

- Mastery. This question is based on the following additional reading material:  
 U. N. Bhat (2008), *An Introduction to Queueing Theory*, Birkhäuser: Chapter 4, Sections 4.1, 4.2 and 4.3, pp. 29–51.
- (a) Describe briefly (i.e. in 1-2 sentences) how a queueing model can be described in the language of birth-death processes.
  - (b) What can be said about the existence of a limiting distribution for an irreducible, homogeneous continuous-time Markov chain with standard semigroup?
  - (c) The following questions refer to the M/M/1 queue.
    - (i) Describe the M/M/1 queue.
    - (ii) Define the traffic intensity.
    - (iii) Find the generator and read off the Kolmogorov forward equations.
    - (iv) Derive the limiting distribution provided that the traffic intensity is smaller than 1.
    - (v) Define *busy period*, *idle period* and *busy cycle*.
    - (vi) Give a brief account on how the distribution of the busy period in an M/M/1 queue can be found, i.e. consider an appropriate generator (you need to justify your choice) and derive the corresponding Kolmogorov forward equations (you do NOT need to solve them!).
  - (d) Write down the generator for an M/M/s queue.