1. If a bucket has a small hole at the bottom, the water leaks from the bucket at a constant rate as long as there is water in the bucket. The rate at which water leaks does not depend on the rate at which the water is input to the bucket unless the bucket is empty. Figure 1 depicts a leaky bucket and its effect.

Fig. 1: Leaky bucket

A common way to exercise *flow control* in communication networks is to use the *leaky bucket* mechanism. Arriving packets from a process is fed into a queue (i.e., the packet queue) of size K (where K may be infinite). The leaky bucket is implemented as a second queue (i.e., the token queue) of size B where "tokens" are stored. The token generation mechanism is deterministic with period T, that is, after every T time units, a token is added to the token queue. When a token finds the token queue full, it is discarded. If an arriving packet finds a token in the token queue, the token is removed from the token queue and the packet is forwarded. In contrast, if an arriving packet finds the token queue empty, it joins in the packet queue. The head-of-line packet from the packet queue is forwarded when a token arrives by removing the token from the token queue. The leaky bucket implementation is illustrated in Fig. 2. The goal of this flow control mechanism is to decrease the variance of the packet interarrival times of the packets while maintaining the packet queue length (and therefore queueing delays) as minimum as possible.

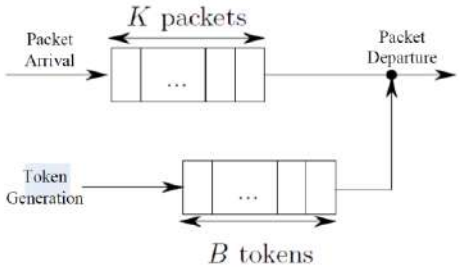

Fig. 2: A leaky bucket implementation by two queues

Assume that both the packet queue and the token queue are initially empty. The system is investigated for the first n packets. With probability 0.6 the next packet interarrival time is fixed at 0.2 seconds, and with probability 0.4 the next packet interarrival time is exponentially distributed with mean $\frac{1}{\lambda}$.

a)	Write down the goals and objectives of the simulation.
b)	What are the state variables and output variables for the simulation model?
c)	Identify the set of events for the simulation model.
d)	Write down the state equations and output equations for the simulation model.
e)	Write down the state space for the simulation model.
f)	Draw separate flow charts of the event routines (i.e., the event handler functions) for each of the events of the system.
g)	Draw the flow chart of the function that updates the necessary statistical variables according to the output equations of the simulation model.
h)	Suppose the system does not want to allow new packets after T time units, though it will forward the already arrived packet from the queue. How would you add such a stopping rule?