Assignment 4: Air Transportation Systems Analysis

Due: February 25, 2022 Instructor: Trani

Problem 1

Use the large twin-engine transport aircraft to answer this question (http://128.173.204.63/courses/cee5614/cee5614_pub/boeing777_class_2006.m).

a) Estimate the aircraft rate of climb after departing New York Kennedy International airport while the aircraft **flies at 500 meters above sea level and 210 knots indicated**. Assume atmospheric conditions are ISA. Assume the wing **flaps are fully retracted** and use the regular table lookup function to estimate *Cdo* provided in the aircraft file. The aircraft departs New York with a mass of 340,000 kilograms.

Using the equations to estimate the point performance of the aircraft the following results are obtained:

True airspeed (knots) : 213.9

Altitude (m) : 500

Thrust (N) : 814,793

Drag (N) : 198,330

Aircraft Mass (kg) : 340,000

Rate of climb (m/s) : 20.3

Rate of climb (ft/min) : 4001.9

b) Estimate the rate of climb after departing New York Kennedy International airport while the aircraft flies at **500 meters above sea level conditions and 210 knots indicated airspeed and with one engine failed** (assume one engine fails just as the aircraft climbs through **500 meters above** sea level conditions). Assume the **wing flaps are fully retracted** and use the regular table lookup function to estimate Cdo provided in the aircraft file. The aircraft departs New York with a mass of 340,000 kilograms.

True airspeed (knots) : 213.9

Altitude (m) : 500

Thrust (N) : 407,396

Drag (N) : 198,330

Aircraft Mass (kg) : 340,000

Rate of climb (m/s) : 6.9

Rate of climb (ft/min) : 1357

c) Compare the rates of climb obtained in parts (a-b). Comment on the implications if the aircraft

The rate of climb with an engine failed is around 1/3 of the rate of climb with two engines.

Problem 2

Use the large twin-engine transport aircraft to answer this question (http://128.173.204.63/courses/cee5614/cee5614_pub/boeing777_class_2006.m). This problem is a continuation of Problem 1. The aircraft departs New York with a mass of 340,000 kilograms.

a) Run the **unrestricted climb Matlab code** demonstrated in class for the aircraft in question. Simulate the climb profile for 3600 seconds (one hour) and estimate the **time to climb** and distance traveled to reach FL 340 (34,000 feet). The aircraft departs JFK at ISA conditions.

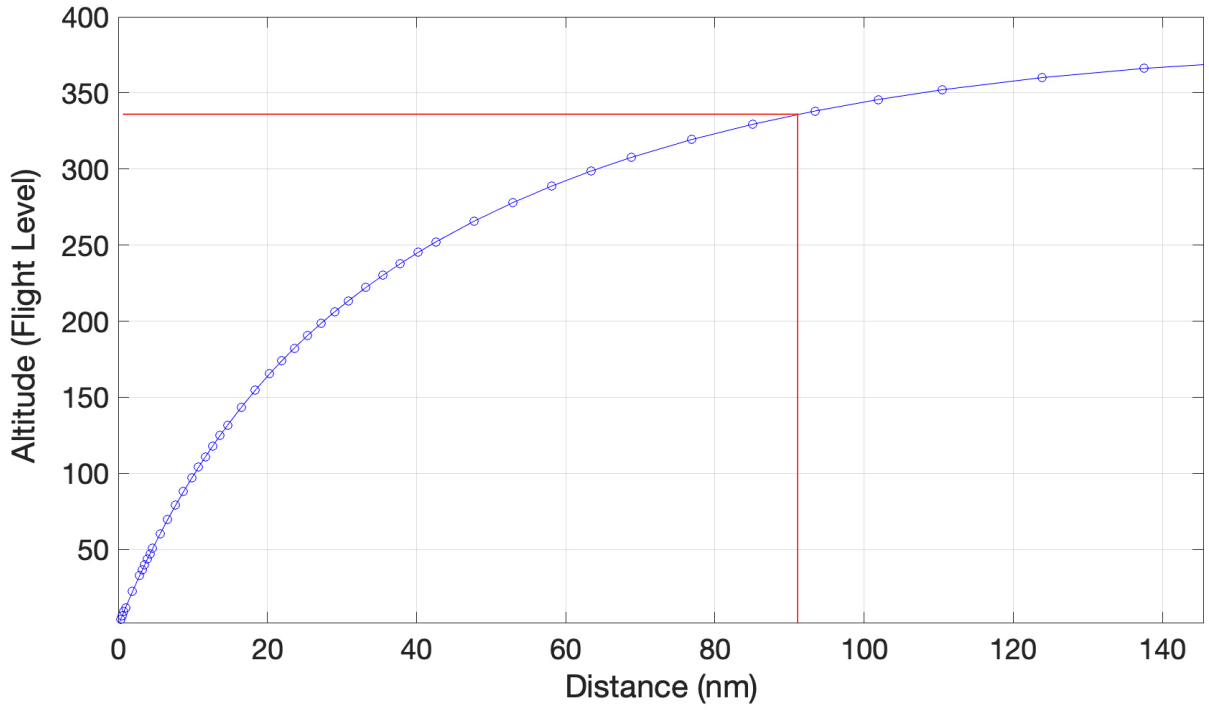

Figure 1. Climb Profile. Distance to Climb to FL 340 is 95.5 Nautical Miles (177 Kilometers).

b) Using the results obtained in part (a), estimate the fuel burned during the climb to reach FL 340.

By interpolation, fuel burned to FL 340 is estimated to be 61,000 N (6,250 kilograms).

c) On the return flight from Dubai, the **temperature conditions are ISA + 30 deg. C**. Dubai is at sea level conditions. Run the computer simulation (similar to part a) using the same initial takeoff mass of 340,000 kilograms and estimate the time to climb, distance traveled, and fuel used to reach FL340. Compare the results obtained in parts (a-c) and comment on the effect of temperature on rate of climb and time to climb.

Rate of climb at sea level ISA = 1280 meters/minute

Rate of climb at sea level ISA + 30 deg. C = 1153 meters/minute

The aircraft requires 153 nautical miles to climb to FL 340 under ISA+30 deg.

d) Another day, the flight departs Toluca (México) at 340,000 kilograms and ISA + 30 deg. C conditions. Toluca airport is located 2,580 meters above sea level conditions. Find the **initial**

cruise altitude if the pilot wants to have a 150 m/minute climb rate capability at the initial cruise altitude. Normally, pilots want to have a small climb rate margin for maneuvering at altitude.

The aircraft has a rate of climb of 150 m/minute at 31,900 feet. Therefore, the pilot could climb to FL 320 after departing Toluca airport.

Problem 3

The large twin-engine transport aircraft to answer this question (http://128.173.204.63/courses/cee5614/cee5614_pub/boeing777_class_2006.m).

a) Estimate the value of Specific Air Range (SAR) for the large twin-engine aircraft reaching the Top of Climb (TOC) point at 10,000 meters and with a mass of 305,000 kilograms. The aircraft cruises at Mach 0.83.

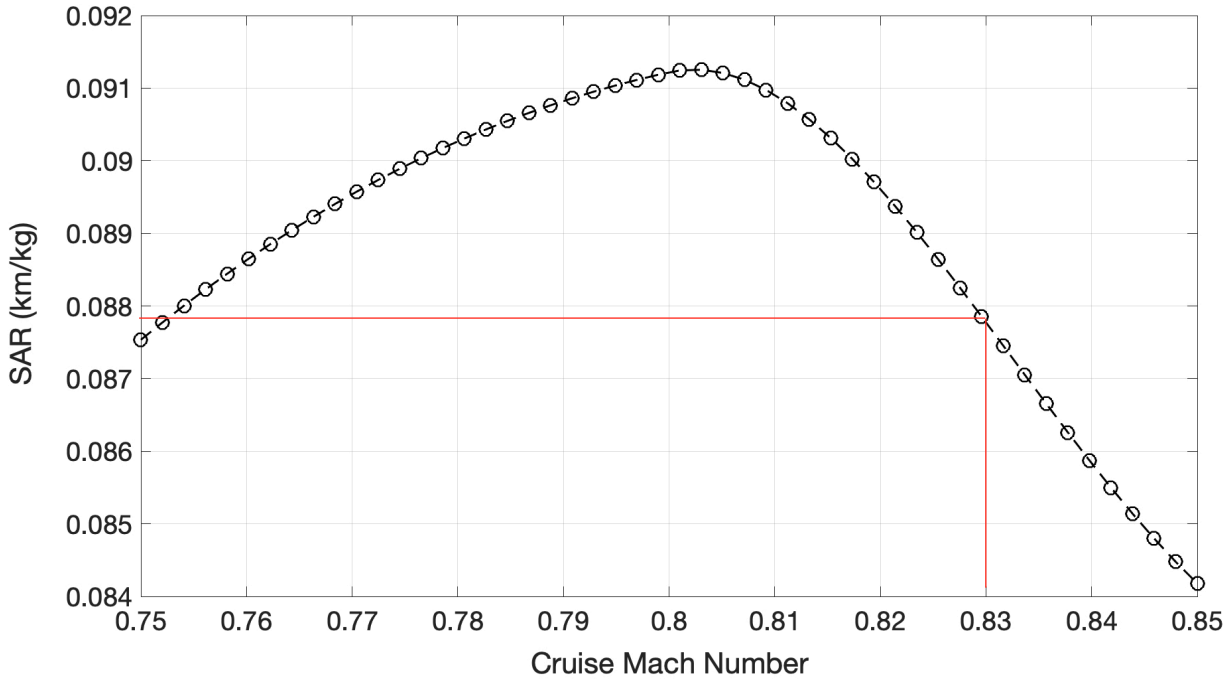

Figure 2. Specific Air Range for the Aircraft as a Function of Mach Number. At Mach 0.83 SAR is 0.0878 km/kilogram.

b) Use the Range equation, to estimate the maximum range for the aircraft if the aircraft reaches the TOC point (10,000 meters) at 305,000 kilograms. The aircraft cruises at Mach 0.83. The pilot estimates the aircraft carries 110,000 kilograms of fuel remaining at the TOC point. In the range calculation, assume the range is calculated using the aircraft mass at the mid-point between TOC and TOD.

Range at Mach 0.83 is 11,648 kilometers (see Figure 3).

c) Solve the problem in part (b) using a piecewise numerical analysis method (as explained class). Use the range value obtained in part (b) and refine the answer obtained by dividing the range into six segments in the numerical solution. Comment on the obtained in parts (b) and (c).

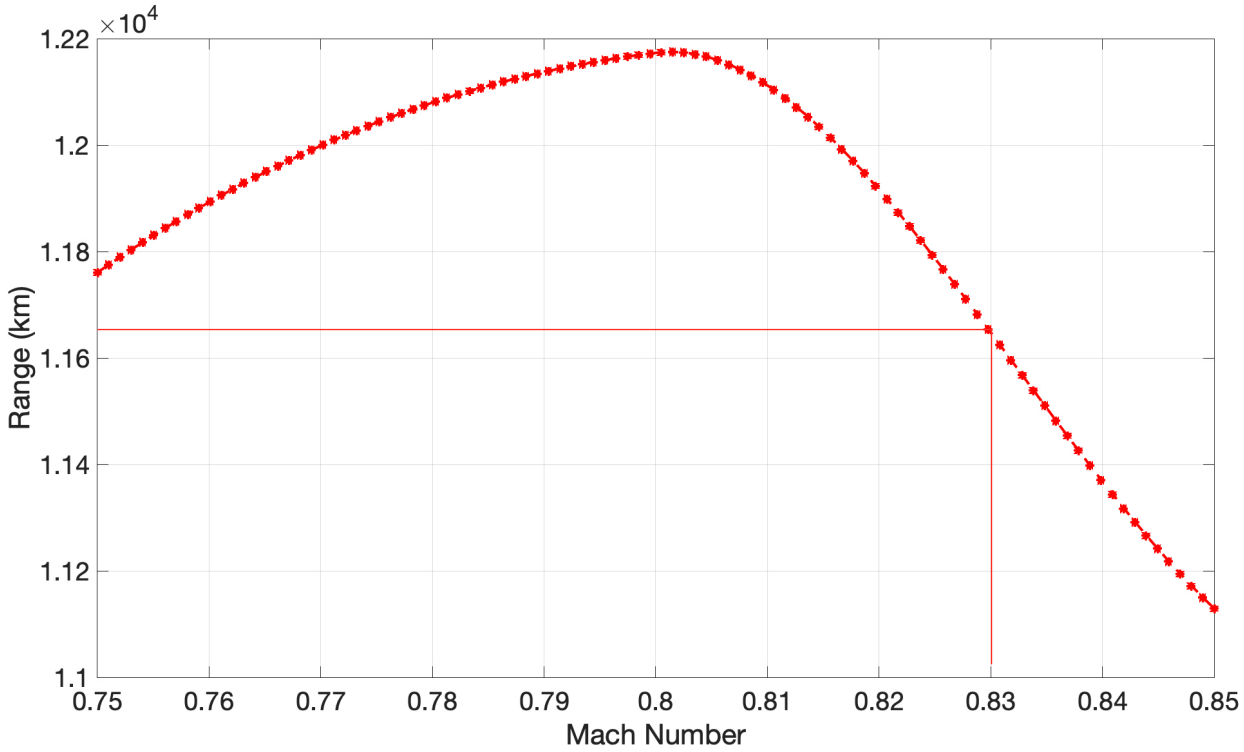

Figure 3. Range for the Aircraft as a Function of Mach Number. At Mach 0.83 the Range is 11,648 kilometers (6,290 nautical miles).