1. Consider a random access system based on Slotted ALOHA. Let T denote the length of a time slot in this system. Let n denote the number of stations using this random access system. Assume that, during interval $[0, 10T]$, each station transmits exactly one packet (no retransmissions due to collisions). What is the maximum value for n if we require that the probability that there will be no collisions during interval $[0, 10T]$ should be greater than 0.5?

2. Consider a connectionless packet switched (trunk) network. There are three nodes connected to each other as a triangle. Each node pair is connected with two one-way links (one in each direction) of capacity 155 Mbps. Assume that the following five routes are used in this network:

   - Route 1: a — b
   - Route 2: a — c — b
   - Route 3: a — c
   - Route 4: c — b
   - Route 5: b — a

   Assume further that the delays due to processing packets in the nodes is negligible (if compared to delays due to packet transmission).

   Model this system as a queueing network. Draw a picture describing this queueing network model. Assume that, for each route, new packets arrive according to an independent Poisson process with intensities $\lambda(1) = 20$, $\lambda(2) = 10$, $\lambda(3) = \lambda(4) = \lambda(5) = 5$ packets per millisecond (ms). Assume further that the packet lengths are independent and exponentially distributed with mean 400 bytes.

   Compute the traffic loads ρ_j in each link j. What is the probability that the network is totally empty of packets (at an arbitrary time). Compute further the average end-to-end delays for each route r.

3. Consider still the connectionless packet switched network defined in the previous problem. However, contrary to the previous problem, we will now take also into account the delays due to processing packets in the nodes. Assume that, in each node, there is a single processor taking care of the routing decisions. Model this processor (and the preceding buffer) as a pure waiting system. The processing rate is assumed to be 50 packets per ms. All the packets arriving a node visit therefore first the processor, after which they are directed to the appropriate output port.

   Expand your queueing network model so that this new feature is included. Draw a picture describing this modified queueing network model. Compute further the traffic loads for each processor, and, finally, the average end-to-end delays for each route r.