Note: Problem 3 is a homework exercise. Deliver your answer sheet (labelled with your student id, name, and signature) into the mail box of the course, or directly to the course assistant *before* the next exercise class on 15 November.

1. Consider the following simple teletraffic model:

   - Customers arrive according to a Poisson process with intensity λ.
   - There is one server ($n = 1$).
   - Service times are IID and exponentially distributed with mean $1/\mu > 0$.
   - The number of waiting places is finite ($0 < m < \infty$).
   - Queueing discipline is FIFO.

   According to Kendall's notation, what is this queueing model? Let $X(t)$ denote the number of customers in the system at time t. Process $X(t)$ is a Markov process. a) Draw the state transition diagram of this Markov process. b) Determine the equilibrium distribution. c) Under which conditions, the system is stable (i.e. the equilibrium distribution exists).

2. Consider data traffic on a link between two routers (from router R1 to router R2) in a packet switched network. Traffic consists of packets arriving at rate λ (packets per second) into the output buffer of router R1. Let L and C denote the mean packet length (in bits) and the link speed (in bits per second), respectively. Assume that the buffer capacity is B packets. Consider this as an $M/M/1/B$ queueing model. Determine a) the probability p_W that an arriving customer has to wait and b) the probability p_L that an arriving packet is lost. Calculate p_W and p_L assuming that $1/\lambda = 0.10$, $L = 3200$, $C = 64000$, $B = 5$.

3. *Homework exercise* (deadline 15 November at 9 o'clock): Consider an ordinary $M/M/1$ queueing model with the following modification: Whenever a customer arrives in a *non-empty* system, he either starts to wait for service or leaves the system immediately (without service). The "waiting" decision is made with probability $1/x$ and the "leaving" decision with probability $(x-1)/x$, where x refers to the number of customers in the system seen by the arriving customer.

   Let $X(t)$ denote the number of customers in the system at time t. Process $X(t)$ is a Markov process. a) Draw the state transition diagram of this Markov process. b) Determine the equilibrium distribution. c) Under which conditions, the system is stable (i.e. the equilibrium distribution exists).