Assignment 3: Air Transportation

Solution Instructor: Trani

Problem 1

An American Airlines Boeing 737-800 departs Mexico City airport and the pilot follows the following indicated speed profile:

Table 1. Indicated Speed Profile for Boeing 737-800 Climbing out of México City Airport. México City is located at 2,230 meters Above MSL Conditions.

Altitude (meters)	Indicated Airspeed (knots)	Rate of Climb (meters/min)	Delta Altitude (m)	Average ROC (m/s)	Time to Climb Segment (s)
2,230	190	701.2	770.0	10.9	70.5
3,000	240	609.8	500.0	9.4	53.2
3500	250	518.3	1000.0	8.4	119.3
4500	275	487.8	1000.0	8.0	125.0
5500	290	472.6	1500.0	7.6	196.8
7000	305	442.1	1000.0	7.0	143.1
8000	310	396.3	1000.0	6.4	157.4
9000	310	365.9	1000.0	4.8	207.2
10,000	305	213.4	1000.0	2.5	395.5
11,000	300	90.0	Difference in Altitudes between segments	Average Rate of Climb at start and ending points	1467.9

Assume ISA atmospheric conditions and zero wind in your calculations.

a) Using the values of rate of climb recorded, estimate the time to climb to the initial cruise altitude of 11,000 meters (~36,000 feet).

The table contains the computations using average climb rates (ROC). The time to climb is estimated to be 1468 seconds (24.4 minutes)

b) Using the values of true airspeed and rate of climb, estimate the distance traveled to reach the Top of Climb (TOC) point at 11,000 meters. Since the distance requires an estimate of the average speed per segment traveled, use the average true airspeed in each climb segment of the trajectory.

Altitude (meters)	Indicated Airspeed (knots)	Time in Segment (s)	True Airspeed (m/s)	Average TAS in Segment (m/s)	Distance in segment
2,230	190	70.5	106.1	121.9	8591.7

Altitude (meters)	Indicated Airspeed (knots)	Time in Segment (s)	True Airspeed (m/s)	Average TAS in Segment (m/s)	Distance in segment
3,000	240	53.2	137.7	142.3	7568.8
3500	250	119.3	146.9	156.75	18696.0
4500	275	125.0	166.6	174.35	21785.4
5500	290	196.8	182.1	192.3	37844.6
7000	305	143.1	202.5	208.1	29784.8
8000	310	157.4	213.7	217.9	34306.2
9000	310	207.2	222.1	224.85	46579.5
10,000	305	395.5	227.6	225.7	89244.2
11,000	300		223.7		294401.3

The distance traveled is 294 km to reach 11,000 meters. This is equivalent to 159 nautical miles.

Problem 2

An airline is evaluating two aircraft to operate flights from Flagstaff airport (FLG). The following table shows two two aircraft proposed by airline executives to operate from the airport. The critical stage lengths the airline would like to fly with the selected aircraft are: a) FLG-LAX and b) FLG-IAH.

Table 1. Aircraft Considered in the Airline Evaluation.

Aircraft Considered
Boeing 737-500 with CFM56-3B-1 engines at 18,500 lb. sea level static thrust) engines. Aircraft maximum design taxi weight is 134,000 lb. with 122 seats in a one-class layout.
Boeing 737-700 (no winglets) powered by two *CFM56-7B24 engines at 20,000* lb. sea level static thrust). Aircraft maximum design taxi weight is 154,500 lb. The aircraft has 128 seats in a two-class layout.

Evaluation of runway length requirements indicates that the Boeing 737-700 is better suited for the mission to operate from Flagstaff airport. The airport has high elevation terrain and this limits the Boeing 737-500 from operating efficiently from the airport on the routes proposed.

Other factors considered are: a) the Boeing 737-700 is a newer aircraft. This aircraft has better spare parts support and maintenance than the older Boeing 737-500; b) fuel efficient is better for the newer generation aircraft.

Problem 3

a) A German airline is evaluating the operation os services between Bogota El Dorado Airport (in Colombia) (ICAO Code SKBO) and Frankfurt (Germany) using Boeing 777 aircraft. Bogota El Dorado Airport is located on a high plateau at 8,361 feet above mean sea level conditions. The airline requires a minimum of 240 seats in a three-class cabin layout. Boeing is offering both the Boeing 777-200LR and the Boeing 777-300ER to the airline. The airline would like to carry an extra 10 metric tons of freight under the fuselage to generate additional revenue in the long routes. In your analysis, use the great circle mapper application and add 6% to the route distance to account for Air Traffic and weather detours. Also consider the runway length available at Bogota El Dorado.

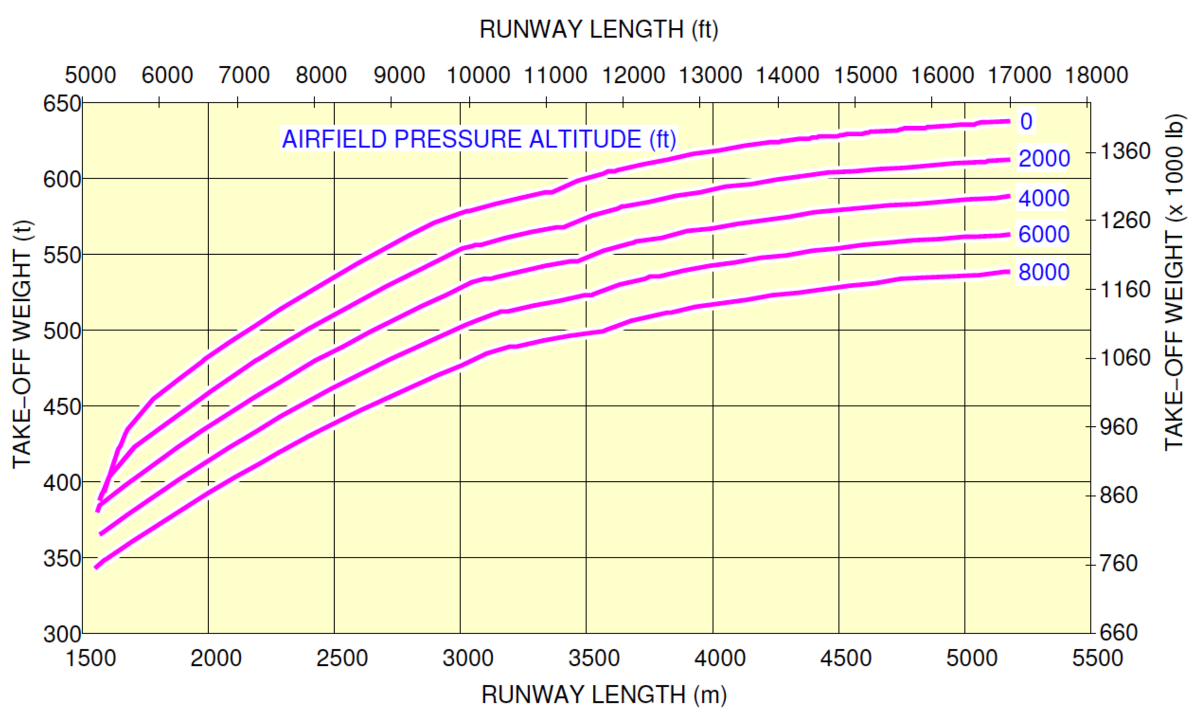
After comparing the takeoff runway length requirements of both aircraft, it is concluded that the performance advantage of the Boeing 777-200LR to operate from a high elevation airfield is significant. The Boeing 777-300ER is not able to operate with the cargo capacity stated as a requirement in the problem statement. The Boeing 777-200LR is able to operate from the 12,500 foot runway at El Dorado International Airport with leads penalties than the Boeing 777-300ER.

Problem 4

A Middle East airline would like to operate Airbus A380-800 from San Francisco International Airport to Dubai. The airline has several A380s in the fleet all powered by the Rolls-Royce Trent 900 engines. If the airline has a version of the A380 with 475 seats and the aircraft has a maximum ramp weight of 577 000 kg, find:

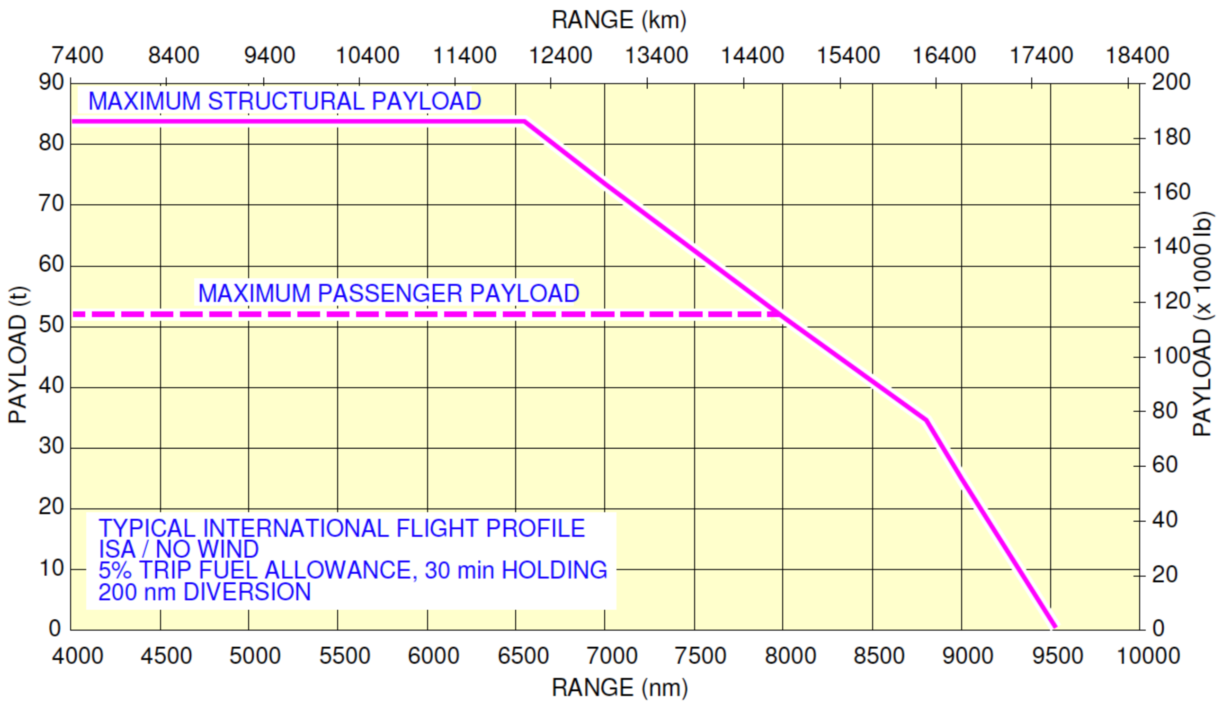
a) The maximum departure weight from SFO (limited by runway length). State the runway length at SFO used in your analysis.

SFO has a runway that is 3,600 meters in length. This allows the aircraft to operate up to 605 metric tons of DTW. However, if the airline buys the aircraft for Max. Ramp weight of 577 metric tons that would be the limit instead.



b) If the aircraft departs SFO at ISA conditions (like a nice Fall day), what is the maximum range the aircraft can fly while carrying 475 passengers and no extra cargo. State the takeoff weight used.

At MTOW (see diagram) the aircraft could fly close to 8,100 nm.



c) If the aircraft departs SFO at ISA conditions (like a nice Fall day), what is the maximum cargo capacity the aircraft can carry above the 475 passengers. State the takeoff weight used.

The aircraft flies to Dubai (7,500 nm with detour included), the aircraft could carry around 62 metric tons between passengers and cargo. This is equivalent to 14.5 metric tons of cargo.

d) For condition (c) estimate the fuel consumption per nautical mile for the trip. Also estimate the specific air range (SAR) expressed as the number of miles flown for each kilogram of fuel used.

The fuel load for the aircraft is:

FW = MTOW - Payload - OEW = 605,000 - (62,000 + 270364) = 245,000 kg

SAR = 0.0306 nm/kg