Quiz 1 (Open Book/Notes)

Solution

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Honor Code Pledge

The information provided in this exam is my own work. I have not received information from another person while doing this exam.

Show all your work. Create a PDF file and send to me by email.

Problem #1 (50 points)

The Los Angeles Airport Authority would like to request your services to study runway length improvements to runway 24R on the North side of the airport. Review Airnav and the satellite images at Google Earth to answer the following questions. The airport authority is to improve runway 24R allowing airlines to support international services and also to serve and some long-distance domestic destinations. Estimate the runway extension needed for runway 06L/24R if the critical stage length services have been identified at this airport for various airlines (see Table 1).

More detailed information about the airport can be found at the AIRNAV database available on the web at: http://www.airnav.com/airports/. In your analysis use the latest version of the Boeing and Airbus documents for airport design (http://128.173.204.63/courses/cee5614/sites_ce_5614.html#Aircraft_Data).

Table 1. Typical Services from LAX to Other Airports Needed to Support Runway 24R Operations.

Origin-Destination Airport Pair	Aircraft Flying the Route
KLAX - LIM Los Angeles - Lima (Peru)	Boeing 767-400ER with *CF6-80C2B8* engines. Aircraft maximum design takeoff weight is 450,000 lb. Aircraft has a typical three-class configuration.
KLAX - HKG Los Angeles - Hong Kong	Boeing 777-300ER powered by two *GE90/115BL* engines rated at 115,000 lb. of thrust. Aircraft maximum takeoff weight is 766,000 lb. Three-class layout.

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 (see below). Add 5% to the distances calculated to account for real Air Traffic route conditions and to account for possible weather deviations from the optimal flight path.

Table 1a. Stage Length for Flights.

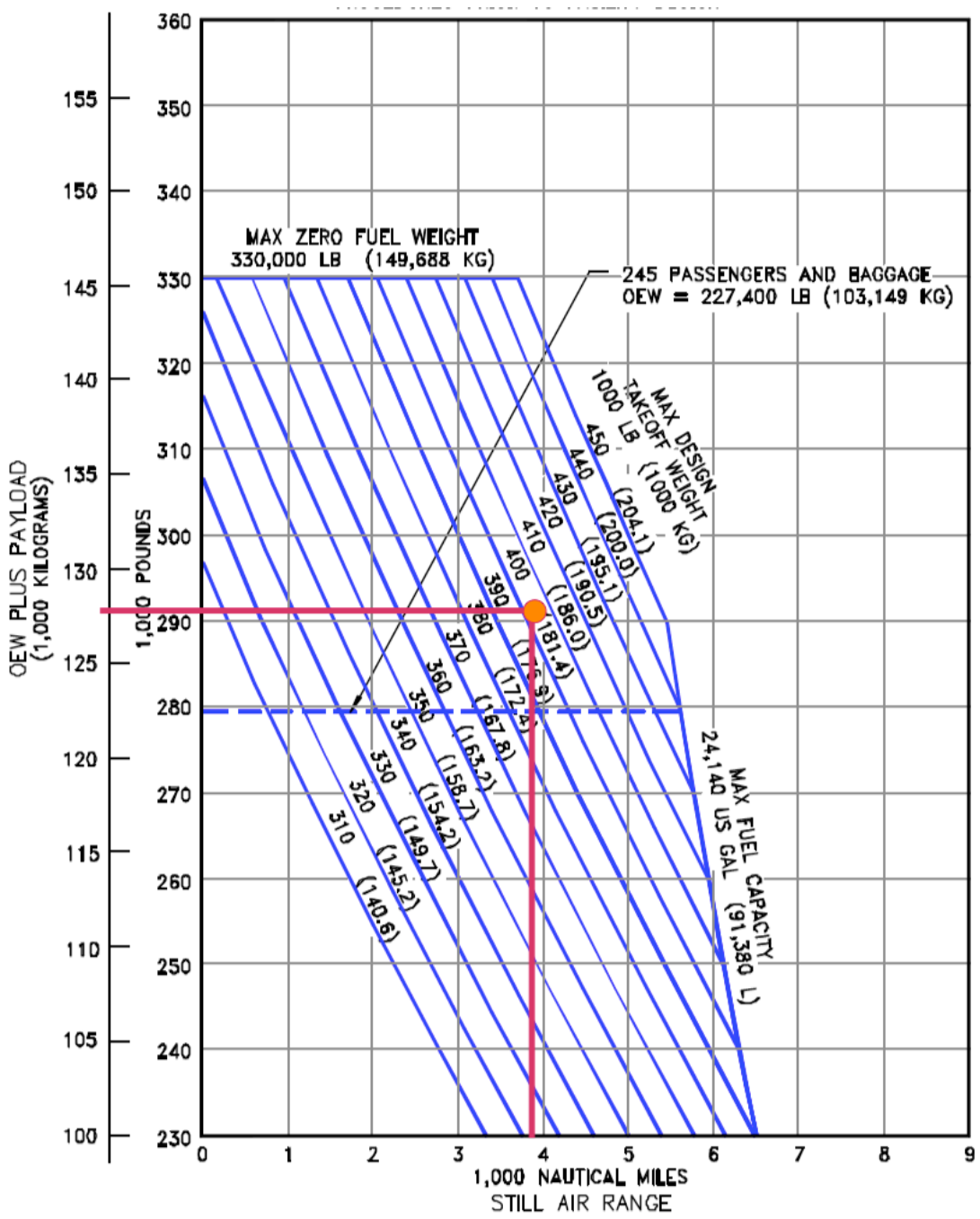
OD Pair	GCD Route (nm)	Planned Route (nm)
LAX-LIM	3,621	3,802
LAX-HKG	6,309	6,624

b) Find the runway length needed for each one of the three routes. Determine which one of the three trips constitutes the critical stage length and design the new runway length extension needed. Comment on your solution.

Table 1b. LAX-LIM Flight. Boeing 767-400ER with General Electric CF6-80C2B8 Engines. 3,802 nm Planned Route Distance.

Parameter	Value (kg)	Remarks
MTOW	204,116	Table 2.1.6 per Boeing Specification
MALW	158,757	Table 2.1.6
OEW	103,147	Table 2.1.6
Max. Payload	46,538	Table 2.1.6
Usable Fuel	73,363	Table 2.1.6
Seating	24,300	243 seats. Three-class layout configuration
	Takeoff Analysis	
Payload + OEW	127,447	
DTW (desired takeoff weight)	183,000	From Payload-Range diagram (Fig. 3.2.9)
Fuel load	55,553	OK. Less than maximum usable fuel
Mean Maximum Temp. of Hottest month	75 deg. F 24 deg. C	Use ISA + 15 deg. C charts
Takeoff Runway Length	8,500 ft 2,592 m.	Use Figure 3.3.28 Boeing 767-400ER Wet pavement ISA + 15 deg. C
	Landing Analysis	
Landing weight for computation	158,757	Value of MALW
Landing runway length	7,100 ft (flaps 30 deg.) 7,300 ft (flaps 25 deg.)	Use the lowest value (higher flap setting) Figures 3.4.10 and 3.4.9

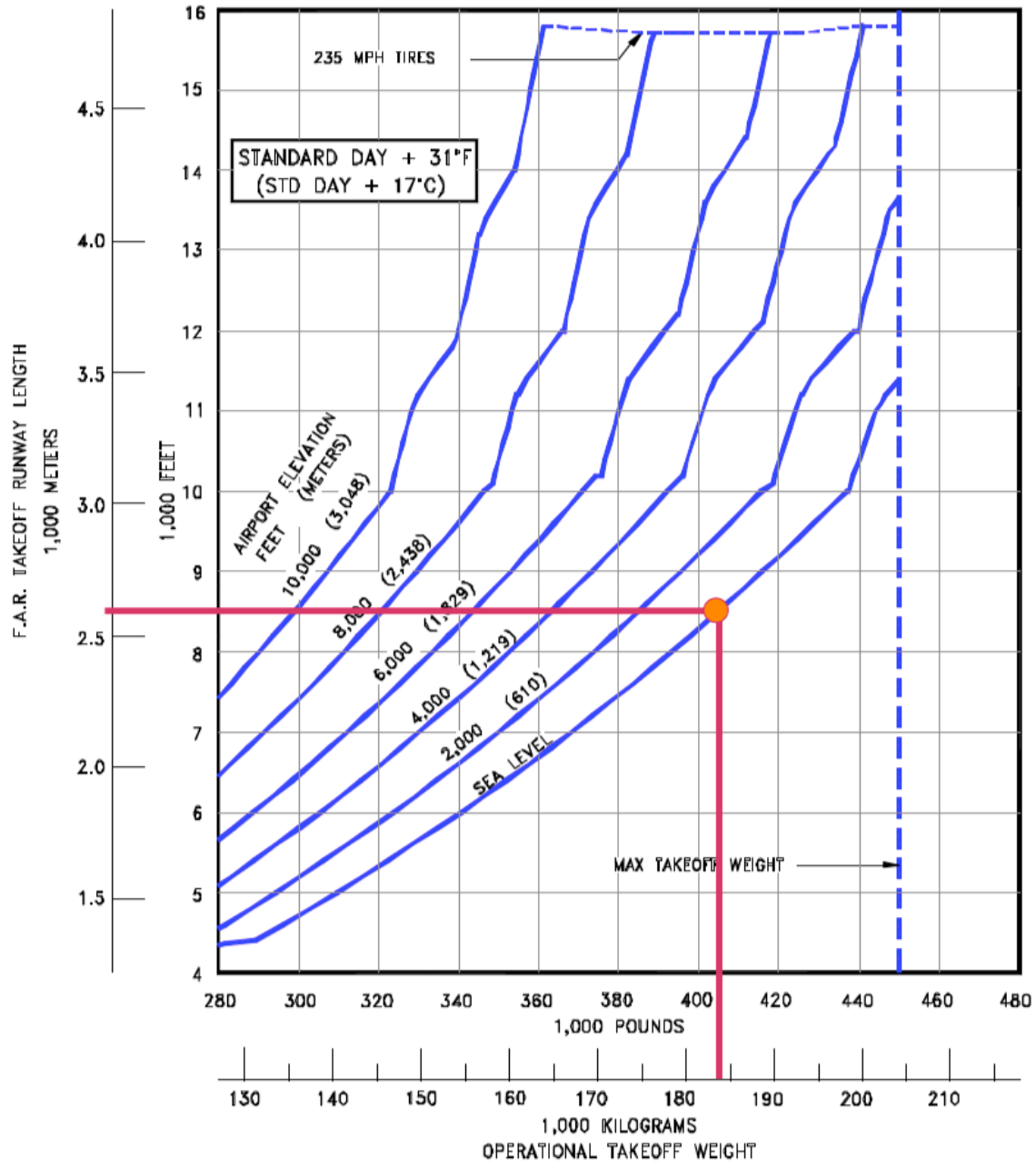
Conclusion: The runway 24R can be used for the LAX-LIM operation.



3.2.9 PAYLOAD/RANGE FOR LONG-RANGE CRUISE

MODEL 767-400ER (CF6-80C2B8 ENGINES)

Figure 1a. Payload-Range Analysis. LAX-LIM Route. Boeing 767-400ER.



3.3.28 F.A.R. TAKEOFF RUNWAY LENGTH REQUIREMENTS

STANDARD DAY + 27°F (STD + 15°C), WET SMOOTH RUNWAY SURFACE

MODEL 767-400ER (CF6-80C2B8F ENGINES)

Figure 1b. Takeoff Analysis. LAX-LIM Route. Boeing 767-400ER.

Table 1c. LAX-HKG Flight. Boeing 777-300ER with General Electric GE90/115BL Engines. 6,624 nm Planned Route Distance.

Parameter	Value (kg)	Remarks
MTOW	351,535	Table 2.1.1 per Boeing Specification (B777 Manual)
MALW	251,290	Table 2.1.1
OEW	167,829	Table 2.1.1
Max. Payload	69,853	Table 2.1.1
Usable Fuel	145,538	Table 2.1.1
Seating and passenger load	37,000	370 seats. Three-class layout configuration
	Takeoff Analysis	
Payload + OEW	204,829	
DTW (desired takeoff weight)	324,000	From Payload-Range diagram (Fig. 3.2.2)
Fuel load	119,171	OK. Less than maximum usable fuel
Mean Maximum Temp. of Hottest month	75 deg. F 24 deg. C	Use ISA + 15 deg. C charts
Takeoff Runway Length	9,000 ft 2,744 m.	Use Figure 3.3.10 Boeing 777-300ER ISA + 15 deg. C
	Landing Analysis	
Landing weight for computation	251,290	Value of MALW
Landing runway length	7,100 ft (flaps 25 deg.) 6,700 ft (flaps 30 deg.)	Use the lowest value (higher flap setting) Figures 3.4.5 and 3.4.6

Conclusion: The airport needs to lengthen runway 24R to 9,000 feet. However, the longest runway at LAX is 12,091 feet long.

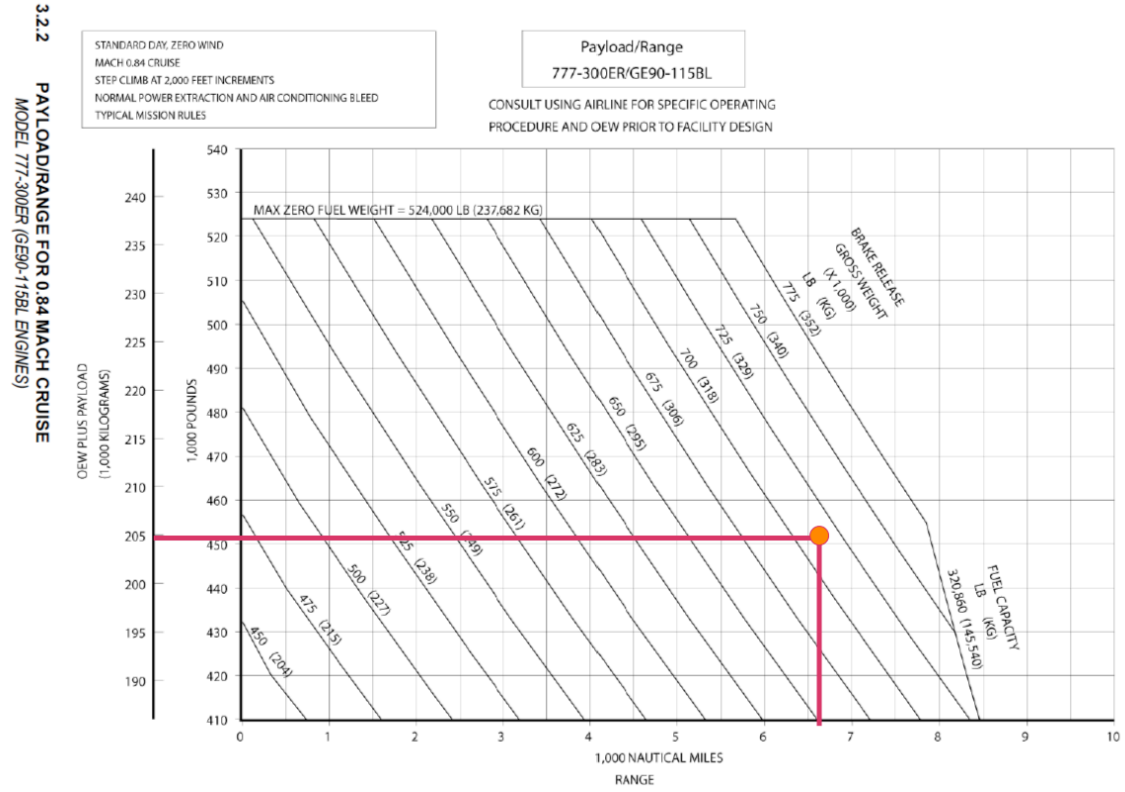


Figure 1c. LAX-HKG Flight. Boeing 777-300ER with General Electric GE90/115BL Engines. 6,624 nm Planned Route Distance.

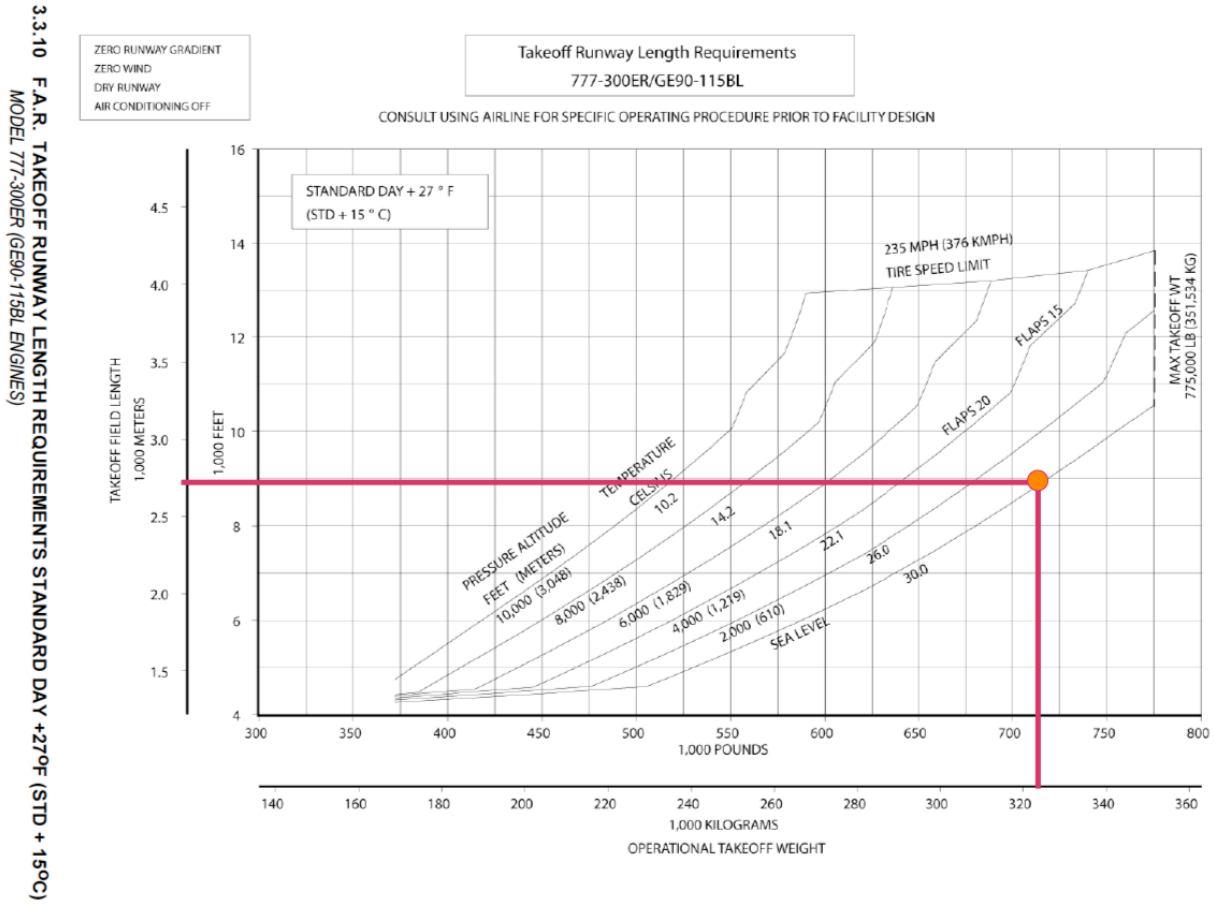


Figure 1b. Takeoff Analysis. LAX-HKG Flight. Boeing 777-300ER with General Electric GE90/115BL Engines. 6,624 nm Planned Route Distance.

Problem # 2 (50 points)

Problem 1

Use the large twin-engine transport aircraft performance file provided in the Matlab files for CEE 5614 (http://128.173.204.63/courses/cee5614/matlab_files_cee5614.html to answer the following questions.

The aircraft is cruising at FL 330 and Mach 0.80 over the Atlantic Ocean enroute from Santo Domingo (SDQ), Dominican Republic to Madrid (Spain) as shown in Figure 1. The aircraft has a mass of 290,000 kg at the departure airport (SDQ). The takeoff mass is comprised of the following:

Operating empty mass = 140,000 kg

Fuel weight onboard= 100,000 kg

Payload = 50,000 kg (300 passengers + 20,000 kg of belly cargo in LD3 containers)

The pilot files a flight plan and requests Flight Level 330 for the cruise portion the flight. The aircraft flies to a waypoint position located 1,700 nm from SDQ (see Figure 1) when the aircraft requests a new cruise flight level to climb to 36000 feet. Assume ISA conditions in the analysis. Figure 1 shows the diversion points if the aircraft where to experience an engine failure.

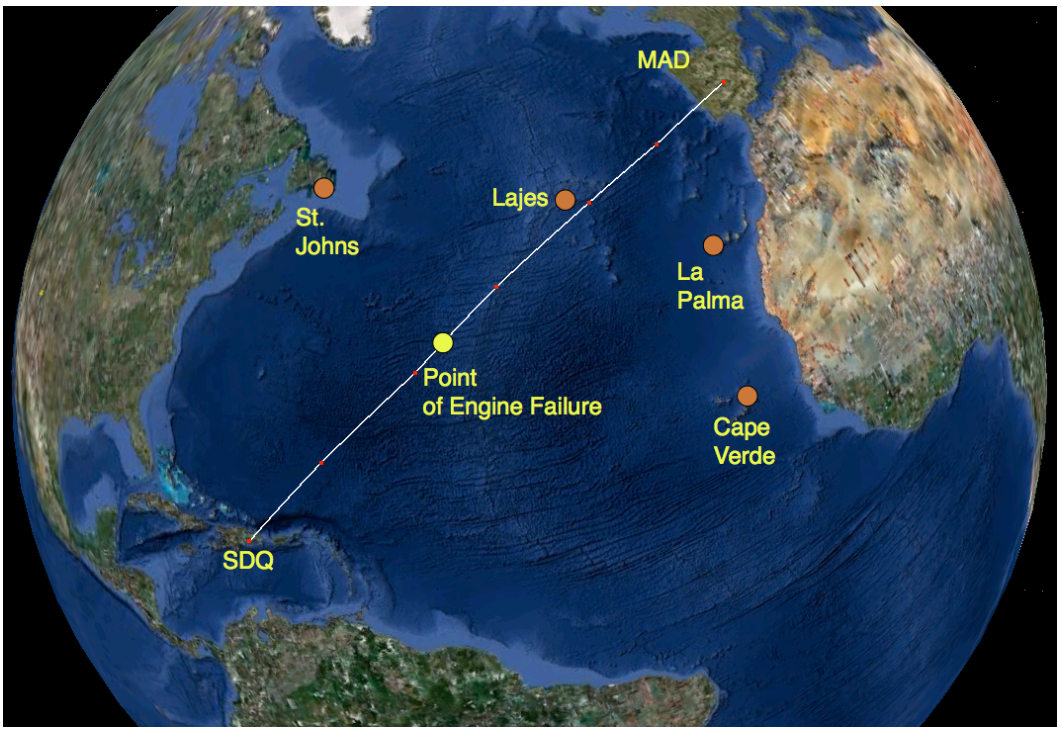


Figure 1. Situation of the Flight for Problem 2. Source of Map: Google Earth.

a) Calculate the distance flown from Santo Domingo to the TOC point (assume great circle distance flown).

b) Estimate the fuel consumed in the climb procedure. State the climb distance and the climb time.

c) Find the fuel burn to the point when the aircraft climbs to 36,000 feet.

d) Find the total fuel consumed in the journey from SDQ to MAD.

Table 1d. SDQ-MADFlight. Large Twin-Engine Transport Aircraft. 4,370 nm Planned Route Distance (4,162 nm GCD).

Parameter	Value (kg)	Remarks
OEW	140,000	Given in statement of the problem
Fuel on-board	100,000	
Passenger load	50,000	300 passengers + 20,000 kg of belly cargo
Takeoff weight	290,000	
	Initial Climb Analysis	
Takeoff weight	290,000	
Cruise Altitude	33,000	Given in problem statement
Time to TOC	10.9	minutes
Distance to TOC	61.5	nm
Fuel to TOC	24,789 N 2,527 kg	Using the unrestricted climb Matlab code provided
	Initial Cruise Analysis	
weight at TOC	287,473	kilograms
Cruise distance	1638.5	In Nautical Miles 3,035 km
Cruise speed	Mach 0.80 @ 33,000 ft 239.4 m/s	320 knots IAS
Cruise time	211.3	minutes
Drag in cruise	155,630	Newtons @ 33,000 feet and Mach 0.80
Fuel flow	24.9	Newtons/second
Fuel (initial cruise)	32,178.4	kilograms
Weight at 1700 nm point	255,294.6	kilograms

Table 1d. SDQ-MADFlight. Large Twin-Engine Transport Aircraft. 4,370 nm Planned Route Distance (4,162 nm GCD).

Parameter	Value (kg)	Remarks
	Step Climb Analysis	
Weight at 1700 nm point	255,294.6	Previous calculation
Time to Step TOC	2.83	minutes from 33,000 to 36,000 feet
Distance to TOC	22	nm
Fuel to TOC	508.4	kilograms. Using the unrestricted climb Matlab code provided
	Second Cruise Analysis	
Weight at Step TOC	254,786.2	kilograms
Cruise distance	2405	In Nautical Miles Calculated as: 4370-1715-250
Cruise speed	Mach 0.80 @ 36,000 ft 236 m/s	305 knots IAS
Cruise time	315.0	minutes
Drag in cruise	138,790	Newtons @ 36,000 feet and Mach 0.80
Fuel flow	22.2	Newtons/second
Fuel (second cruise segment)	42,770.6	kilograms
Weight at TOD	212,015.6	kilograms
	Descent Analysis	
Descent Distance	250.0	nm
Descent fuel	3,747.0	kg
Final weight	208,268.6	kg
Total fuel used	81,731.4	kilograms

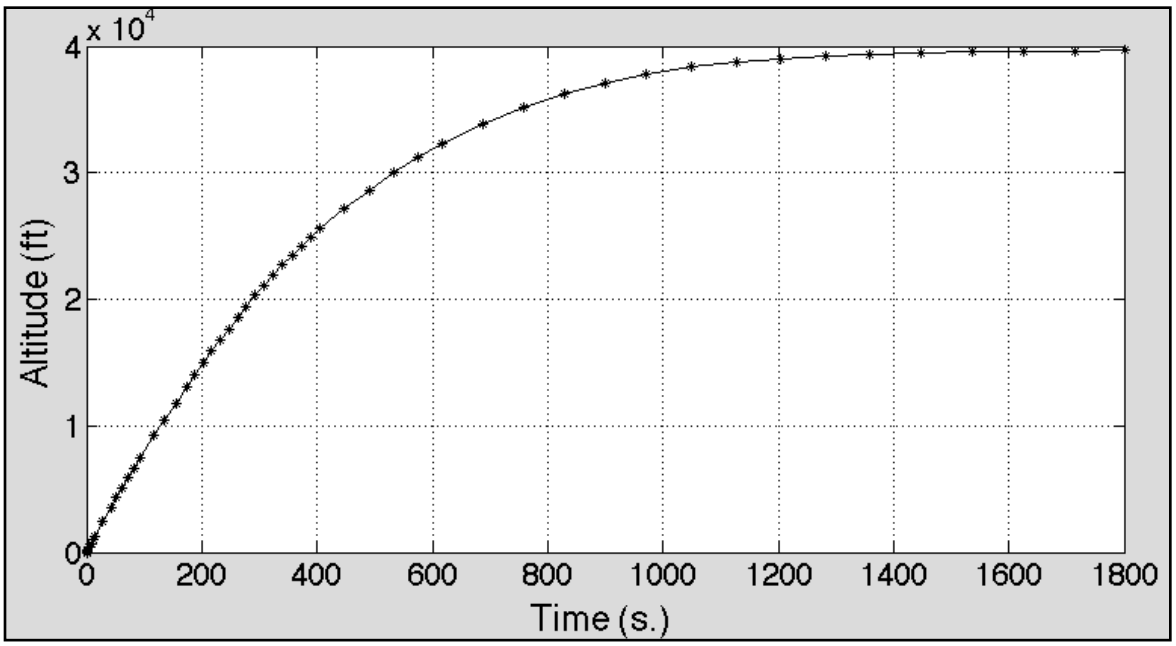


Figure 2a. Climb Profile for Large Twin Engine Aircraft. Initial Airport Elevation is at Sea Level Conditions. Time to Climb to 33,000 feet is 652 seconds (10.9 minutes).

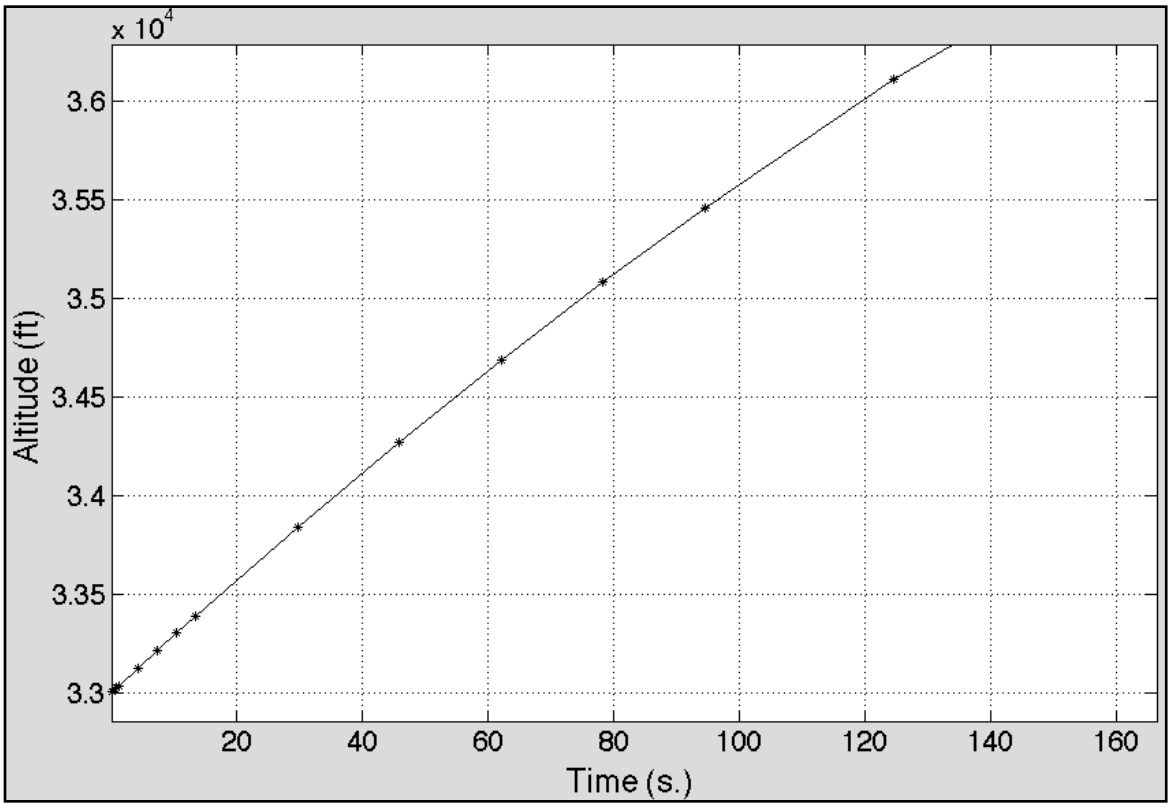


Figure 2b. *Climb Profile for Large Twin Engine Aircraft. Initial Flight Level is 33,000 feet. Time to Climb to 36,000 feet is 120 seconds (2 minutes). Mach 0.80 Climb Speed.*

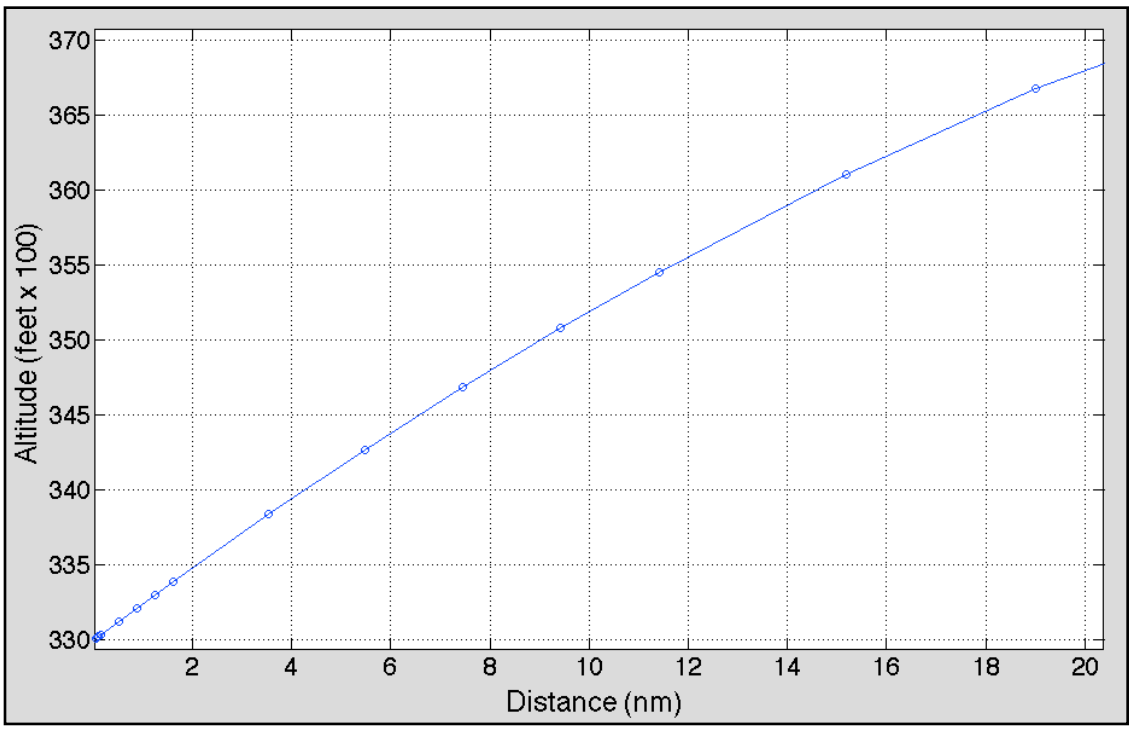


Figure 2c. *Climb Profile for Large Twin Engine Aircraft. Initial Flight Level is 33,000 feet. Distance to Climb to 36,000 feet is 15 nm. Mach 0.80 Climb Speed.*

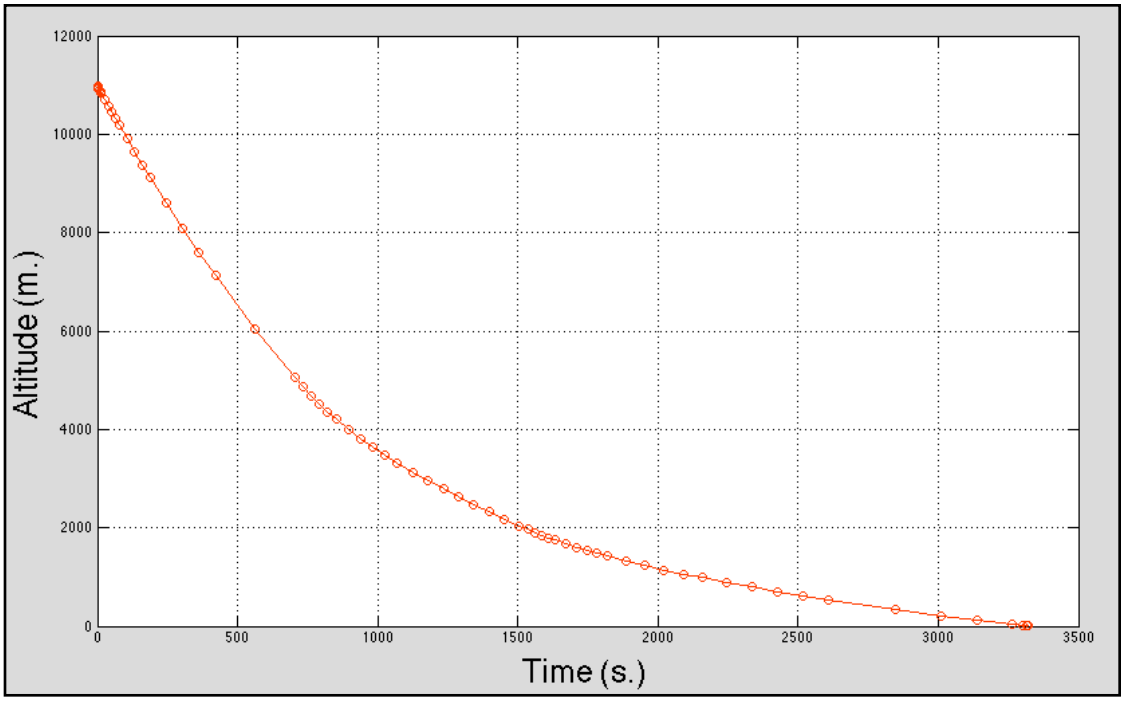


Figure 2d. Descent Profile. Large Twin Transport Aircraft.