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Problem Set No. 9 Date Due: May 6

1) Airplanes arrive for landing at San Francisco airport at a rate of 1 every 45 seconds. Each airplane spends an average of 15 minutes in the air above San Francisco before landing (circling + approach). Once on the ground each plane spends an average of 5 minutes taxiing to the gate. Finally, each plane spends an average of 60 minutes at the gate before turning around for another take-off.

A) What is the average number of planes circling in the air above San Francisco?
B) What is the average number of planes on the runways and taxiways?
C) What is the average number of planes waiting at the gates?
D) Do the above numbers make sense? If not, what's wrong with them?

2) Suppose now that planes line-up for take-off at a rate of 1 per 45 seconds. Also suppose that San Francisco airport has a capacity of two take-off per minute (i.e., the average amount of time between take-offs is 30 seconds and is Exponentially distributed).

A) What is the average delay per take-off?
B) Suppose that due to foggy conditions at the airport, the airport is operating at a rate of one take-off per minute. What is the average delay experienced per take-off? Can you explain your answer?

3) A professor schedules two meetings with students for the same time. Each meeting has an average duration of 30 minutes (exponentially distributed). Suppose that the first student arrives on time and that the second student arrives 5 minutes late. Compute the average amount of time between the arrival of the first student and the departure of the second (Hint: This problem deals with the exponential distribution and the answer is: 60.394 minutes).

4) Packets arrive at link at an average rate of 10 per second. The transmission rate of the link is 20,000 bits per second and the average packet length is 1000 bits. Assume that packet lengths are Exponentially distributed, and that arrivals are Poisson.

A) What is the transmission rate in packets per second?
B) What is the average queueing delay?
C) What is the average number of packets in the buffer?
D) What is the probability that the system is empty?
E) Repeat parts B and C assuming that the packets are all the same length.
F) Repeat parts B and C assuming that 1/2 the packets are 500 bits and 1/2 are 1500 bits.

5) A communications satellite company establishes a direct connection between a remote town and the company's central office for providing telephone services. Calls arrive as a Poisson process at a rate of 30 calls per minute. Call durations are Exponentially distributed with an average of 3 minutes. How many circuits should the company provide to ensure that a blocking probability of less than 1% is maintained?