Airport. Estimate the value of true airspeed under ISA conditions.

Figure 1. Air Canada Express Bombardier CRJ-200 (A. Trani).

c) If the the Flight Management Computer (FMS) for SIA flight 25 reports a 65 knot tailwind when the aircraft in part (b) cruises at FL390. Find the ground speed of the aircraft.

Problem 2

A United Express Embraer 175 departs Raleigh-Durham airport. The pilot in command follows the following indicated speed profile:

Figure 2. United Express Embraer 175 (A. Trani).

Table 1. Indicated Speed Profile for Embraer 175 departing RDU Airport.

Altitude (meters)	Indicated Airspeed (knots)
133	160
1,500	185
2,200	195
3,100	240
5,200	260
6,800	265
7,400	270
8,600	280
9,146	280

a) Estimate the true airspeeds (TAS) for each one of the points in the climb profile. Assume ISA atmospheric conditions and zero wind in your calculations. Plot the values of TAS vs altitude.

b) Find the Mach number immediately after departure from RDU runway 23R and at the top of climb point (TOC).

c) Estimate the true airspeed of the aircraft at 10,000 feet.

Problem 3

The minimum flight speed achievable in steady-flight (called stalling speed V_{stall}) can be estimated using the fundamental lift equation:

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

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 by the aerodynamic capability of the aircraft). According to Federal Aviation Regulations (FAR Part 121), the approach speed of an aircraft should be 1.3 times the stalling speed. According to the same regulations, the initial safe climb speed is 1.2 times the stalling speed after takeoff.

Estimate the stalling and approach speeds for a commonly used twin-engine, jet aircraft with the following parameters: S= 127 square meters, $C_{l\max}$ = 2.68 (with flaps down 30 degrees in the landing configuration) ,landing mass of 66,800 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.

a) Repeat the analysis of part (a) for landing mass of 50,000, 55,000 and 60,000 kilograms. Plot the trend of landing speeds.

b) Repeat the analysis for altitudes ranging from sea level to 3,000 meters (every 500 meters). Comment of the observed trends and also comment on how landing distance is affected by airport elevation.

c) If the same aircraft has a $C_{l\max}$ = 1.75 (with flaps down 10 degrees in the takeoff configuration), find the initial safe climb speed at the maximum takeoff mass of 78,000 kilograms. Repeat for values of takeoff mass ranging from 65000 to 78,000 kilograms.

Figure 3. Boeing 737-800 at the Liftoff Point (A. Trani).

Problem 4

A new low-cost airline is evaluating two aircraft to operate flights from LaGuardia Airport in New York. The following table shows the aircraft proposed by airline executives to operate from LGA. The critical stage lengths the airline would like to fly with the selected aircraft are: a) LGA-SDQ and b) LGA-OAK.

Table 2. Aircraft Considered in the Airline Evaluation.

Aircraft Considered
Boeing 737-8 Max with CFM LEAP-1B28 engines. Aircraft maximum design takeoff weight is 181,000 lb. 162 seats in a two-class layout.
Boeing 737-800 (with winglets) powered by two *CFM56-7B24/-7B26/-7B27 engines at 26,000 LB SLST)*). Aircraft maximum design takeofff weight is 174,200 lb. The aircraft has 160 seats in a two-class layout.

The design airport temperature used should be the average of the high temperatures of the hottest month of the year. More detailed information about the airport can be found at the AIRNAV database available on the web at: http://www.airnav.com/airports/ or visit the airport site.

In your analysis use the latest version of the Boeing documents for airport design (http://128.173.204.63/courses/cee5614/sites_ce_5614.html#Aircraft_Data).

a) Find the average stage length to be flown between each one of the critical OD airport pairs. In your analysis use the Great Circle Flight Path mapper link provided in our interesting web sites. Add 6% to the distances calculated to account for real Air Traffic route conditions and to account for possible weather deviations from the optimal Great Circle flight path.

b) Find the runway length needed for each one of the aircraft operating the critical route. Determine if LGA has enough runway length to support these flights.

c) Estimate the average fuel per passenger assuming a load factor of 0.83 (83% of the seats used) for both routes. Can the airline achieve good fuel savings using the new Boeing 737-8 Max.

d) Considering various factors which aircraft is the best for this airline? Explain.