Final Exam for CEE 4674

Date Due: December 8, 2023 at midnight
Instructor: Trani

Sign VT Honor Code Pledge

This exam is the product of my own group's work (two students per group). We have not received help from anyone outside our group.

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Problem 1 (30 Points)

Evaluate the runway length required for aircraft operations from a new airport located at sea level and with a design temperature of 82 degrees Fahrenheit. The critical aircraft is the Boeing 787-8 (see Figure 1). **The airline would like to operate the aircraft at maximum takeoff weight**.

Boeing 787-8 with Rolls-Royce engines. Aircraft maximum takeoff weight is 502,500 lb. 242 seats in dual-class seating layout.

Figure 1. Japan Airlines Boeing 787-8 Dreamliner Landing at San Diego International Airport. Source: A. A. Trani.

a) Find the runway length needed for the aircraft to operate at **maximum takeoff weight** (unconstrained) from the new airport. Please be clear in all your assumptions to solve the problem.

b) Find the number of cargo containers the aircraft can carry departing at the maximum takeoff weight.

c) If the aircraft departs at maximum takeoff weight, find the maximum distance the aircraft can fly (i.e., range). Show me the steps in your analysis.

Problem 2 (40 Points)

The problem is to estimate delays for departures and arrivals for the airport configuration provided in Figure 2. The airport aircraft mix, runway occupancy times and approach speeds are shown in Table 2. The airport has an airport surveillance radar (ASR) and ADS-B surveillance to track aircraft up to 60 nautical miles form the airport site. The ADS-B system can update the position of aircraft every one second. The airport conducts departures from runway 5L and arrivals from runway 5R.

Tables 1 through 3 show the technical parameters and the Air Traffic Control separations at the airport under Instrument Meteorological Conditions (IMC). Two aircraft groups (of the nine groups included in the Consolidated Wake Categories defined by FAA) operate at the airport. The airport has the following technical parameters: a) in-trail delivery error of 17 seconds, b) probability of violation is 5%. Air traffic controllers direct traffic to intercept a final approach path at a fix in space located 13 miles from the runway threshold. Arrivals follow in-trail after crossing the final approach fix.

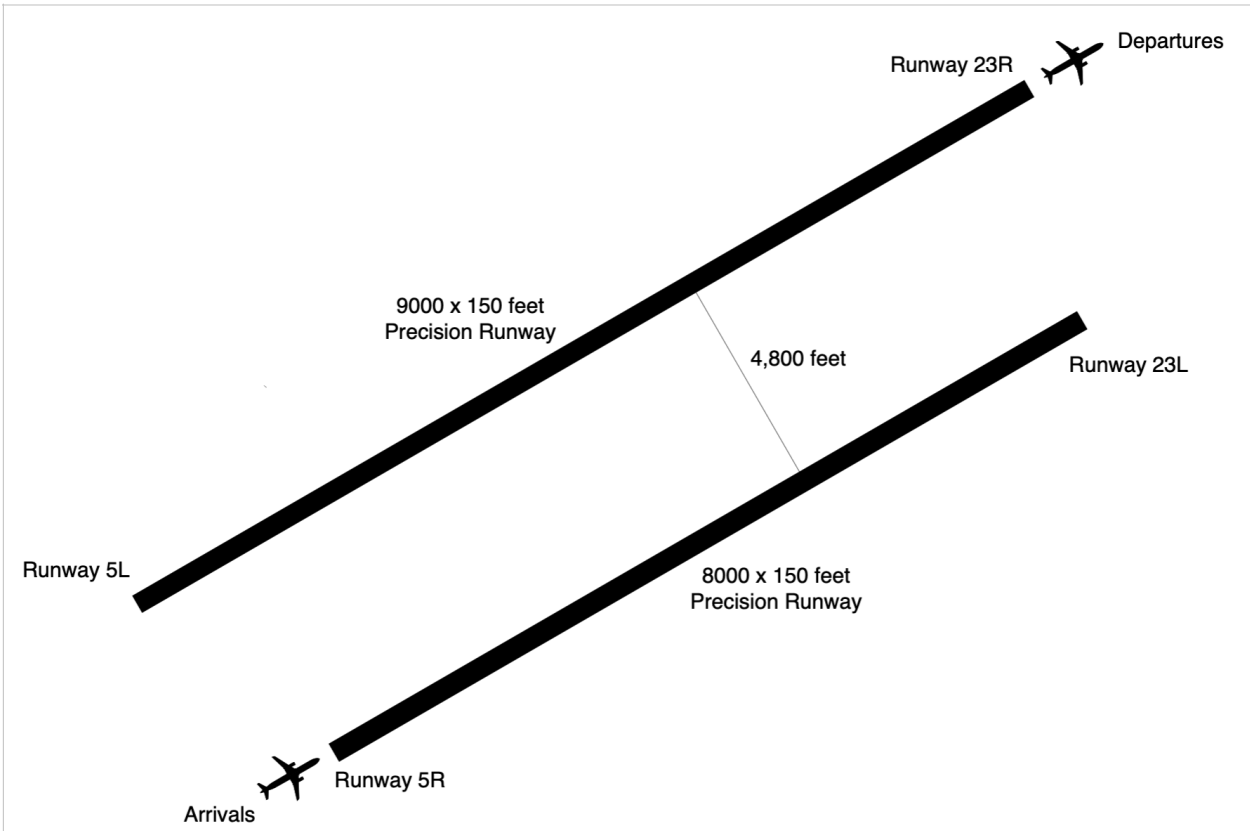

Figure 2. Airport Configuration for Problem 2.

You are allowed to modify the spreadsheet provided in class to solve the problem. Show me sample calculations for both opening and closing cases so that I know that you can do such calculations by hand.

a) Calculate the arrivals-only saturation capacity under IMC conditions.

b) Calculate the departures-only saturation capacity under IMC conditions.

c) **Draw the arrival-departure capacity diagram** (Pareto diagram) under IMC conditions. No sketches are accepted.

Table 1. Runway Occupancy Times and Fleet Mix for Problem 3.

Consolidated Weight Turbulence Group	Percent Mix (%)	Runway Occupancy Time (s)	Typical Approach Speed (knots) from FAF
F	86	56	138
B	14	67	152
Totals	100		

Table 2. Minimum arrival-arrival separations under IMC conditions. Values in are nautical miles. ***Values Shown Do Not Include Buffers.*** *Full Table Available on Page 54 of Aircraft Classifications Handout.*

	Trailing Aircraft (Columns 2-3)	
Lead (Column 1)	**F**	**B**
F	3	3
B	5	3

Table 3. Minimum departure-departure separations under IMC conditions. Values in are seconds. ***ATC Buffers are Included.***

	Trailing Aircraft (Columns 2-3)	
Lead (Column 1)	**F**	**B**
F	70	75
B	130	125

Figures 3 and 4 show the arrival and departure schedules for the future year of analysis.

d) Use the Deterministic Queueing theory method explained in class to estimate the total delay (in units aircraft-hours) for arrivals to runway 5L. You can use the MATLAB code provided in class. Show me the input parameters that you changed to solve the problem. Specifically estimate the following:

e) Estimate the average delay (in minutes per arrival) for arrivals to runway 5R. Show how many arrivals are subject to delays.

f) Estimate the average delay for departures (in minutes per departure operation). Show how many departures are subject to delays.

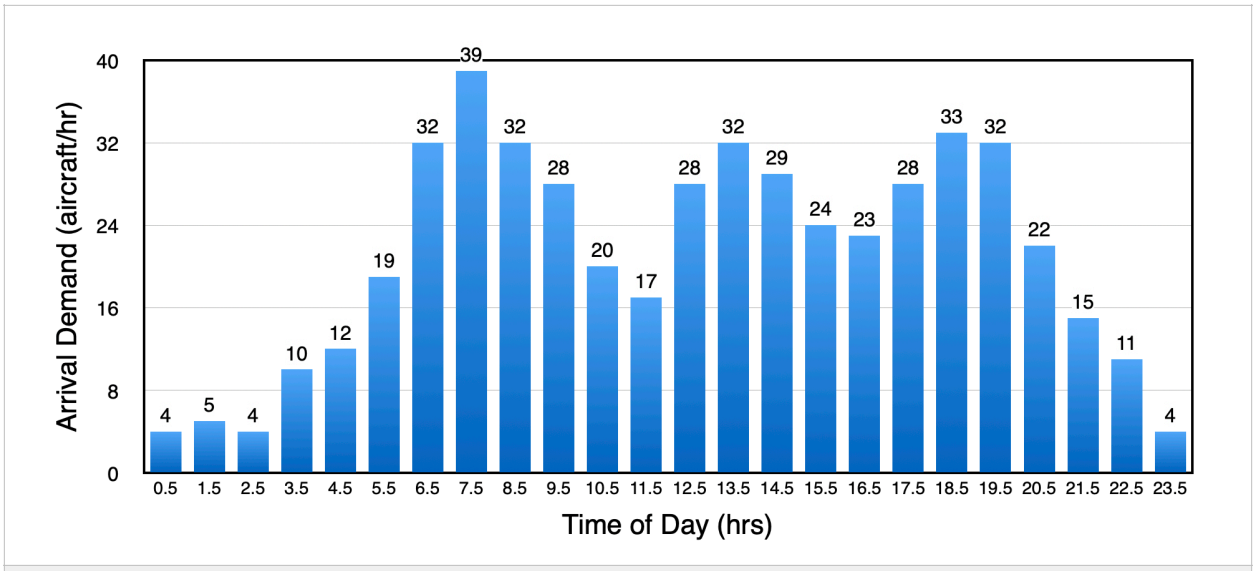

Figure 3. Airport Arrivals Schedule for Problem 2.

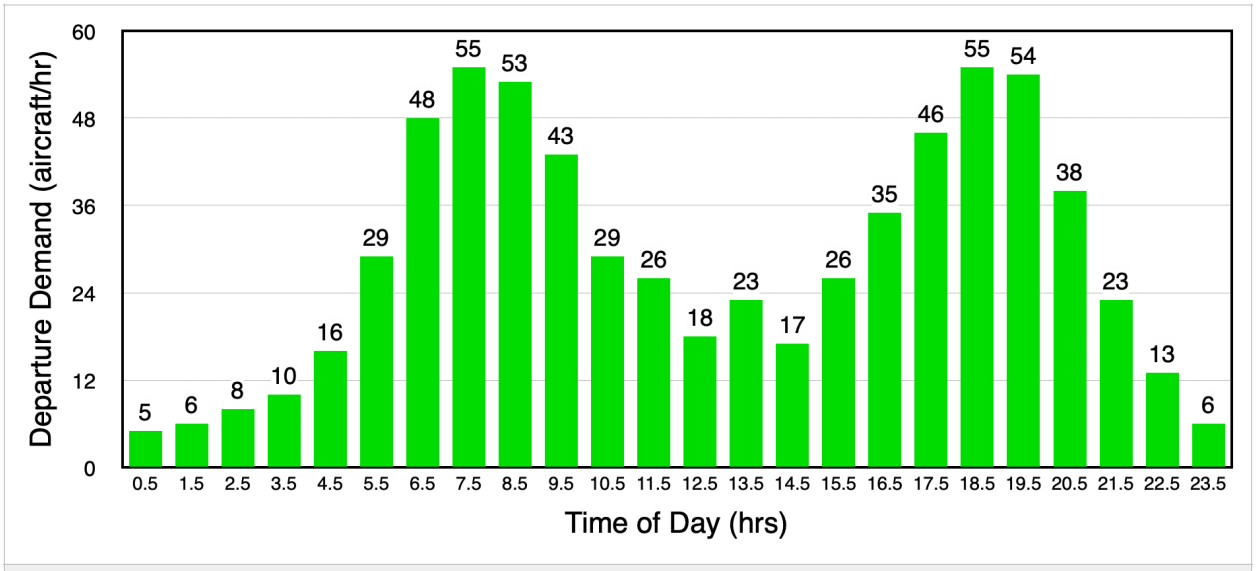

Figure 4. Airport Departures Schedule for Problem 2.

Problem 3 (30 Points)

Table 4 shows data collected at a proposed airport site. The data is supplied as a companion spreadsheet to the problem. The critical aircraft for this airport is expected to be the Cessna Citation Excel (560 XLS) (see Figure 5). The airport site is located at 850 feet above sea level with a design temperature of 80 deg. Fahrenheit.

Table 4. Data for Wind Rose Analysis.

		Wind Speed in Knots					
Azimuth (degrees)	Calm Winds	3.0 - 4.9	5.0 - 9.9	10.0 - 15.9	16.0 - 20.9	21.0 - 26.9	> 27.0
355-004		0.375	1.085	0.578	0.116	0.034	0.012
005-014		0.306	0.959	0.702	0.212	0.095	0.015
015-024		0.235	0.924	0.831	0.368	0.149	0.020
025-034		0.200	0.827	0.851	0.317	0.093	0.025
035-044		0.218	0.759	0.713	0.278	0.088	0.023
045-054		0.186	0.727	0.714	0.223	0.064	0.016
055-064		0.203	0.796	0.707	0.224	0.066	0.012
065-074		0.218	0.793	0.765	0.199	0.040	0.005
075-084		0.210	0.717	0.508	0.121	0.029	0.008
085-094		0.194	0.561	0.367	0.075	0.023	0.005

Figure 5. Cessna Citation Excel (model 560 XLS) used as Critical Aircraft for Problem 3.

a) State the crosswind component used in the wind rose analysis.

b) Find the optimal runway orientation for the new runway using the wind rose analysis.

c) Is one runway good enough to satisfy the FAA 95% coverage criteria? Comment.

d) Show the wind rose used in your analysis.

e) Use the SARLAT tool to design the runway length for the critical aircraft using a 90% useful load.