Assignment 2: Runway Length Analysis for Small Aircraft

Date Due: September 12, 2025 Instructor: Trani

Reading Assignment: Review Chapters 1 and 2 of the FAA Advisory Circular 150/5325-4b. Also, review the course notes on aircraft runway length estimation (http://128.173.204.63/cee4674/cee4674_pub/runway_calculations_Aircraft_upTo_60000lbs.pdf).

To do this homework, you need to download and install the Small Aircraft Runway Length Analysis Tool (SARLAT version 2.0.013) per instructions provided in Canvas.

Problem 1

Use the Small Aircraft Runway Length Analysis Tool (SARLAT 2) to **design a runway** at a new airport located 2,050 feet above mean sea level conditions. The average maximum daily temperature of the hottest month of the year is 85 degrees Fahrenheit. Table 1 shows the representative aircraft at the airport.

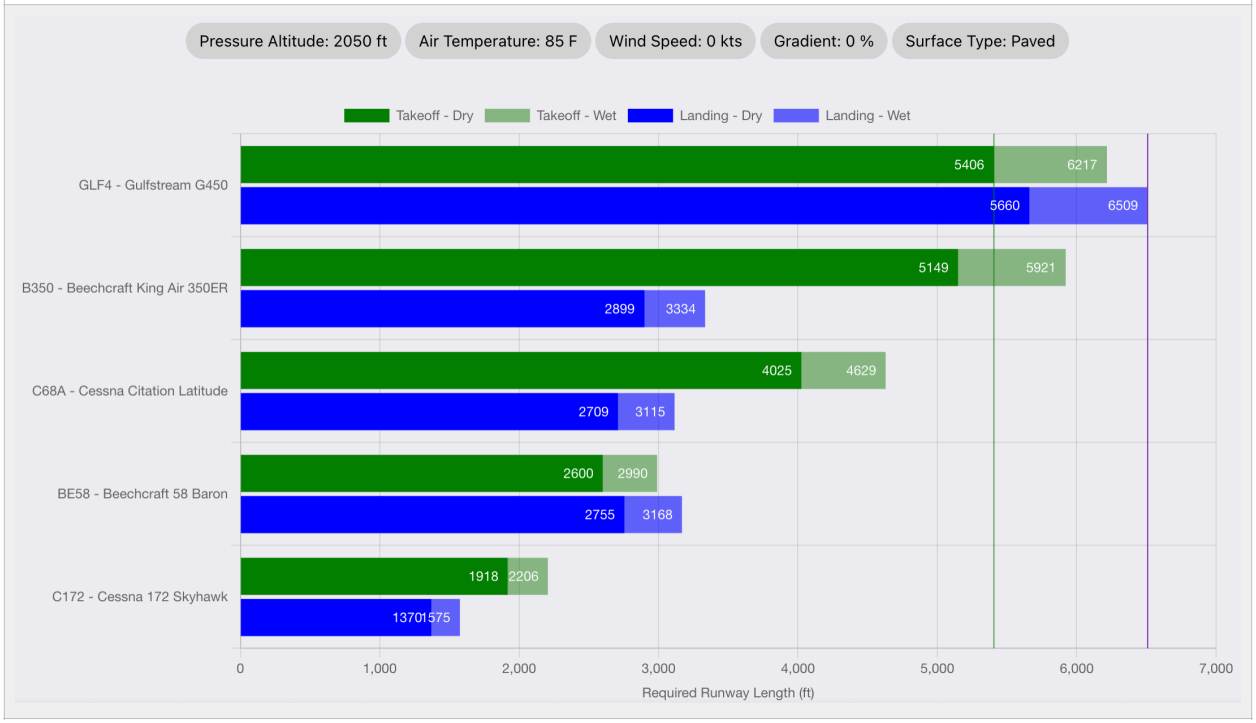
a) Find the required runway length to satisfy the fleet mix's runway performance requirements in Table 1. List the following runway lengths for the critical aircraft: 1) dry runway takeoff distance and 2) wet runway landing distance. These are the distances the FAA Airport Improvement Program (AIP) supports in runway improvement projects. Provide your recommended runway length to serve the fleet mix in Table 1. The recommended runway length should be rounded to the nearest 100 feet (if the answer is above 30 feet).

Critical aircraft for takeoff (dry). Gulfstream 450 5,406 feet (round to 5,400 feet)

Critical aircraft for landing (wet). Gulfstream 450 6,509 feet (round to 6510 feet)

b) Show the SARLAT bar chart of runway length requirements for each aircraft for your solution.

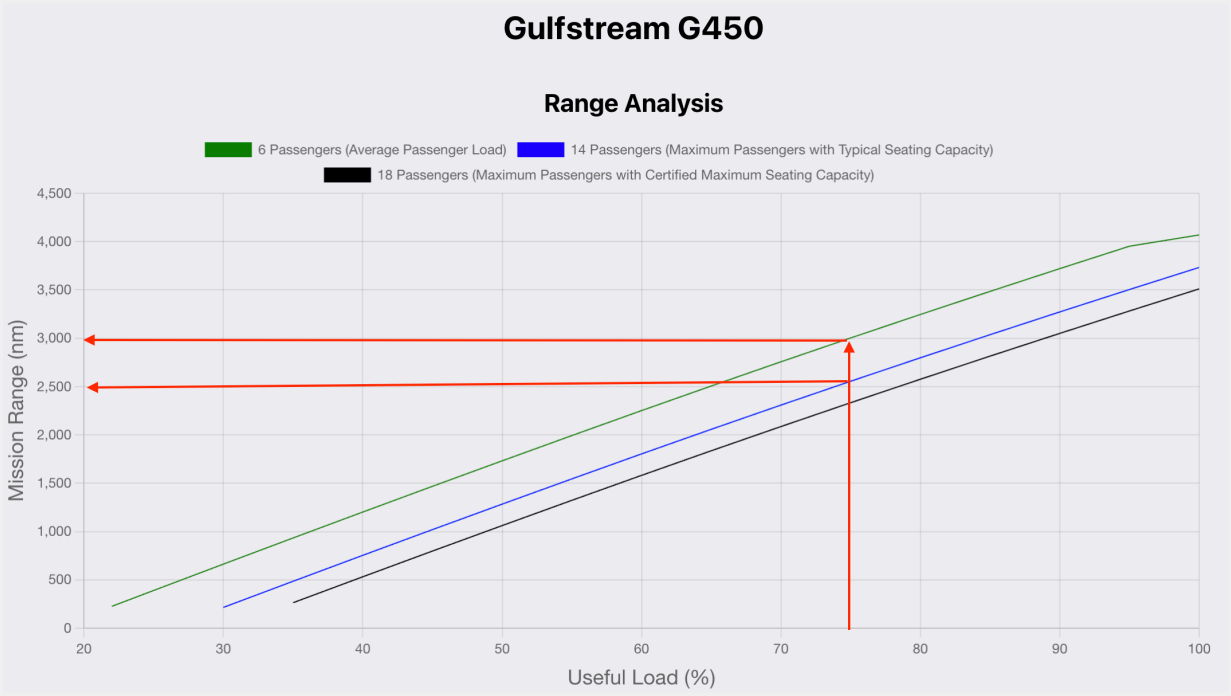
Solution b: Runway Lengths for the Fleet Mix.



c) Find the maximum distance that can be flown with a Gulfstream 450 operated at 75% useful load on takeoff with the average passenger load of 6 passengers and two pilots.

The payload-range diagram shows 3,000 nm of range with 75% useful load (six passenger and two pilots).

Solution c: Payload-range diagram for Gulfstream 450.



d) Find the maximum distance that can be flown with a Gulfstream 450 operated at 75% useful load on takeoff with the 14 passengers and two pilots.

The payload-range diagram (see above) shows 2,500 nm of range with 75% useful load (14 passenger and two pilots).

e) Using solutions (c) and (d) estimate the change in aircraft range for each passenger added.

This shows that a reduction of 500 nm range for 8 passengers. This translates that for each passenger, the range is ceded by 62.5 nautical miles.

f) Find the percent of the flights in the US that can be flow with the King Air B350 operated at 75% useful load. Use the **Stage Length Analysis** procedure in SARLAT 2.

75% useful load in a King Air B350 produces 1,381 nautical miles range based on Range Analysis feature or Critical Range with Average Passenger Load (nm) in Fleet Mix of Runway Design feature. Using the stage length analysis, 1,381 nm covers 100% of the flights in the US.

Solution f: King Air B350.

B350 - Beechcraft King Air 350ER	500	1381	75

Critical Range with Average Passenger Load (nm) in Runway Design Feature

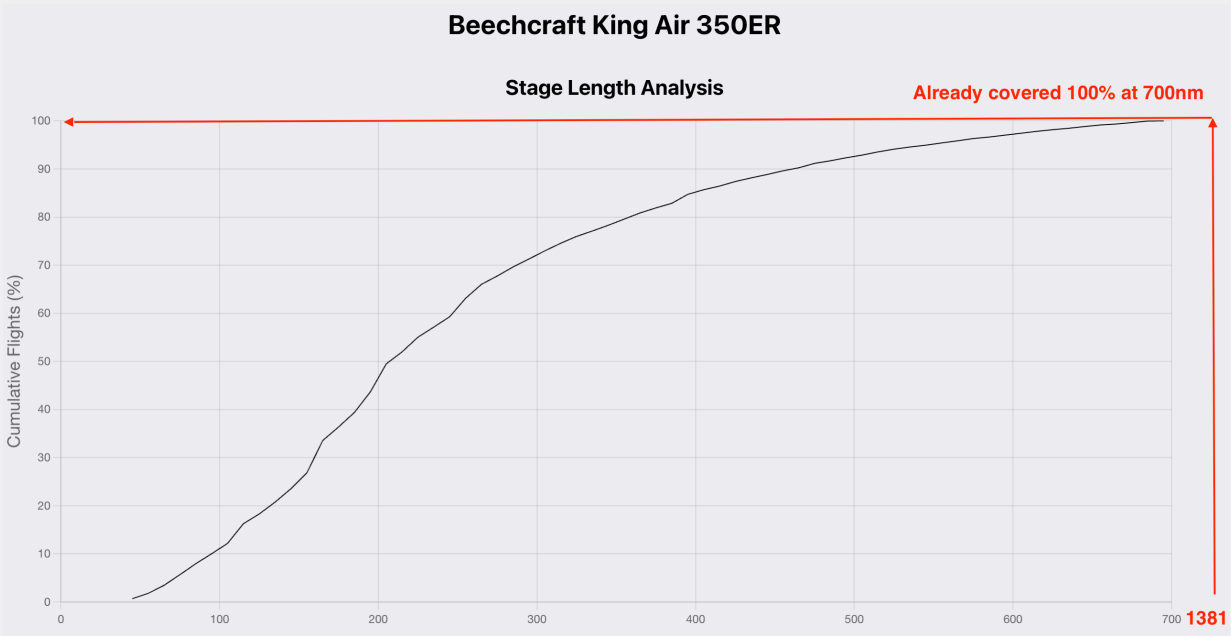


Table 1. Aircraft Fleet Mix for Problem 1.

Aircraft Type	Aircraft	Useful Load (%)	Annual Operations	Picture
Piston	Cessna 172	100	3,400	
Piston	Beech Baron 58	100	1200	
Turboprop	Beechcraft King Air B350	75	800	
Jet	Cessna Citation Latitude	75	680	

Aircraft Type	Aircraft	Useful Load (%)	Annual Operations	Picture
Jet	Gulfstream 450	75	820	

Problem 2

Use the Small Aircraft Runway Length Analysis Tool (SARLAT 2) to **evaluate the existing runway** at Bolinder Field/Tooele Valley Airport (TVY) in Utah. Table 2 shows the aircraft fleet mix operating at the airport.

1) Use airnav.com to summarize the following information for the airport:

- **Longest runway length available: 6,102 feet**
- **Airfield elevation: 4,321 feet**
- Runway gradient (use the two published runway end elevations to make your calculation)

Runway 17 threshold elevation: 4,273 feet

Runway 35 threshold elevation: 4,321 feet

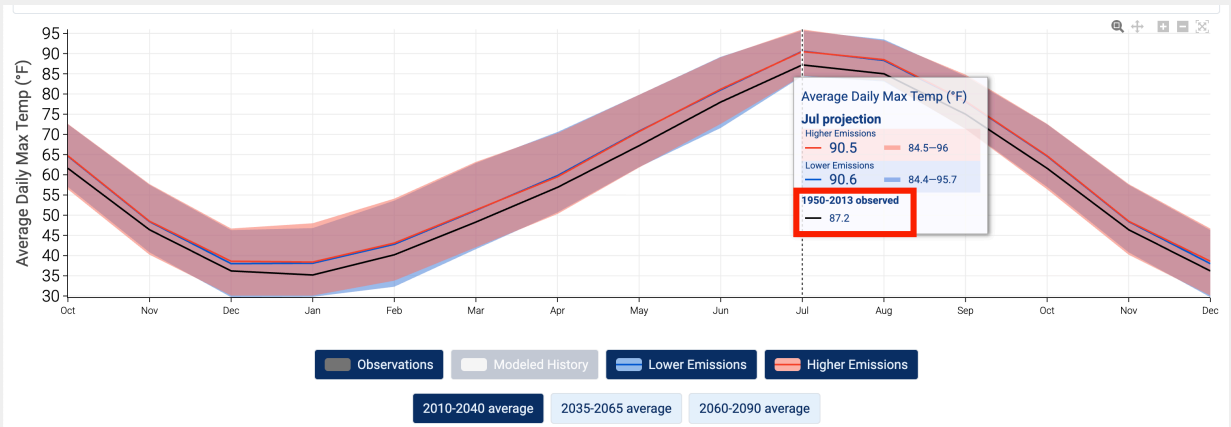
Elevation difference : 48 feet

Equivalent runway grade: 0.7% or 0.8% (48/6102*100 = 0.787) (Solution used 0.7%)

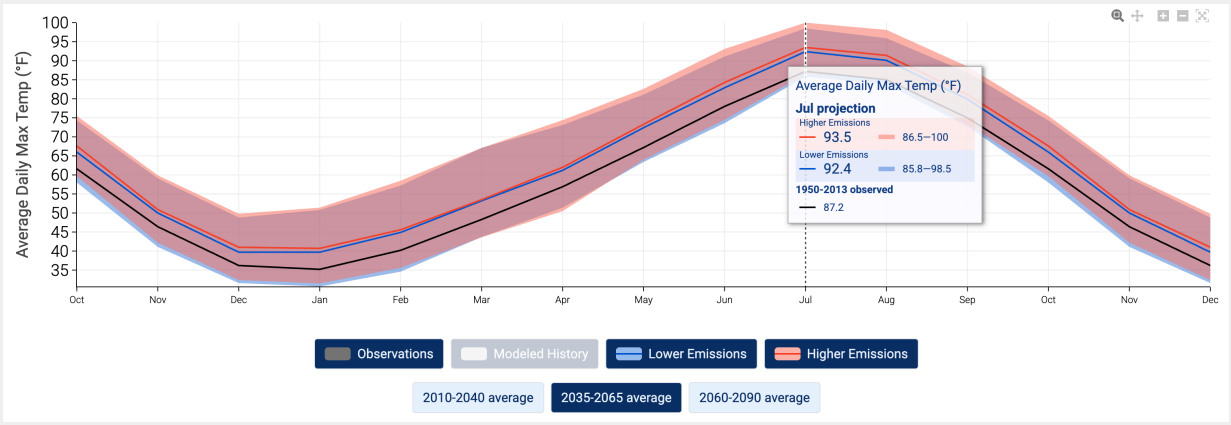
2) Use the Climate Explorer website to estimate the design temperature conditions for the airport. The link to the Climate Explorer is on our interesting web site page (http://128.173.204.63/cee5614/sites_ce_5614.html#Weather). Use the temperature profile for Salt Lake City (the closest metropolitan area to TVY).

- Find the historical maximum daily temperature for the hottest month of the year: **87.2 deg. F.**
- Consider climate change effects (i.e., higher emissions) and find the future design temperature. Use the future temperature profile for years 2035-2065: **93.5 deg. F.**

Solution 2.1: Climate Explorer. Salt Lake City with Climate Change.



- historical



- future design temperature

Table 2. Existing Aircraft Fleet Mix for Problem 2.

Aircraft Type	Aircraft	Annual Departures / Arrivals	Picture
Piston	Cessna 182	5,300	
Piper PA-28-161	Piper Cherokee 161	4,800	
Turboprop	King Air B300	890	
Turboprop	Beechcraft King Air B200GT	560	

For **existing runway length conditions** and the **historical design temperature** answer the following:

a) For dry runway conditions, find the **takeoff weight** and **useful load** possible for the Beechcraft King Air B200 and the Beechcraft King Air B300 operating from the existing runway.

Solution 2.a

Aircraft	Takeoff Weight (lbs)	Useful Load (%)
King Air B300	12,289	69
King Air B200 GT	12,500	100

Runway Takeoff and Landing Restrictions

Pressure Altitude: 4321 ft | Air Temperature: 87 F | Wind Speed: 0 kts | Runway Length: 6102 ft | Gradient: 0.7 % | Surface Type: Paved

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at Maximum Landing Weight					
						No Correction		Part 135 Eligible		Part 135	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Piston											
C182 - Cessna 182 Skylane	46%			100 % 2950 lbs	100 % 2950 lbs	✓	✓				
P28A - Piper 28 161 Cherokee	42%			100 % 2325 lbs	100 % 2325 lbs	✓	✓				
Turboprop											
BE30 - Beechcraft 300 Super King Air	8%	100 % FLIGHTS IN NAS 817 nm / 4 pax		69 % 12289 lbs		✓	✓			✗	✗
BE20 - Beechcraft King Air B200GT	5%	100 % FLIGHTS IN NAS 891 nm / 4 pax	100 % FLIGHTS IN NAS 891 nm / 4 pax	100 % 12500 lbs	100 % 12500 lbs	✓	✓			✓	✓

b) Using the existing runway length at TVY, find the maximum distance that can be flown by a Beechcraft B300 with the average passenger load and two pilots?

B300 can fly 817 nm with useful load of 69%.

Turboprop		
BE30 - Beechcraft 300 Super King Air	8%	100 % FLIGHTS IN NAS 817 nm / 4 pax

c) Considering climate change future temperature projections and dry runway conditions, find the takeoff weight and useful load possible for the Beechcraft King Air B300 operating from the existing runway. Comment on any changes compared to part (a).

Solution 2.c Using 94 deg. F.		
Aircraft	**Takeoff Weight (lbs)**	**Useful Load (%)**
King Air B300	11,605	57
King Air B200 GT	12,500	100

Runway Takeoff and Landing Restrictions

Pressure Altitude: 4321 ft | Air Temperature: 94 F | Wind Speed: 0 kts | Runway Length: 6102 ft | Gradient: 0.7 % | Surface Type: Paved

Aircraft Name	Aircraft Mix	NBAA IFR Maximum Range		Useful Load (Takeoff Weight)		Landing at Maximum Landing Weight					
						No Correction		Part 135 Eligible		Part 135	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Piston											
C182 - Cessna 182 Skylane	46%			100 % 2950 lbs	100 % 2950 lbs	✓	✓				
P28A - Piper 28 161 Cherokee	42%			100 % 2325 lbs	100 % 2325 lbs	✓	✓				
Turboprop											
BE30 - Beechcraft 300 Super King Air	8%	89 % FLIGHTS IN NAS 537 nm / 4 pax		57 % 11605 lbs		✓	✓			✗	✗
BE20 - Beechcraft King Air B200GT	5%	100 % FLIGHTS IN NAS 891 nm / 4 pax	100 % FLIGHTS IN NAS 891 nm / 4 pax	100 % 12500 lbs	100 % 12500 lbs	✓	✓			✓	✓

A reduction of 684 lbs. in the takeoff weight (3.5 passengers) is observed when operating the King Air B300 assuming higher temperatures associated with climate change. This is significant in real air taxi operations.

Problem 3

The airport described in **Problem 2** is planning a possible runway expansion to accommodate mid-size turbofan-powered aircraft such as the Cessna Citation Longitude and the Hawker 800XP. Table 3 shows information for two aircraft identified in the new airport master plan.

Table 3. Additional Fleet Mix for Problem 2.

Aircraft Type	Aircraft	Annual Operations	Picture
Jet	Hawker 800XP	910	
Jet	Cessna Citation Longitude	1,600	

Provide answers to the airport client for a **proposed runway extension.**

a) Find the **runway extension** needed to allow both all turbofan-powered aircraft to operate at a **useful load of 65%**. In the analysis consider dry runway conditions and future climate change temperature conditions (2035-2065).

With the existing runway length (6100 feet) and climate change conditions, the Hawker operates at 50% useful load. The Cessna Longitude operates at 66%.

Jet					
C700 - Cessna Citation Longitude	11%	99 % FLIGHTS IN NAS 1825 nm / 4 pax	91 % FLIGHTS IN NAS 1230 nm / 4 pax	66 % 34023 lbs	51 % 31737 lbs
H25B - Hawker 800XP	6%	74 % FLIGHTS IN NAS 745 nm / 5 pax	47 % FLIGHTS IN NAS 383 nm / 5 pax	50 % 22011 lbs	38 % 20604 lbs

Change the runway length iteratively to find that 7,200 feet of runway yields a 65% useful load for the Hawker 800XP. The solution is shown below. The runway needs to be extended 1,100 feet.

C700 - Cessna Citation Longitude	8%	100 % FLIGHTS IN NAS 2514 nm / 4 pax	100 % FLIGHTS IN NAS 1942 nm / 4 pax	84 % 37002 lbs	69 % 34599 lbs	✓	✓	✓
H25B - Hawker 800XP	6%	97 % FLIGHTS IN NAS 1182 nm / 5 pax	79 % FLIGHTS IN NAS 834 nm / 5 pax	65 % 23868 lbs	53 % 22360 lbs	✓	✓	✓

b) With the proposed runway extension, how far can a Hawker 800XP fly with five passengers and two pilots?

The Hawker can fly 1,182 nm with two pilots and five passengers (see solution below).

c) With the proposed runway extension, what percent of the US flights by Cessna Citation Latitude are covered?

The runway extensions to 7,200 feet allows 100% of the US flights performed with Cessna Citation Longitude.

Jet		
C700 - Cessna Citation Longitude	11%	100 % FLIGHTS IN NAS 2476 nm / 4 pax
H25B - Hawker 800XP	6%	97 % FLIGHTS IN NAS 1182 nm / 5 pax

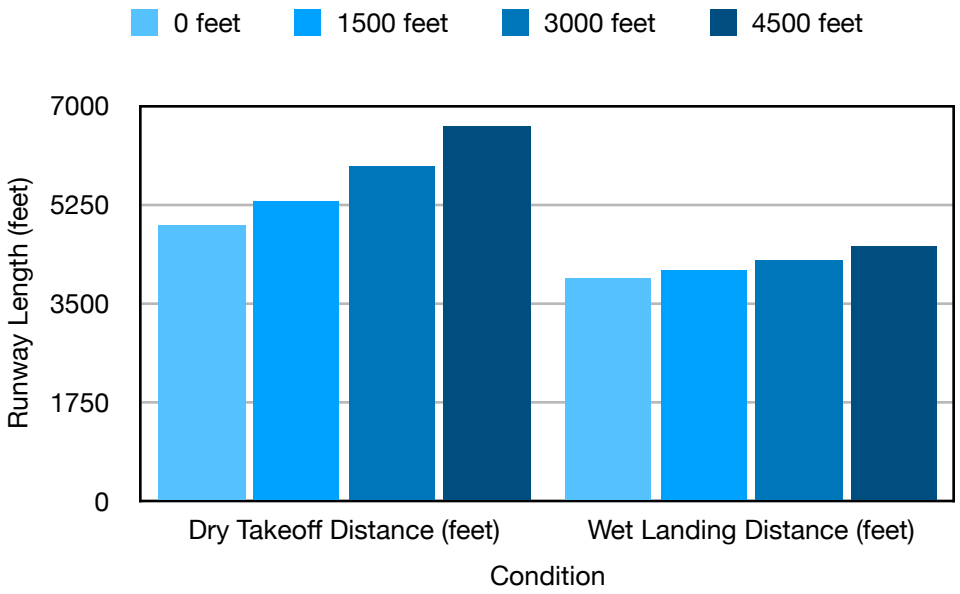
Problem 4

Use the SARLAT tool to estimate the takeoff runway length needed for the Gulfstream G200 (GALX) (see Figure 1).

a) Find the required runway length (dry takeoff or wet landing whichever is higher) at **sea level conditions**, a design temperature condition of 85 degrees Fahrenheit, a 70% load factor, and zero runway grade.

Dry Takeoff: 4870, Wet Landing: 3,927

b) Repeat the analysis performed in part (a) for the same temperature condition but airport elevations of 1500, 3000, and 4500 feet. Plot the runway length required versus airfield elevation. Comment on the trend observed.



Elevation (feet)	Dry Takeoff Distance (feet)	Wet Landing Distance (feet)
0	4,870	3,927
1500	5,325	4,102
3000	5,918	4,288
4500	6,615	4,487

Figure 1. Gulfstream G200 (A. Trani).

Problem 5

Please answer true or false.

Question	True / False
Increased aircraft weight decreases aircraft acceleration on the runway during takeoff.	TRUE
Piston engine performance improves at higher airport elevations.	FALSE
Long runways are needed at higher airport elevations.	TRUE
Departing an upslope runway increases runway length needed.	TRUE
Landing speeds increase at higher elevation airports.	TRUE
For a constant airspeed, higher air density increases the aircraft wing lift.	TRUE
Liftoff speed decreases at higher takeoff weight.	FALSE
Use of flaps decreases approach speed but increases aircraft drag.	TRUE