Assignment 2: Runway Length Analysis

Date Due: February 2, 2018 (Ground Hog Day) Instructor: Trani

Reading Assignment: Review Chapters 1 through 3 of the FAA Advisory Circular 150/5325-4b before working on this homework.

Problem 1

Design the runway length for a new General Aviation airport to be constructed at a site located 2,450 feet above sea level. Data from a temperature survey indicates a mean daily maximum temperature of the hottest month of 83 degree F. The aircraft fleet mix expected to operate at the airport is shown in Table 1.

Table 1. Expected Aircraft Fleet at Proposed General Aviation Airport. Aircraft in Boldface Text is shown in the Picture.

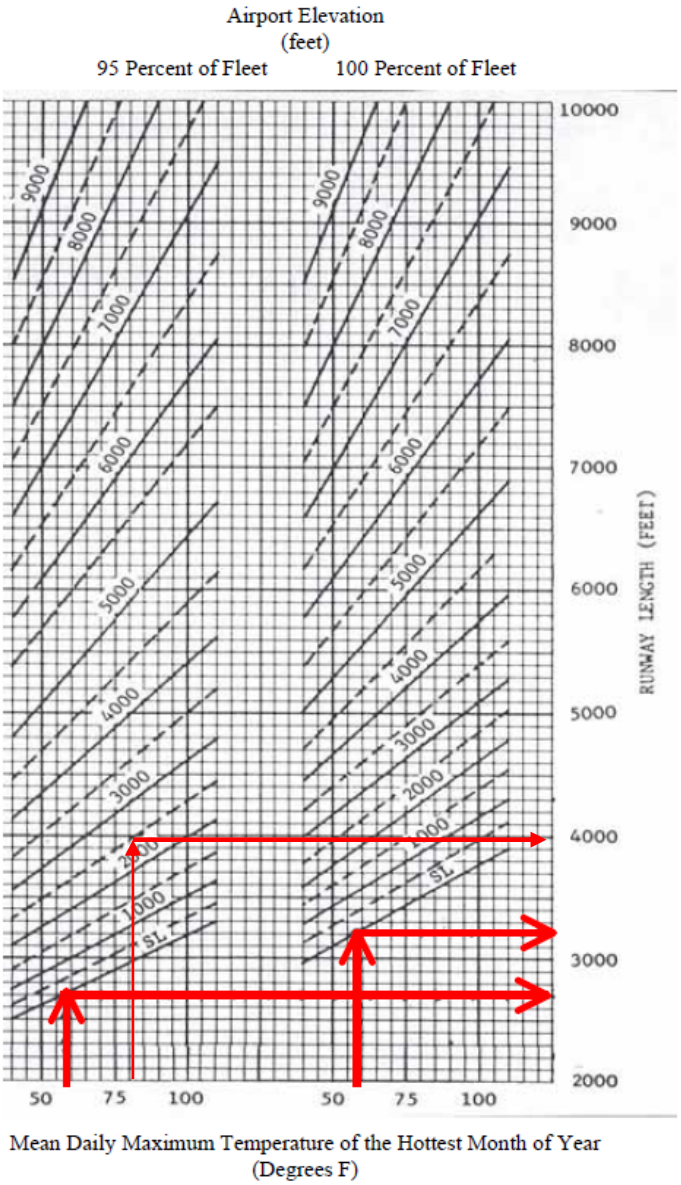
Aircraft Type	Sampled Aircraft	Sample Picture
Single Engine Piston	**Cessna 182**, Cirrus SR-22, Raytheon Beech Bonanza A36	
Multi-engine Piston	**Raytheon Beech G58 Baron** and Diamond DA-62	

a) Find the recommended runway length required to serve the aircraft fleet listed in Table 1.

∵ General Aviation airport

∴ Use 95% Of Fleet

These are small aircraft with less than ten seats

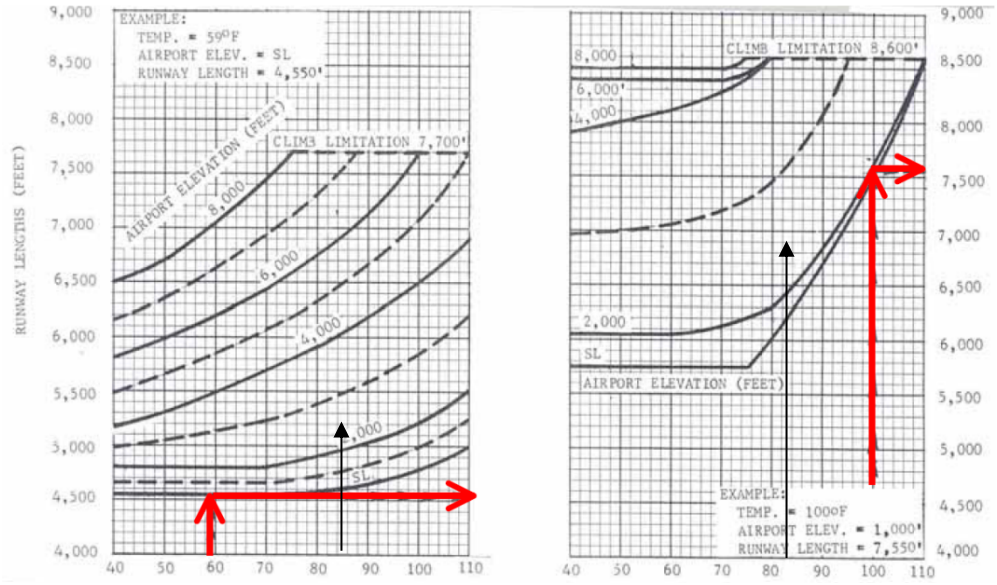


From the given graph, the needed runway length for that fleet mix is round 4000 ft.

b) If the runway at the same airport is designed to accommodate small corporate jets such as the Cessna CitationJet 3 (see Figure 1) instead, estimate the new runway length requirement.

Use 75% of Fleet

Figure 3-1. 75 Percent of Fleet at 60 or 90 Percent Useful Load

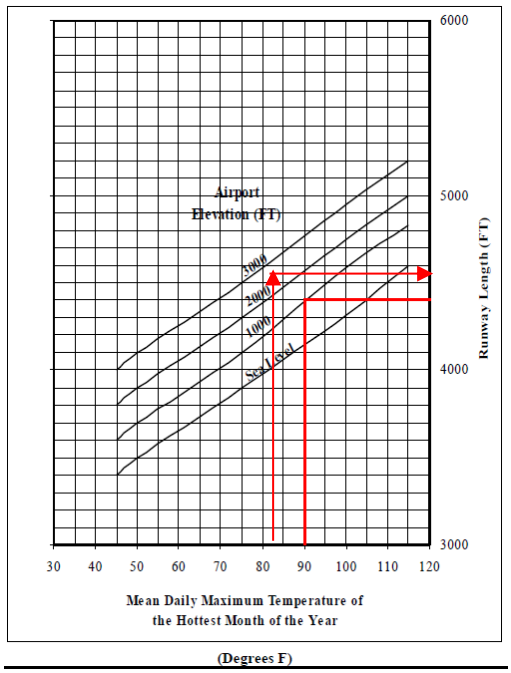


From the graph, the needed runway length for Cessna CitationJet 3 is 5165 ft

A correction of 15% is needed to correct runway length : the needed runway length for Cessna CitationJet 3 is 5500 ft (up to 5500 ft).

c) Estimate the runway length to support turboprop aircraft such as the Raytheon King Air B350 (shown in Figure 2). The King Air B350 carries up to 11 passengers plus two pilots.

The Raytheon King Air B350 is a small aircraft with more than 10 seats. However, the Raytheon King Air B350 has a MTOW of 15000lbs, so Table 3-1 should be used:



From the given graph, the needed runway length for that fleet mix is round 4550 ft.

Figure 1. Cessna CitationJet 3 (Cessna Model C525B) (A. Trani).

Figure 2. Raytheon Beech King Air B350(A. Trani).

Problem 2

Virginia Tech Montgomery County Executive airport is expanding its single runway (labeled 12-30) to 5,500 feet in length to serve larger corporate jet aircraft. Use the runway length estimation method described in class to **find three representative corporate jets** that could be accommodated in the future at the airport. Find the aircraft design group of each aircraft in your solution.

Airport information: BCB

Elevation: 2131.7 ft. / 649.7 m (surveyed)

Length (future) : 5500 feet

Dimensions (current): 4539 x 100 ft. / 1383 x 30 m

From http://www.weather.gov/rnk/MonthlyClimateNormals, the daily temperature of the hottest month of year is around 83 F°

For Small Aircraft with MTOW > 12,500 lb (5,670 kg) and less than 60,000 lb (27,200 kg)

Figure 3-1. 75 Percent of Fleet at 60 or 90 Percent Useful Load

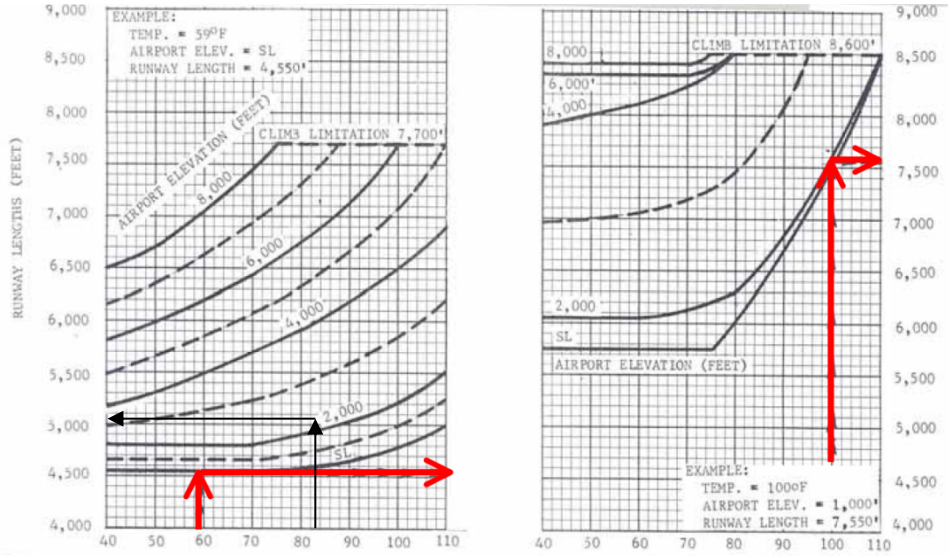
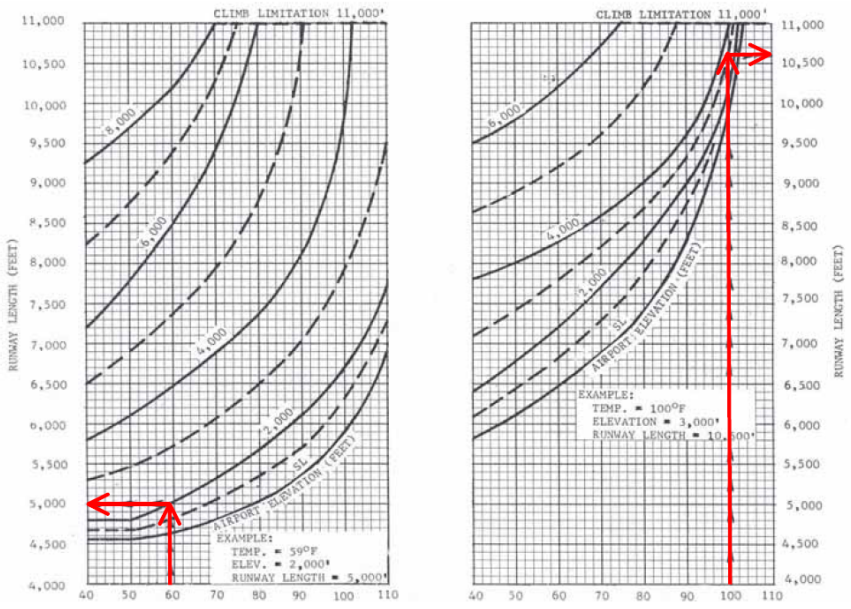


Figure 3-2. 100 Percent of Fleet at 60 or 90 Percent Useful Load



Mean Daily Maximum Temperature of Hottest Month of the Year in Degrees Fahrenheit

100 percent of feet at 60 percent useful load **100 percent of feet at 90 percent useful load**

Three representative corporate jets are: a) Cessna Citation III, b) Bombardier Challenger 300 and c) Learjet 45

Problem 3

The Roanoke-Blacksburg Regional Airport (ROA) is in discussion with an airline to start services from Roanoke to Houston (IAH) and to Orlando (MCO). The airline purchased a new Boeing 737-8 Max with characteristics shown in Table 2. For this analysis, use the latest version of the Boeing documents for airport design.

Table 2. Aircraft Considered in the ROA Airport 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.

a) Find the average stage length to be flown between each one of the critical Origin-Destination airport pairs. Use the Great Circle Flight Path mapper link provided in our interesting web sites (http://www.gcmap.com//). Add 6% to the distances estimated by the Great Circle mapping application to account for real Air Traffic route conditions and to account for possible weather deviations from the shortest flight path.

From the great-circulator, the distance between ROA to IAH (including 6% route detour) is:

Stage length=885*1.06=938 nm

From the great-circulator, the distance between ROA to MCO (including 6% route detour) is:

Stage length=537*1.06=569 nm

b) Find the Desired Takeoff Weight (DTW) to fly the proposed routes. Assume 100% passenger load in this analysis.

Aircraft type: Boeing 737-8 Max

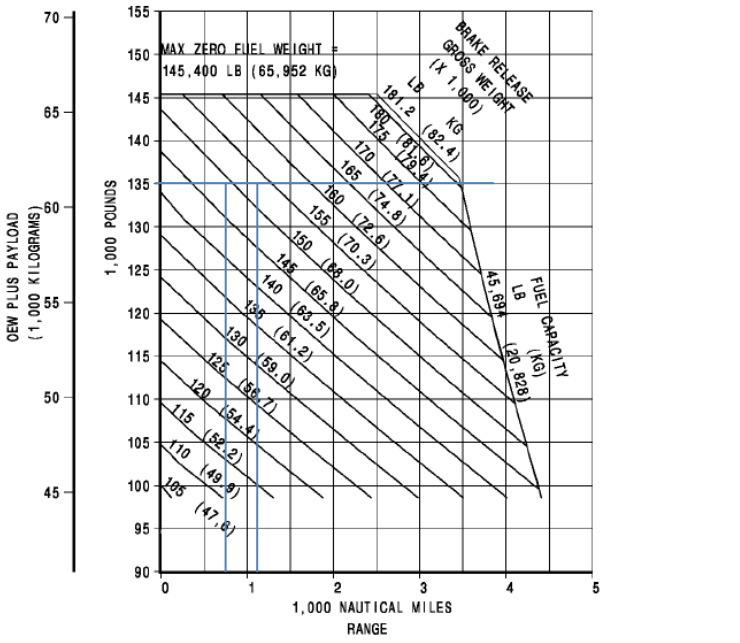
OEW=99,360 lb MTOW=181,000 lb

PYW=16200 kg=35715 lb

OEW+PYW=135075 lb

Payload/Range
737-8 (LEAP-1B series)

- STANDARD DAY, ZERO WIND
- CRUISE MACH = LRC
- NORMAL POWER EXTRACTION AND AIR CONDITIONING BLEEDS
- TYPICAL MISSION RULES
- CONSULT USING AIRLINE FOR SPECIFIC OPERATING PROCEDURE AND OEW PRIOR TO FACILITY DESIGN.



From the Payload-Range diagram read off the Desired Takeoff Weight (DTW)

ROA – IAH:

DTW = 152000 lb

ROA – MCO:

DTW = 147000 lb

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

ROA airport:

According to weather website, mean daily maximum temperature of the hottest month at the airport is about 89°F

Elevation: 1175.2 ft.

Takeoff analysis:

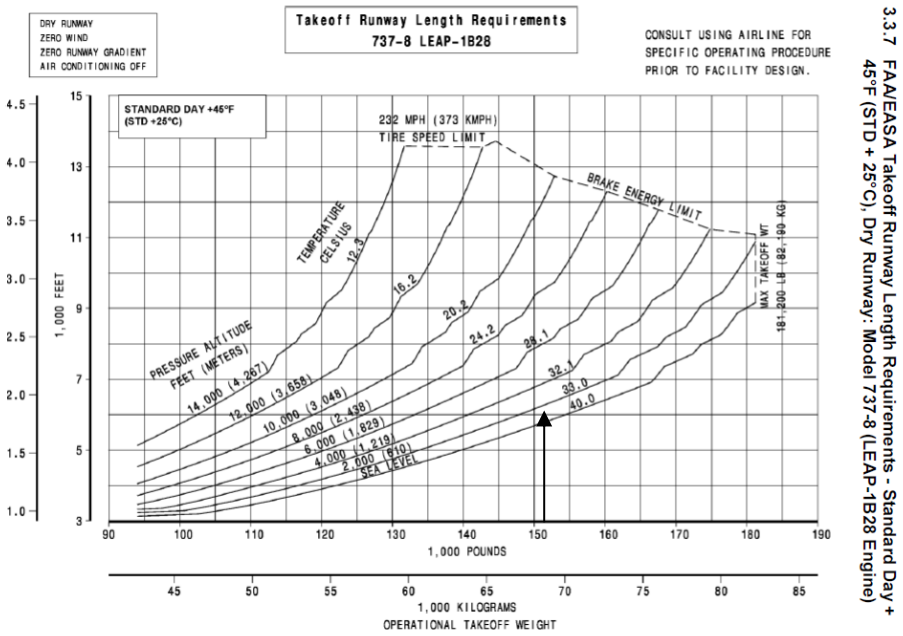
Temperature under ISA at 1175.2 ft elevation: 54.9° F

Use ISA + 45° F graph because ISA + 30 F is more than 3 deg. F from the design temperature.

Aircraft：B737-8

MTOW: 181200 lb MALW: 152800 lb

Takeoff analysis:



3.3.7 FAA/EASA Takeoff Runway Length Requirements - Standard Day + 45°F (STD + 25°C), Dry Runway: Model 737-8 (LEAP-1B28 Engine)

ROA – IAH:

From the performance chart we conclude: RL_TAKEOFF = 6000 ft

ROA – MCO:

From the performance chart we conclude: RL_TAKEOFF = 5800 ft

(correct the gradiant)

Landing analysis:

ROA – IAH:

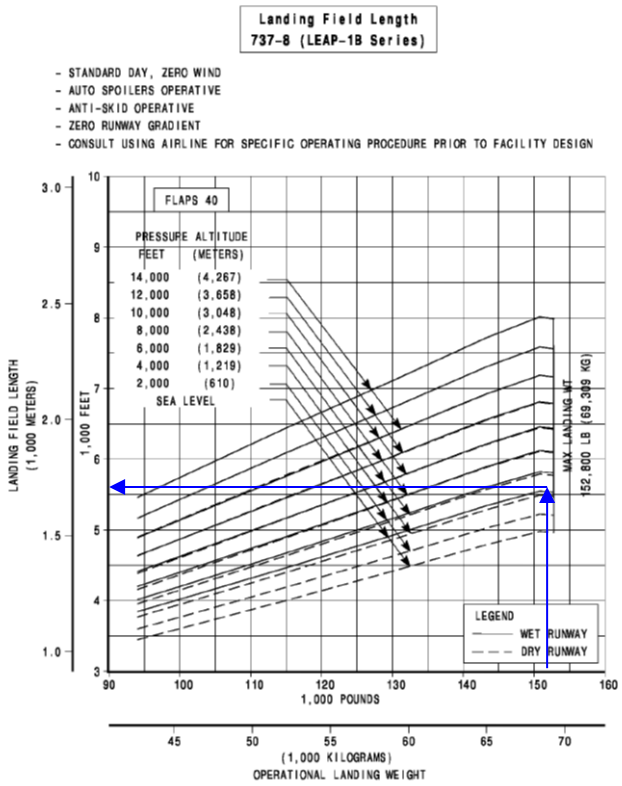
Consider an emergency situation and compute the landing weight at the departing airport

DTW = 152000 lb; MALW: 152800 lb

∵ DTW<MALW

∴ Use DTW

Assume Flaps degree is 40, use graphs under wet conditions



From the performance chart we conclude: $RL_{landing}$ = 5600 ft

DCA – MCO:

Consider an emergency situation and compute the landing weight at the departing airport

DTW = 148000 lb; MALW: 152800 lb

Use the MALW

From the performance chart we conclude: $RL_{landing}$ = 6000 ft

∵ the longest runway in ROA is Runway 6/24, which is 6800 ft > 6000 ft

∴ ROA has enough runway length to support these flights

d) If the runway length estimated in part (c) exceeds the runway length available at ROA, find the runway extension needed to support the proposed flights.

Not applicable. The aircraft can operate the two routes from ROA.

Problem 4

Find the runway length for a new airport to be located 90 miles south of Chicago. The new airport is to be located in a 3,200 acre parcel located 830 feet above sea level. Use temperature data for Peoria, Illinois in solving this problem. Design the runway to provide flexibility to operate flights at Maximum Takeoff Weight from this new airport location. Table 3 shows two representative commercial aircraft to be used in the runway design process.

Table 3. Critical Aircraft to be Considered for Problem 4.

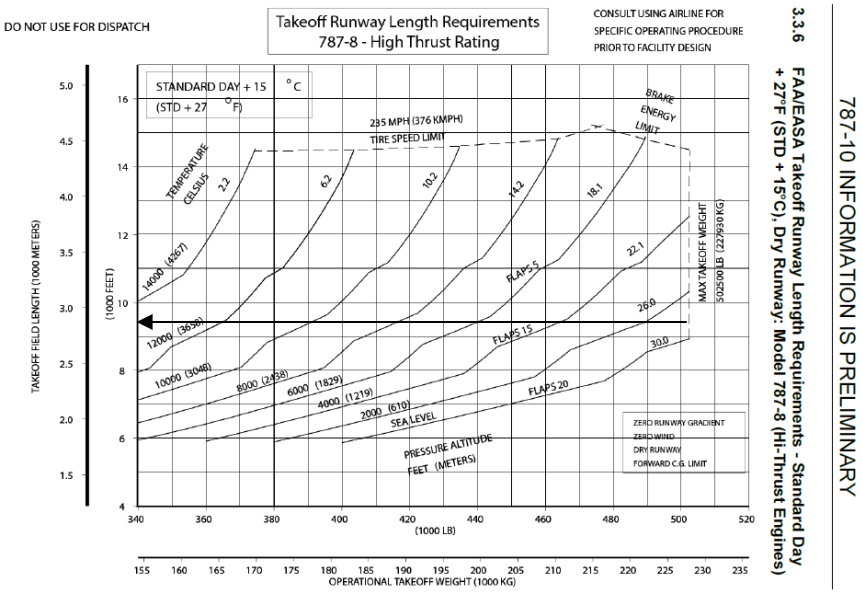
Aircraft	Engine	Remarks
Boeing 737-800 (with winglets)	Two CFM56-7B24/-7B26/-7B27 engines at 26,000 lb (static sea level conditions)	Aircraft with maximum design takeofff weight is 174,200 lb. The aircraft has 160 seats in a two-class layout.
Boeing 787-8	GE Engines Genx (High thrust engines)	Plane has 242 seat three-class configuration. 227,930 kg MTOW.

a) Find the runway length needed to operate the aircraft shown in Table 3. Propose the runway length needed for the new airport. In your solution state the figure numbers used in the Boeing APM documents.

Elevation: 830 ft
Aircraft: 737-800
MTOW: 174200 lb
Aircraft: 787-8
MTOW: 227930 kg

Mean daily maximum temperature of the hottest month of the year = 86 ° F
Temperature under ISA at elevation of 830 feet: 56.1
Use ISA + 27°F graph

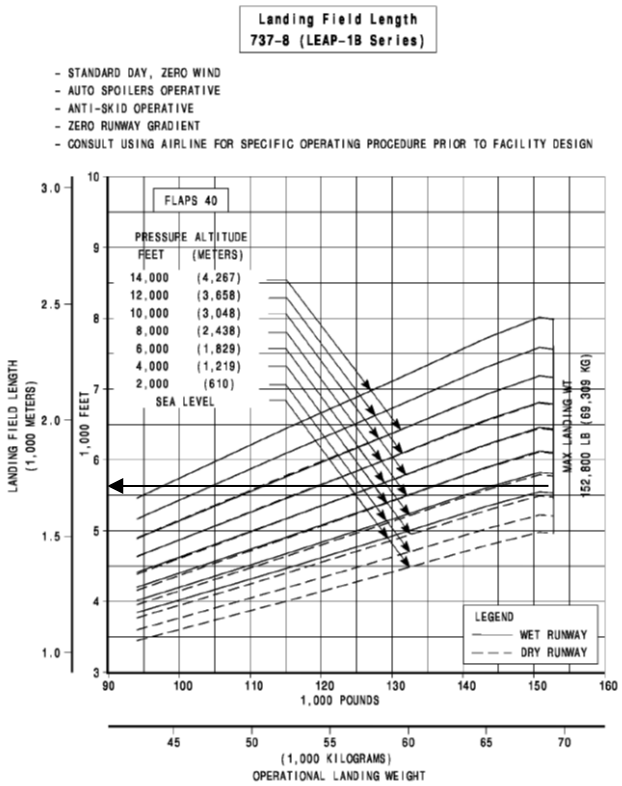
Aircraft 787-8



From the performance graph, the minima runway length needed is:
$RL_{TAKEOFF}$=9200 ft

For landing analysis:
Assume the airport could operate landing under MALW (maximum allowable landing weight)

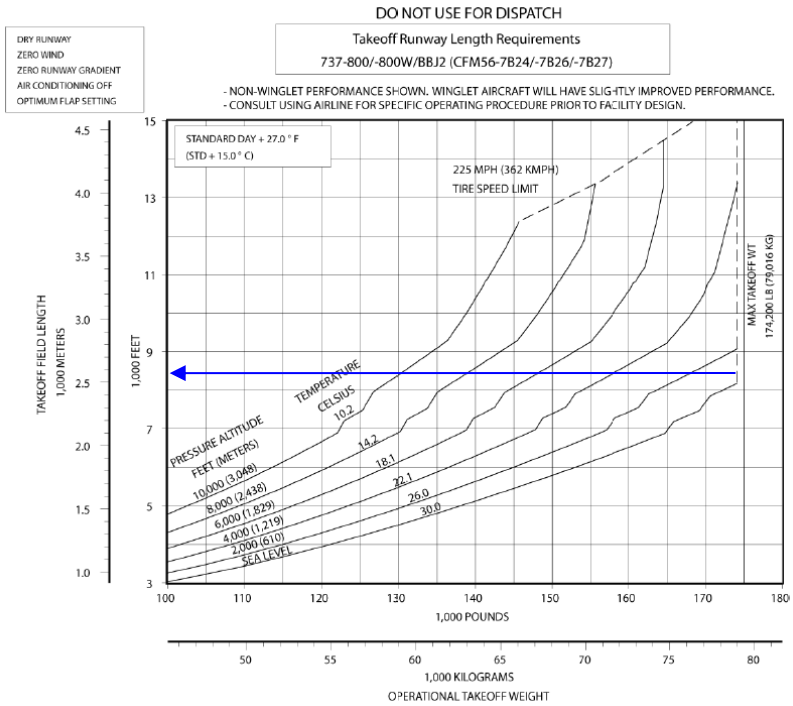
Assume the flap setting is 40:



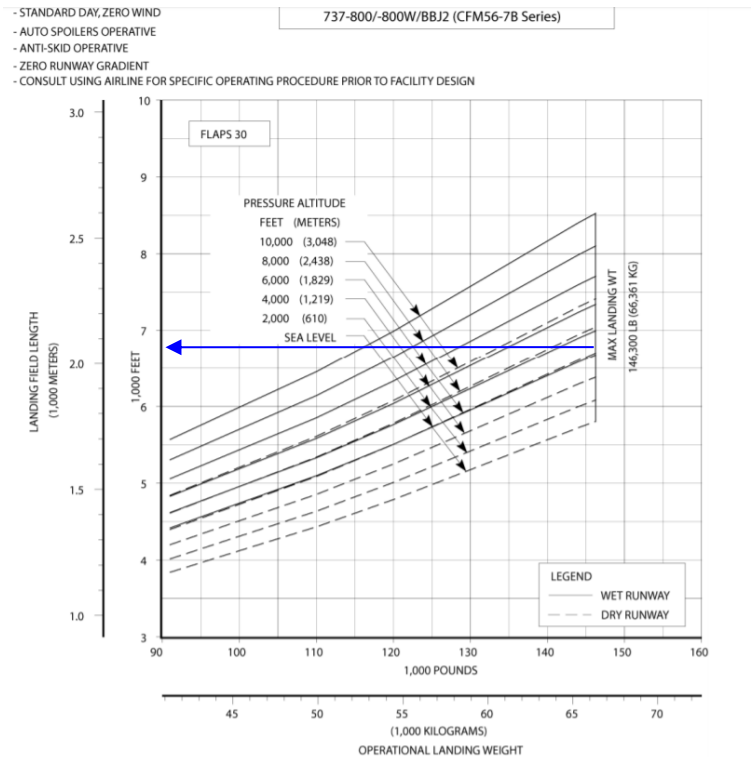
From the performance chart, the needed runway length for landing is round:
$RL_{Landing}$=5600 ft

Aircraft 737-800
Engine: Two CFM56-7B24/-7B26/-7B27 engines

For take-off analysis



From the performance graph, the minima runway length needed is:
$RL_{TAKEOFF}$=8400 ft



For landing analysis:
Assume the airport could operate landing under MALW

Assume the Flaps is 30:
From the performance chart, the needed runway length for landing is round:
$RL_{Landing}$=6800 ft

In conclusion, the runway length needed to operate the aircraft shown in Table 3 is 9200 ft

b) Comment on the different runway lengths needed to operate a the Boeing 737-800 (winglets) vs the Boeing 787-8 Dreamliner.

The Boeing 787-8 Dreamliner requires a longer runway length than the Boeing 737-800.

c) if the same Boeing 787-8 is operated from Dubai International Airport (62 feet airport elevation) with a design temperature of 103 degrees F, find the runway length needed.

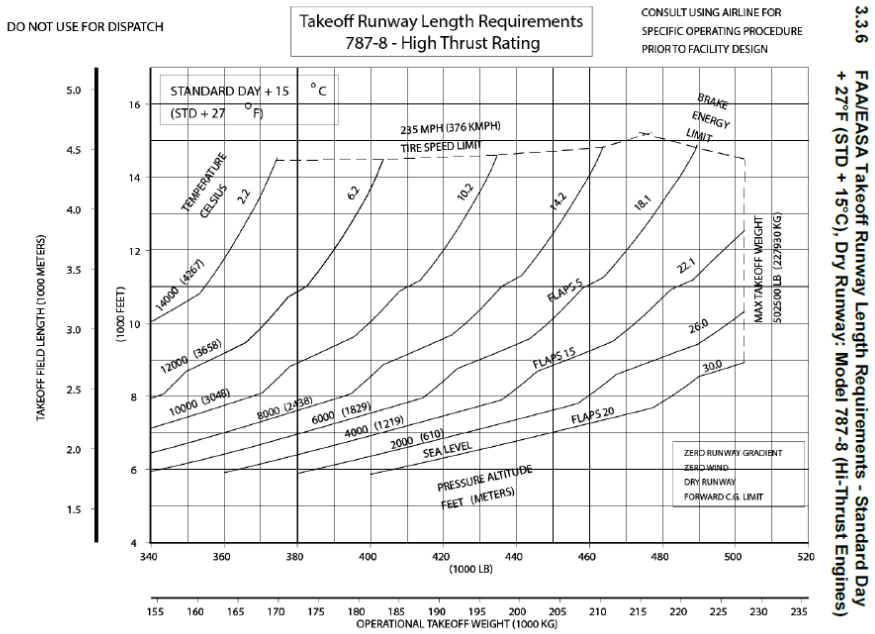
Elevation: 62 feet=

Temperature: 103 ° F

Use ISA + 45° F

Takeoff analysis:

Aircraft: 787-8
MTOW: 227930 kg



From the graph, the B787-8 needs 11900 ft runway to operate.

d) Explain the differences in runway length as a function of temperature.

With the increase in temperature, the air density decreases, which reduces the engine thrust. Lower density also increases stalling speed which affects (increases) takeoff speeds. This provides a double effect on runway length required for takeoff.