Quiz 1 - CEE 4674

Airport Planning and Design

Open Book and Notes (75 Minutes)

Your Name: **A. Trani**

Solution1

Your Signature * ____

Problem 1. (35 points) Show all your work.

The Providence (RI) Airport Authority would like to request your services to study runway length improvements to runway 5/23 at the airport (PVD). The airport authority wants to improve runway 5/23 allowing airlines to conduct takeoffs supporting international services to Europe. Estimate the runway extension needed for runway 5/23 if the critical stage length services have been identified at this airport are shown in Table 1.

In your analysis use the latest version of the Boeing documents for airport design (http://128.173.204.63/courses/cee5614/sites_ce_5614.html#Aircraft_Data). Add 6% to the distance calculated to account for real Air Traffic route conditions and to account for possible weather deviations from the shortest flight path.

Table 1. Critical Aircraft Used in the Potential Re-design of PVD Runway 5/23.

Origin-Destination Airport Pair	Aircraft Flying the Route
PVD - FRA Providence to Frankfurt (Germany)	Boeing 757-200 with RB211-535E4B engines. Aircraft maximum design takeoff weight is 255,000 lb. Aircraft has a typical two-class configuration.

a) Find the runway length needed to satisfy the proposed route allowing maximum flexibility to the airline. 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.

Maximum flexibility means operating at MTOW. Here are some of the important weights to keep in mind while solving the problem.

OEW=136,940 lb (62,100 kg)

MTOW = 255,000 lb (115,650 kg)

MSP = 47,060 lb (21,350 kg)

Desired Payload = 186 passengers = 18,600 kg.

GCD = 3,227 nm (3,421 nm)

Use Figure 3.2.2 in the Boeing 757-200 with RB211-535E4B engines.

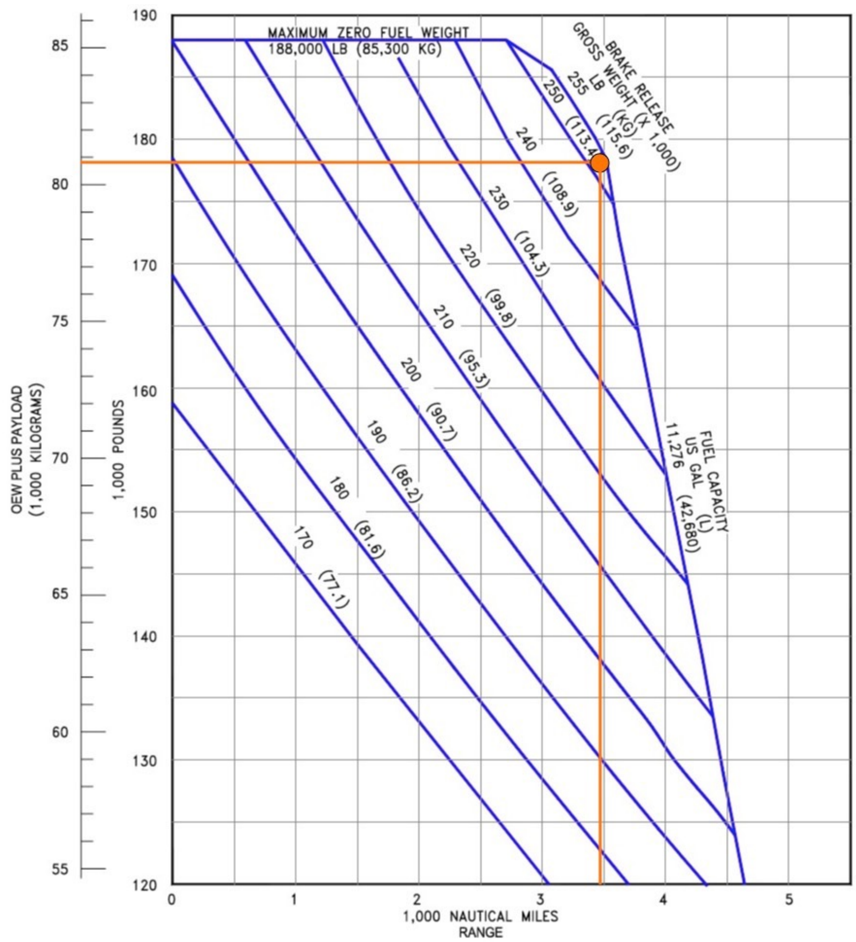

Figure 1. Payload-Range Diagram for Boeing 757-200 with RB211-535E4B engines. Orange line shows the value of OEW+Payload with 186 passengers and to fly a route length of 3,421 nm. Notice that the Desired Takeoff weight (DTW) is pretty much aligned with the value of MTOW.

Table 1. Boeing 757-200 Analysis.

Weight Component	Weight (kg)
OEW	62100
PAY	18600
MTOW	115650
OEW+PAY	80700

Design temperature = 80.8 deg. F. (27.2 deg. C) mean of the maximum temperatures registered in the hottest month of the year - July). Airport is located at 55 feet above mean sea level (practically at sea level). This means the design temperature for our analysis should be ISA + 12.2 deg. C. Looking at the Boeing documents for the 757-200 we find charts for ISA + 14 deg. C. (see Figure 2). These are the charts to be used in the analysis.

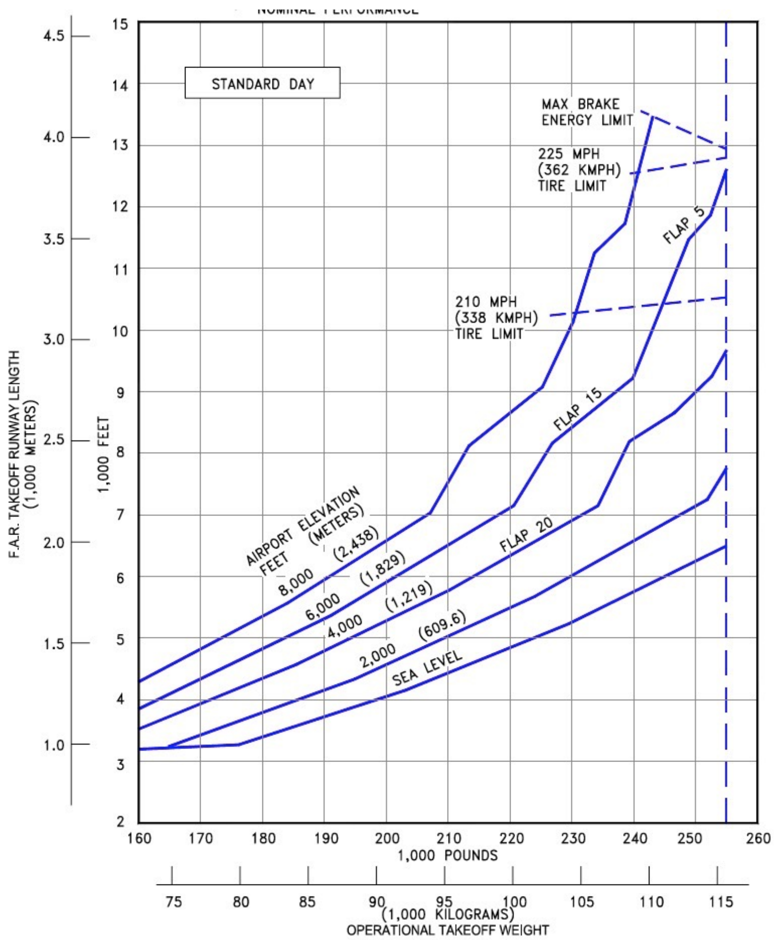

FIGURE 2. BOEING 757-200 TAKEOFF CHART. ISA + 14 DEG. C.

Using the value of MTOW and sea-level conditions we find a runway length requirement of 6,500 feet (uncorrected for gradient). The following grade corrections would apply to both runways at PVD.

Table 2. Grade Corrections for Runways at PVD.

Runway	Length (ft)	Grade (%)	Difference in Centerlines (ft)	Grade Correction (ft)
5/23	7166	0.10	7.166	71.66
16/34	6081	0.4	24.324	243.24

Adding 72 feet to the runway length requirement calculated previously yields 6,572 feet. This means the aircraft can use the existing airport without a runway extension.

b) Find if the airline could carry two 2,000 kilogram LD-3 containers plus a full load of passengers on the same route. Briefly explain.

No, the aircraft is operating at near MTOW due to route length constraints. The aircraft cannot carry extra payload.

Problem # 2 (35 points) Short Answers

a) An airport in the West Coast is considering installing an Engineering Man-made Arresting System (EMAS). The critical aircraft is the Boeing 747-400 aircraft class. Find the length of the EMAS system to stop an overun. State the design speed used in your analysis.

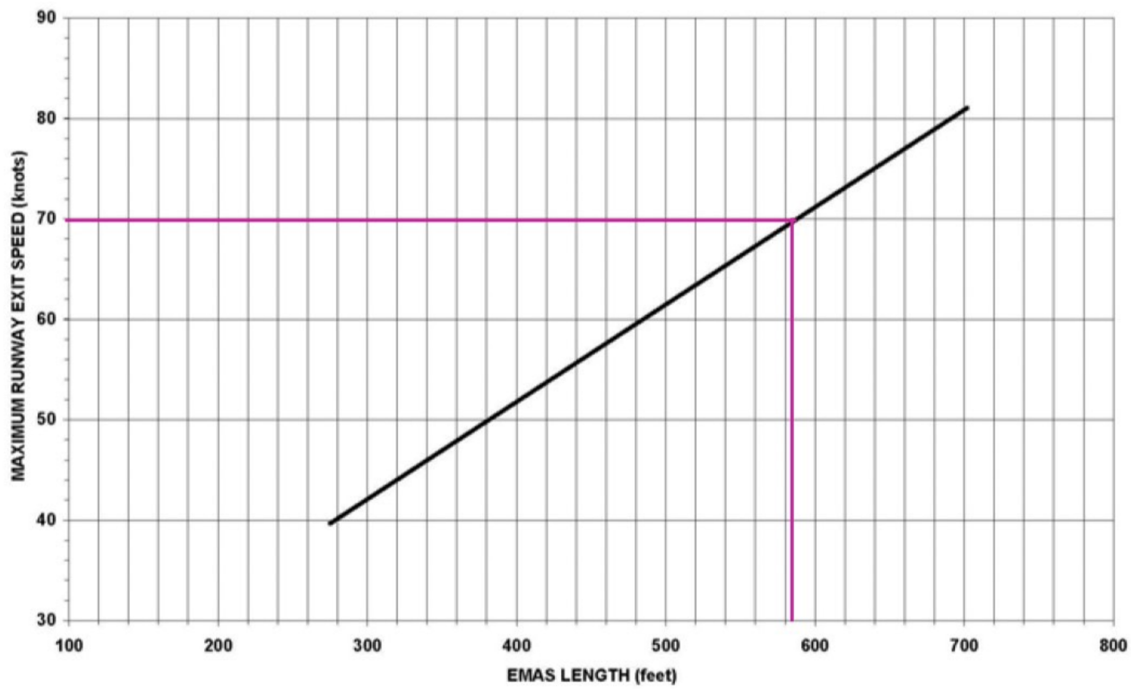

FIGURE 3. PLANNING DOCUMENT FOR BOEING 747 CLASS EMAS.

The expected length of the EMAS is 600 feet. The design speed should be 70 knots.

b) The Payload Range diagram shown in Figure 1 applies to a narrow-body commercial aircraft with 150 seats (OEW ~ 84,000 lb.). Find the average fuel used per passenger (in kilograms per passenger) to fly 2,000 nautical miles (already corrected for ATC and weather detour) with a full passenger load plus 3,000 lbs. of extra cargo.

150 passengers = 33,000 lb. OEW+Payload = 117,000 lb. Adding cargo of 3,000 lb we have: DTW = 120,000 lb. The intersection of 120,000 lb and the 2,000 nm is 150,000 lb. in the Payload-Range diagram.

FW = DTW - (Payload + OEW) = 150,000 lb - (36,000 + 84,000 lb)

FW = 30,000 lb. for the journey. At 150 passengers, the fuel per passenger is:

$$FW / pax = \frac{30000 lb}{150\, pax / flight} = 200 lb / passenger$$

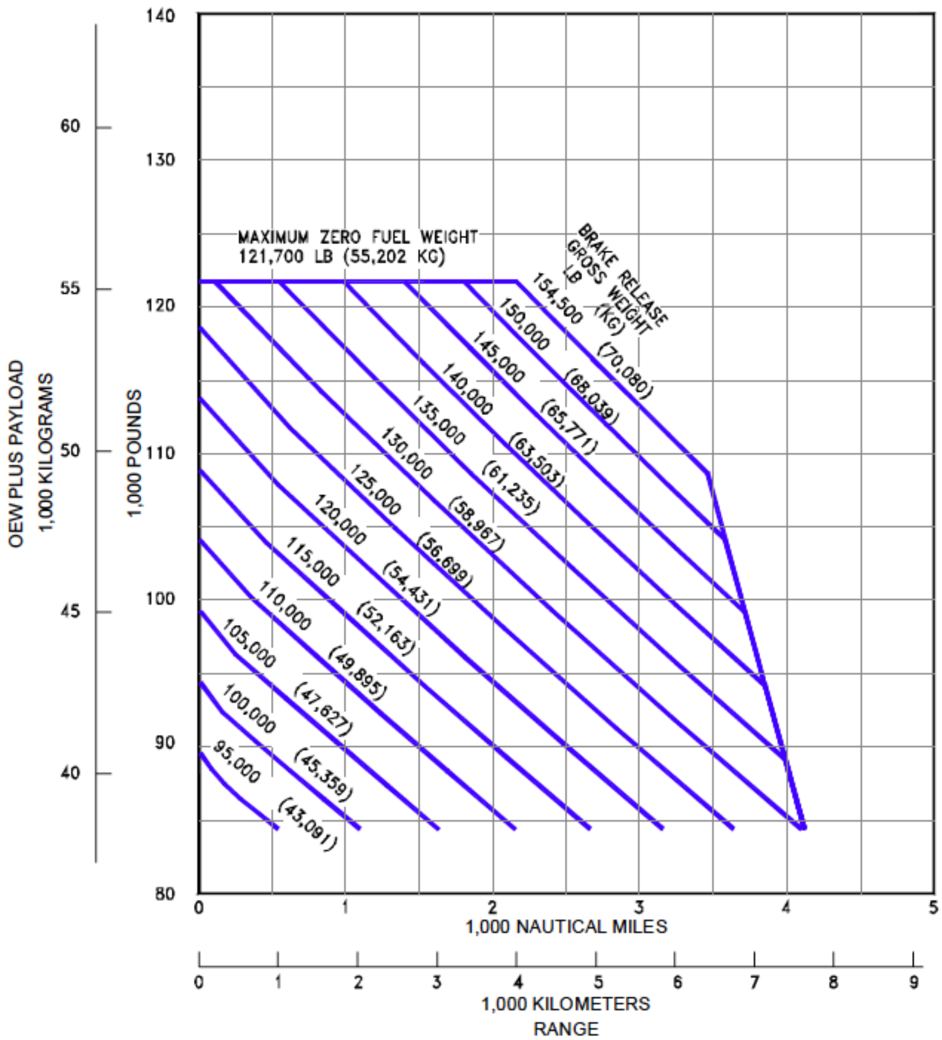

Figure 1. Payload Range Diagram for Part (b) of Problem 2.

Problem #3 (30 points) - Short Answers

a) A new general aviation airport is to be designed and the Gulfstream G550 is used as critical aircraft. State the FAA and ICAO airport design code used for runways and taxiways geometric design standards.

Use FAA airport design standards C-III for this airport.

ICAO runway Code 3 (landing distance is between 1,200 and 1,800 meters). The ICAO design standard is C (28.5 meters of wingspan)

b) In the revision of an existing runway length for a GA airport serving 75% of the fleet of aircraft (using the 60% useful load curves) in the weight range of 12,500-60,000 lbs., an engineer determines 5,350 feet of runway is needed without corrections for wet pavement or runway grade. Suppose the existing runway has a maximum centerline elevation difference of 12 feet. Find the corrected runway length considering wet pavements and grade corrections.

Grade correction = Add 10 feet for each foot in runway celebration.

Grade correction = 12(10) = 120 in feet

Grade correction (runway length) = 5,350 ft + Gradient Correction = 5,470 feet.

Wet pavement correction 15% above uncorrected up to 5,500 feet. Since 1.15 * 5,350 feet > 5,500 feet, we only correct the **runway up to 5,500 feet.**

Wet pavement and grade corrections are mutually exclusive.

c) Explain what is the impact of high flap settings (i.e., large flap deflections) in the landing distance of an aircraft. Use the Boeing 757-200 (used in Problem 1) performance data to illustrate as needed.

High flap setting produce a large amount of drag. High flap settings are associated with landing.

d) Find the suitable runway length needed to accommodate Light Sport Aircraft (LSA) such as the Flight Design CTLS (see the figure below) whose approach speed is 49 knots. The airport is to be built at an elevation of 3,100 feet above mean sea level conditions.

The baseline runway length is 800 feet. However we need to correct due to airport density effect.

Increase runway by 80 feet for every 1000 feet in airfield elevation (0.08 x airfield elevation)

Runway length = 800 feet + 3100/1000 * 80 feet = 1,048 feet