# Quiz 1

**Solution**

**Instructor: Trani**

## Instructions

Write your solutions in a single MSWord or PDF file. Cut and Paste all your answers using screen captures. Show all your work. Label your file with your last name and CEE4674. Create a PDF file and email your solutions to vuela@vt.edu. In the email header use the words CEE 4674 Quiz.

### 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.

____________________________________________________________ (your signature/name)

# Problem #1 (40 points)

The Los Angeles Airport Authority is planning runway length improvements to runway 24L on the North side of the airport. The airport authority would like to improve runway 24L allowing airlines to conduct takeoffs supporting international cargo services to South America (a growing market). Estimate the runway extension needed for runway 06R/24L if the critical stage length service has been identified at this airport and shown in Table 1.

In your analysis use the latest version of the Boeing documents for airport design and design the runway according to Federal Aviation Regulations (F.A.R.). Add 5% to the distance calculated to account for real Air Traffic route conditions and to account for possible weather deviations from the shortest flight path. In your analysis, consider that cargo airlines would like to carry as much payload as possible.

*Table 1. Critical Aircraft Used in the Redesign of LAX Runway 24L.*

| Origin-Destination Airport Pair | Aircraft Flying the Route |
|---|---|
| LAX - EZE<br><br>Los Angeles to Buenos Aires International Airport (EZE) | Boeing 747-400ER Freighter with General Electric CF6-80C2B5F engines and a maximum takeoff weight of 910,000 *lbs*. |

a) Estimate the fuel load carried and desired takeoff weight to perform the trip LAX-EZE.

| CHARACTERISTICS | UNITS | GE ENGINES CF6-80C2B5-F | PW ENGINES PW4062 | RR ENGINES RB211-524H8-T |
|---|---|---|---|---|
| MAX DESIGN TAXI WEIGHT | POUNDS | 913,000 | 913,000 | 913,000 |
| | KILOGRAMS | 414,130 | 414,130 | 414,130 |
| MAX DESIGN TAKEOFF WEIGHT | POUNDS | 910,000 | 910,000 | 910,000 |
| | KILOGRAMS | 412,770 | 412,770 | 412,770 |
| MAX DESIGN LANDING WEIGHT | POUNDS | 666,000 | 666,000 | 666,000 |
| | KILOGRAMS | 302,093 | 302,093 | 302,093 |
| MAX DESIGN ZERO FUEL WEIGHT | POUNDS | 611,000 | 611,000 | 611,000 |
| | KILOGRAMS | 277,145 | 277,145 | 277,145 |
| SPEC OPERATING EMPTY WEIGHT (1) | POUNDS | 362,400 | 362,400 | 362,400 |
| | KILOGRAMS | 164,382 | 164,382 | 164,382 |
| MAX STRUCTURAL PAYLOAD | POUNDS | 248,600 | 248,600 | 248,600 |
| | KILOGRAMS | 112,763 | 112,763 | 112,763 |
| TYPICAL CARGO – MAIN DECK CONTAINERS (2) | CUBIC FEET | 18,720 | 18,720 | 18,720 |
| | CUBIC METERS | 530 | 530 | 530 |
| MAX CARGO - LOWER DECK CONTAINERS (LD-2) | CUBIC FEET | 5,600 | 5,600 | 5,600 |
| | CUBIC METERS | 159 | 159 | 159 |
| MAX CARGO - LOWER DECK BULK CARGO | CUBIC FEET | 520 | 520 | 520 |
| | CUBIC METERS | 15 | 15 | 15 |
| USABLE FUEL CAPACITY | U.S. GALLONS | 53,765 | 53,985 | 53,985 |
| | LITERS | 203,501 | 204,333 | 204,333 |
| | POUNDS | 360,226 | 361,700 | 361,700 |
| | KILOGRAMS | 163,396 | 164,064 | 164,064 |

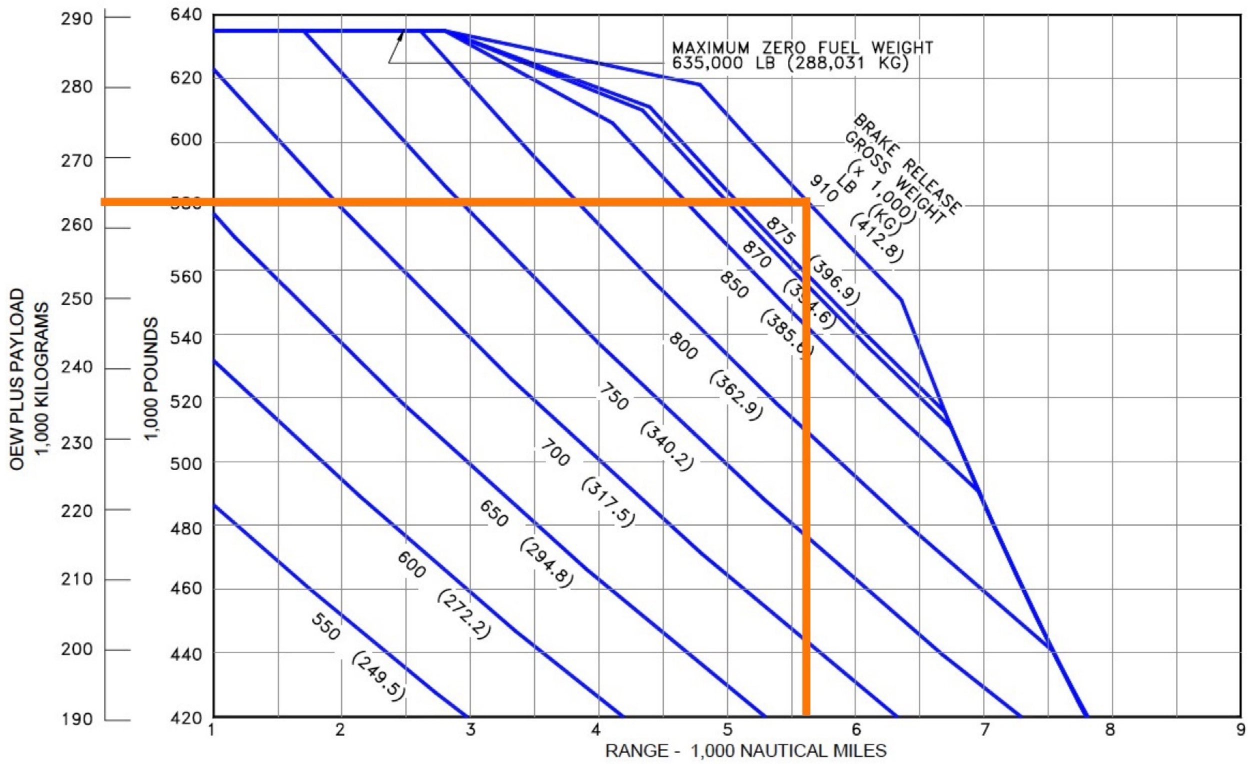



*Figure 1. **Boeing 747-400ER** Freighter Payload Diagram.*

Stage length (Great Circle Route) = 5313 nm

Corrected stage length = 5,578 nm

OEW = 362,400 lb.

MTOW = 910,000 lb.

Maximum Structural Payload = 248,600 lb

Average high temperature of hottest month of the year = 75 deg. C. **(equivalent to ISA + 16.4 deg. F)**

Using the maximum takeoff weight as Desired Takeoff Weight (910,000 lb):

OEW + PYL = 582,000 lb. from payload range diagram.

FW = DTW - (PYL + OEW) = 910,000 - (582,000 lb)

**FW = 328,000 lb (check that it does not exceed the maximum fuel capacity to be 361,700 lb)**

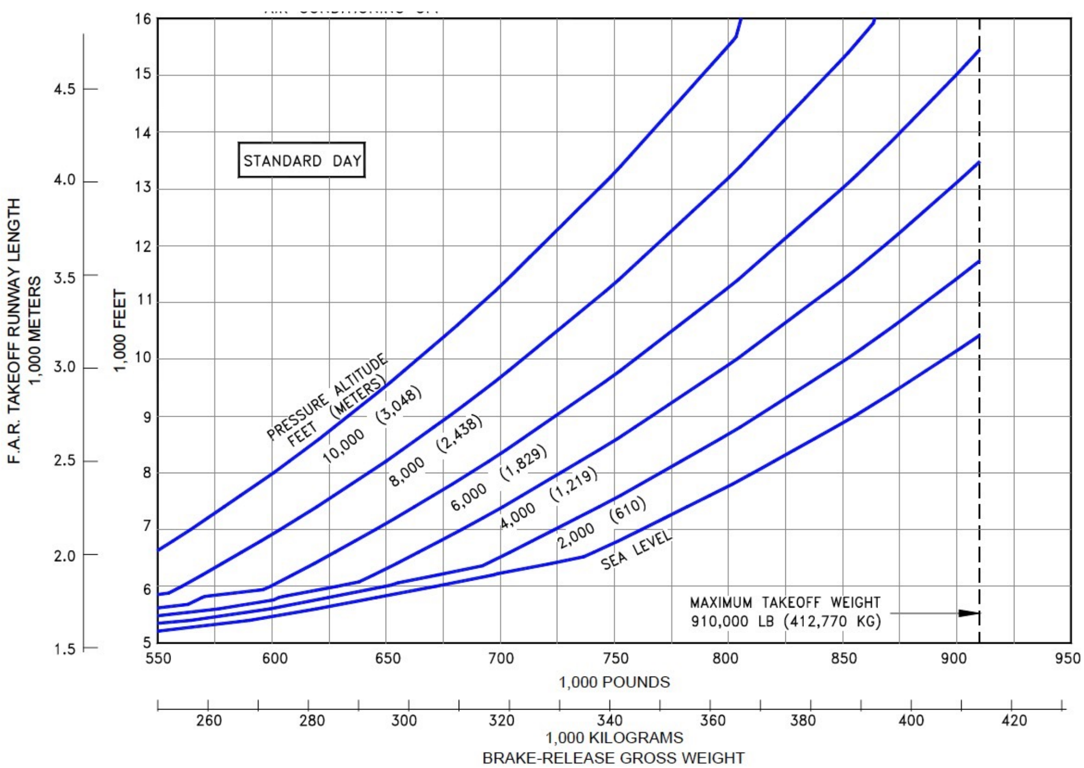



*Figure 2. Boeing 747-400ER FAR Takeoff Runway Length. ISA Conditions.*

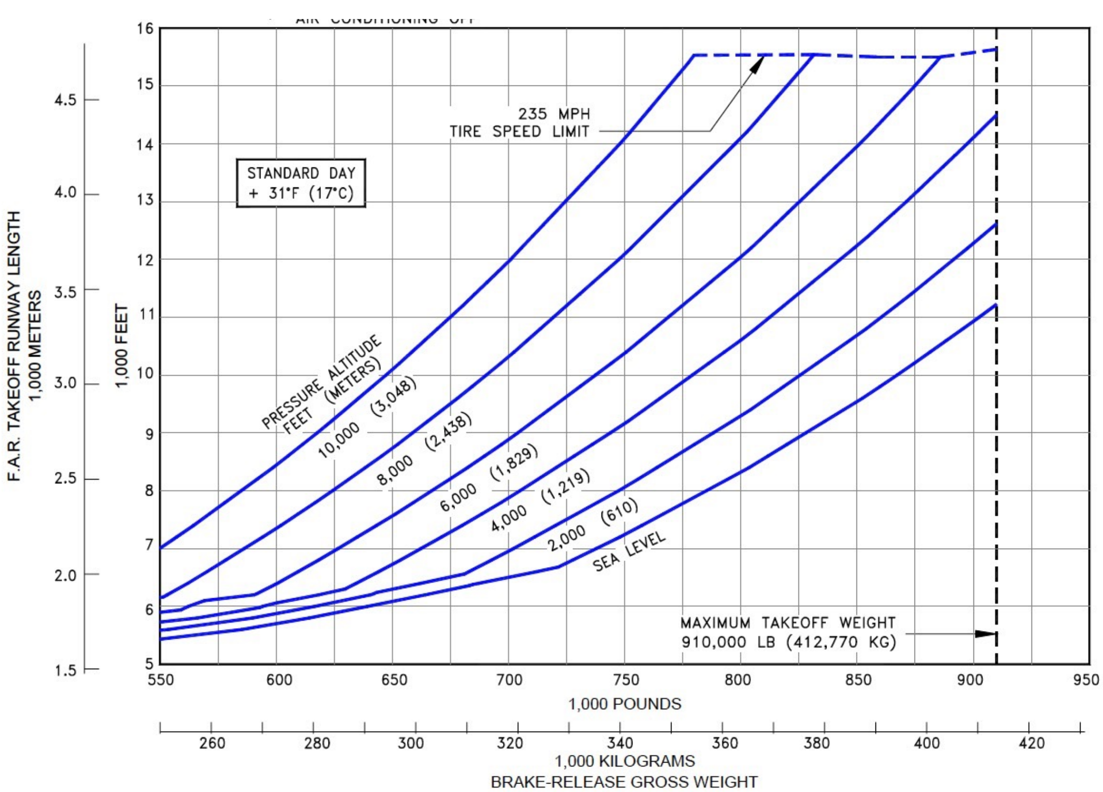



*Figure 3. Boeing 747-400ER FAR Takeoff Runway Length. ISA + 31 deg. F. Conditions.*

b) Find the runway length needed to conduct cargo operations in the proposed route. State the airport design temperature, airport elevation and other environmental conditions and assumptions used in your calculations. State the figure(s) used in the aircraft manufacturer documents.

At Maximum takeoff mass (910,000 lbs and ISA + 31 deg. F) the aircraft needs 11,100 feet of runway.

At Maximum takeoff mass (910,000 lbs and ISA) the aircraft needs 10,300 feet of runway.

**At Maximum takeoff mass (910,000 lbs and ISA + 16.4 deg. F) the aircraft needs 10,800 feet of runway. Apply minimal correction for grade (0.1% at LAX). 10 Feet for each foot en elevation difference yields 10.900 feet.**

The runway length estimated meets F.A.R. regulations. This implies design conditions that include wet/dry conditions.

c) What percent of the maximum structural cargo payload can the airline carry in the LAX-EZE route given your design in part (b) of the problem?

The payload carried is:

PYL = (OEW + PYL) - OEW = 582,000 lb - 362,400 lb.

PYL = 219,600 lb

**This is (219,600 / 248,600) * 100 = 88% of the maximum structural payload**

# Problem # 2 (30 points)

The airport shown in Figure 1 is the subject of the analysis in this problem. The airport serves two small commuter airlines operating Bombardier CRJ-200 and Embraer 145 aircraft. The runway is located 3,100 feet from a small building and for this reason a displaced threshold is provided.

a) Use the declared distance concept, find the Landing Distance Available (LDA) for aircraft landing on runway 33. In your analysis provide full **Runway Safety Area (RSA)** protection prior to the landing threshold and beyond the runway.

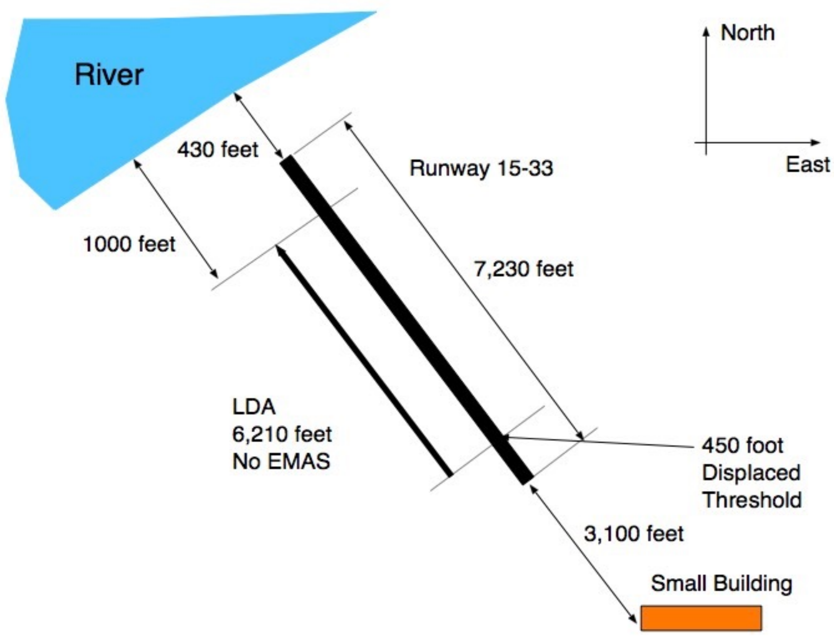



*Figure 4. Solution to Runway Configuration for Problem 2(a).*

**The LDA is 7230 ft - (450 ft) - (1000-430 ft) = 6,210 feet.**

b) Find the Accelerate and Stop Distance Available (ASDA) while taking off on runway 33. In this analysis protect the RSA at the end of the departing runway.

**The ASDA is 7230 ft - (1000-430 ft) = 6,660 feet. With protection of the RSA at the end of the departing runway.**

c) Can an engineered materials arresting system help in this situation? Estimate the size of the EMAS needed and explain.

Yes it would help. With EMAS (330 feet long), the values of the LDA and ASDA would be:

**The LDA is 7230 ft - (450 ft) = 6,780 feet.**

**The ASDA is 7230 ft (full length)**

The length of the EMAS required for a Regional Jet (CRJ-200) is 330 feet long (see next figure).

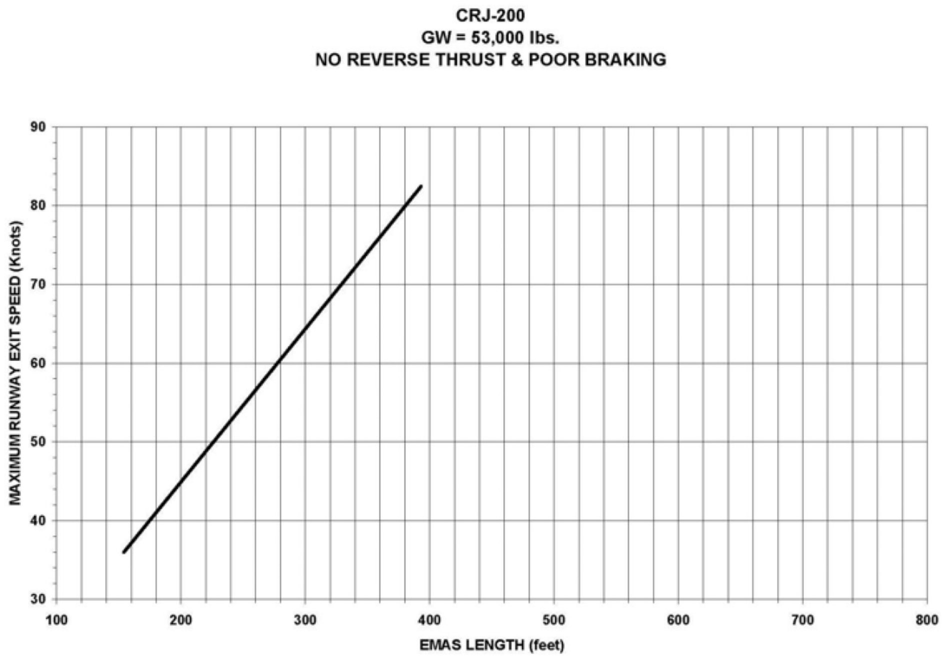



*Figure 5. EMAS for Regional Jet (CRJ-200).*

## Problem #3 (30 points) - Short Answers

a) A new corporate aviation airport is designed to accommodate aircraft such as the Cessna Citation 680 Sovereign (shown below) and used as the critical aircraft. State **all the FAA design codes** used for runway and taxiway geometric design standards.


*Figure 2. Cessna Citation Sovereign at Montgomery County Airport (A. Trani).*

Read the design codes on Appendix 1 in FAA AC 150/5300-13A

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cessna | Citation Sovereign | | II | 3 | 63.3 (19.3) | 20.3 (6.2) | 63.5 (19.4) | 25ǂ (7.6)ǂ | | 12ǂ | 30,300 (13744) | |

**The approach speed is > 91 knots but less than 121 knots. The aircraft belongs to group B.**

b) Can an airport with two parallel runways with centerlines located 2,700 feet apart and with a 200 foot stagger conduct simultaneous departures? Explain any ATC equipment needed for such operations.

**Yes as long as the airport has a standard surveillance radar (scan rate of 5 seconds or less).**

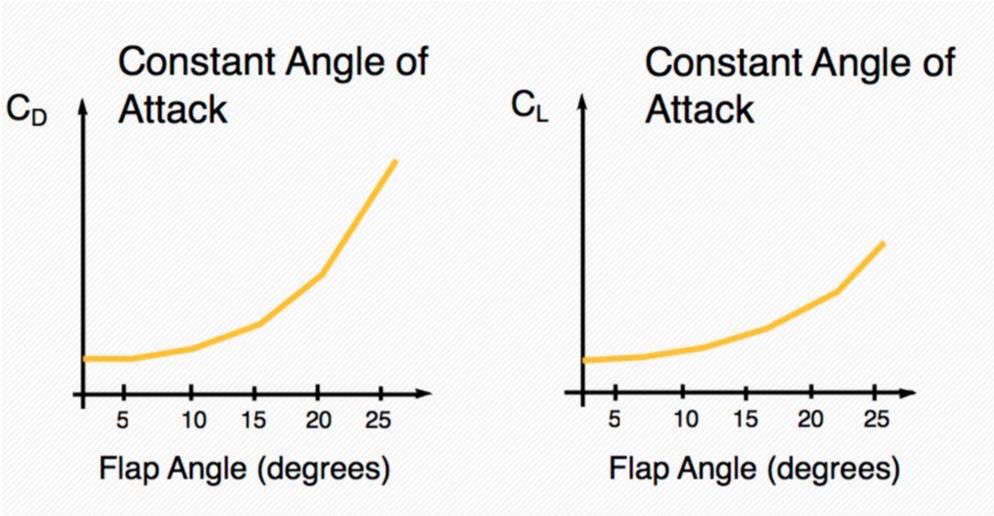
c) Air traffic service that controls the airspace volume while aircraft descend through 9,000 feet at a location 25 nm from Washington Reagan Airport.

**Terminal Radar and Approach Control facility (TRACON).**

d) The following is a short description of an incident that happened on February 20, 2016. "A United Boeing 757-200, performing flight from San Francisco to Denver was on approach to Denver when the crew reported problems with the flaps and advised they would be **landing at a higher than normal speed**" (Aviation Herald, 2016).

Using the basic lift equation explain why would the aircraft have to land at "higher than normal landing speed" if the flaps cannot be deflected to their normal landing position.

**The landing speed increases because less flap reduces the lift coefficient. This produces higher approach and stall speeds.**




e) Find the suitable runway length needed to accommodate light sport aircraft such as the Evektor-Aerotechnik EV-97 (see Figure 3) with a stalling speed of 40 knots. The runway will be at an airport located 4,510 feet above mean sea level conditions.

*Figure 6. Evektor-Aerotechnik EV-97 (source: Wikipedia).*

**Table 1-1. Airplane Weight Categorization for Runway Length Requirements**

| Airplane Weight Category Maximum Certificated Takeoff Weight (MTOW) | | | Design Approach | Location of Design Guidelines |
|---|---|---|---|---|
| 12,500 pounds (5,670 kg) or less | Approach Speeds less than 30 knots | | Family grouping of small airplanes | Chapter 2; Paragraph 203 |
| | Approach Speeds of at least 30 knots but less than 50 knots | | Family grouping of small airplanes | Chapter 2; Paragraph 204 |
| | Approach Speeds of 50 knots or more | With Less than 10 Passengers | Family grouping of small airplanes | Chapter 2; Paragraph 205 Figure 2-1 |
| | | With 10 or more Passengers | Family grouping of small airplanes | Chapter 2; Paragraph 205 Figure 2-2 |

Aircraft is an LSA. Approach speed ~ 50 knots.

For LSA aircraft use 800 feet and increase runway by 80 feet for every 1000 feet in airfield elevation (0.08 x airfield elevation)

**RL = 800 +(4510/1000)*80 = 1,160 feet**

**Alternative Method:**

Use the curves for aircraft with approach speeds above 50 knots (Chapter 2 in FAA Advisory Circular). Note: LSA are not certified under FAR Part 25. Hence the approach speeds need to be checked with the manufacturer.