Final Exam for CEE 4674

Date Due: December 16, 2024 at midnight
Instructor: Trani

Sign VT Honor Code Pledge

This exam is the product of my own group's work. I pledge that I have not received help from anyone outside.

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Problem 1 (25 Points)

Evaluate the runway length required for aircraft operations from a new airport located 1,850 feet above mean sea level conditions and with a design temperature of 86 degrees Fahrenheit. The critical aircraft is the Boeing 787-10 (see Figure 1). The aircraft information is described in Figure 1. **The airline would like to operate the aircraft at maximum takeoff weight**.

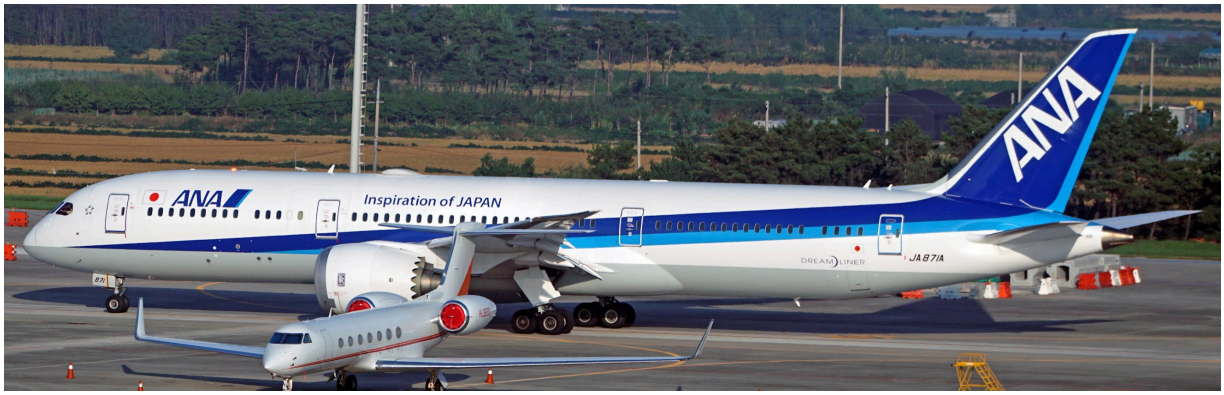

Figure 1. Boeing 787-10 with High-Thrust Rolls-Royce engines. Aircraft maximum design takeoff weight is 560,000 lb. 330 seats in a two-class layout. See other characteristics in the Boeing documents for airport planning and design.

a) Find the runway length needed for the aircraft to operate at **maximum allowable takeoff weight** from the new airport. Please be clear in all your assumptions about solving the problem. Also, please show me the aircraft manufacturer figures used in your solution.

b) Find the amount of “belly” cargo (in addition to the full passenger load) the aircraft can carry departing the new airport.

c) If the aircraft departs at the maximum allowable takeoff weight, find the maximum range possible.

d) Find the maximum passenger and cargo capacity if the runway is limited to 10,500 feet and the airline wants to fly 4000 nautical miles.

Problem 2 (30 Points)

The problem is to estimate departure and arrival delays 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 from the airport site. The ADS-B system can update the position of aircraft every second. The airport conducts departures from runway 09 and arrivals from runway 5.

Table 1 shows the technical parameters at the airport under Instrument Meteorological Conditions (IMC). Three aircraft groups (of the nine groups included in the Consolidated Wake Categories defined by FAA) operate at the airport. The airport has the following additional technical parameters: a) in-trail delivery error of 18 seconds, b) probability of violation is 5%. Air traffic controllers direct traffic to intercept a final approach path at a fix-in space 12 miles from the runway threshold. Arrivals follow in trail after crossing the final approach fix. To solve the problem, use the Consolidated Wake Separations provided in class (see your class notes). Use the departure-departure separations supplied in class.

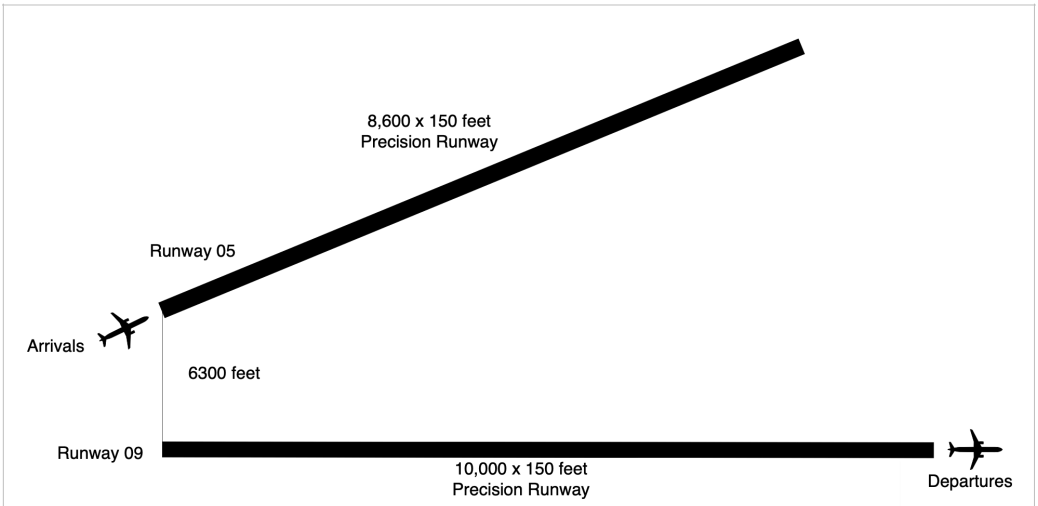

Figure 2. Airport Configuration for Problem 2.

You can modify the spreadsheet provided in class to solve the problem. Show me sample calculations for opening and closing cases so that I know 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 2.

Consolidated Weight Turbulence Group	Percent Mix (%)	Runway Occupancy Time (s)	Typical Approach Speed (knots) from FAF
F	65	56	135
G	26	53	131
H	9	51	124

d) Use the Deterministic Queueing theory method explained in class to estimate the total delay (in units of aircraft hours) for arrivals to runway 5. You can use the MATLAB code provided in class. Please 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 5. Show how many arrivals are subject to delays.

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

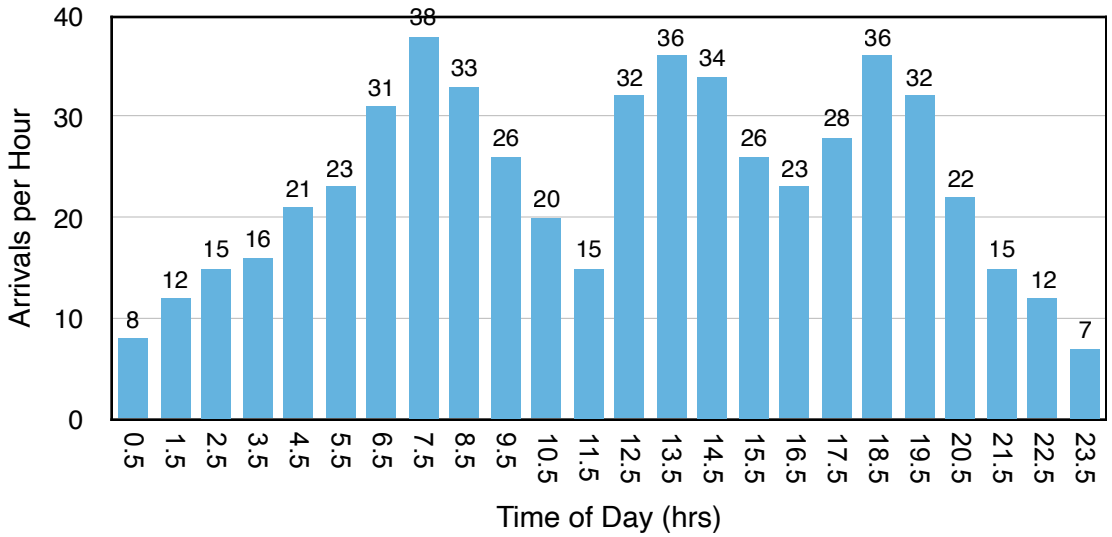

Figure 3. Airport Arrival Demand over Time.

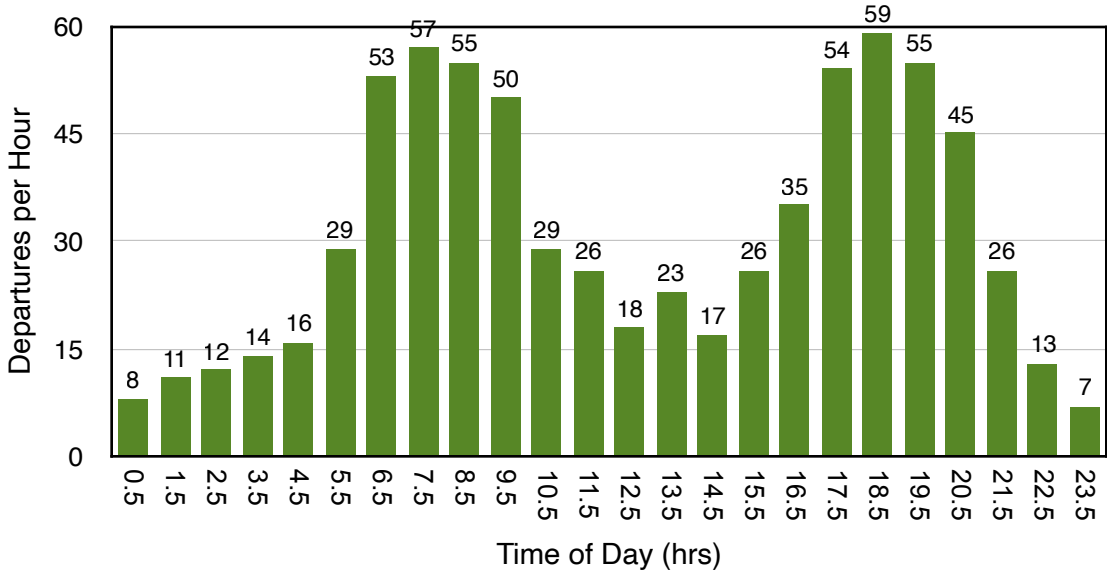

Figure 4. Airport Departure Demand over Time.

Problem 3 (25 Points)

Provide quick answers to each question.

a) State the critical crosswind design value if the Airbus A330-900 is the largest aircraft operating at the airport.

b) Use the SARLAT tool to estimate the dry runway length required for a Honda Jet 420 operating at a 90% load factor from an airport at 2,600 feet above sea level and 89 degrees Fahrenheit.

c) Find the EMAS length required to stop a Boeing 747-400 at the FAA-recommended design speed. Compare that against the FAA RSA length needed.

d) Find the runway width, the runway shoulder width, and the blast pad length for a Boeing 747-8i. Assume low visibility operations below 1/2 mile.

e) Why do low visibility operations require more protection around a runway? Briefly explain.

f) Find the taxiway design group for the Boeing 777-300ER.

Problem 4 (20 Points)

Use Google Earth to comment on the airport terminal design configuration for one of the following airports (pick one and comment).

a) Los Angeles International Airport

b) Atlanta International Airport

c) Singapore International Airport

d) Beijing Daxing International Airport

1) Tell me the airport terminal configuration (vertical and horizontal distribution elements)
2) Explain some of the positive aspects of the selected airport terminal configuration.
3) Explain some of the negative aspects of the selected airport terminal configuration.
4) Explain how the airport terminal fits between the runways, taxiways, and other airside design elements. Explain the runway separations observed and the possible use of the runways for simultaneous operations.
5) Find the number of gates at the airport terminal(s)
6) Comment on the possible need for people movers to transport passengers from the land to the air. Consider the distance from the area where passengers are dropped off to the gates.