Northeastern

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Problem Set #3
Due: Friday, February 21, 2025

1. An airport services three types of airplanes: Heavy (H), Large (L) and Small (S). The approach to the runway is n =5 n. miles. The planes have the following characteristics:

Type	Approach Speed (knots)	Mix (%)	Occupancy (sec)
H	150	25	40
L	120	50	40
S	90	25	30

The minimum separation between the various airplane types is given in the table below:

		Trailing aircraft		
		H	**L**	**S**
Leading aircraft	**H**	5	5	6
	L	4	4	4
	S	4	4	4

The above separation distances include a safety buffer, so there is no need to add extra time.

a. Find the landing capacity of the runway, assuming a random sequencing of landings.
b. Find the corresponding average delay per airplane (assuming an arrival rate of 20 arrivals per hour).
c. Assuming that the approach speed for small airplanes can increase to 120 knots find the corresponding capacity.
d. Assume that the minimum separation criteria for S-L, S-H, L-H cases (i.e cases with no wake vortex considerations) is decreased to 3 n. miles. Find the corresponding capacity.
e. Assume now that the ATC can deliberately control the sequence of landings. Air traffic controllers can land small aircraft first at intervals equal to 160 sec, then transition to large planes with one 120-sec interval, and land the sequence of large planes at 120-sec intervals; then transition to heavy aircrafts with a 96-sec interval followed by 120-sec intervals between all the heavy aircrafts. For this sequence and intervals find the corresponding capacity (assuming that 100 aircrafts landed, i.e., 99 intervals).
f. Based on the above results identify different approaches to improve runway capacity. Discuss relative advantages and disadvantages of the various approaches.

2. An airline operates 2 check-in counters. The service time is exponentially distributed with an average of 2 min per customer. Customers arrive according to a Poisson process at a rate of 40 customers per hour. The airline is considering two alternative modes of operation.

   a) customers form a single line and use the first available check-in counter.

   b) customers form two separate lines, one for each check-in counter. Each arriving customer is assigned randomly to one of the check-in counters (regardless of its status).

   Compare the two alternatives in terms of average waiting time. Make a recommendation in terms of the preferred option.

3. Show that:

$$k = \frac{\%o}{100} * \frac{1}{L_v + L_D}$$

   where,
   % o: percent occupancy
   k: corresponding density
   L_v: Average vehicle length
   L_D: detection zone length

4. Answer the following:
   a) A traffic stream displays average vehicle headways of 2.2 sec. at a speed of 50mi/h. Compute the density and flow for this traffic stream.
   b) At a given section, the space mean speed is measured as 40 mi/h and the flow as 1,600pc/h/ln. What is the density for the analysis period?

5. A single loop detector has a length of 9 feet. It recorded 6 vehicles over a period of 142 sec. The occupancy times of the vehicles are (in seconds): 0.46, 0.48, 0.53, 0.42, 0.52, 0.45. The lengths of the vehicles are known and given by (in feet): 18, 21, 20, 23, 17, 19.

   a) Find the occupancy of the detector
   b) Find the speeds of the vehicles and the average speed
   c) Find the flow and the density
   d) Assume now that the lengths of the vehicles are not known but the average length is known (given by the average of the lengths given above). Calculate vehicle speeds, flow and density. Comment on the difference with the values found in b) and c).