1 Instruction 6: Selection of exercises from Chapter 6 of Kulkarni

Theory: paragraphs 6.4, 6.5, 6.6

Conceptual Problems:

6.20 See the text in the book. Add the following asumption to the text of this exercise: the service time of a customer is exponentially distributed with parameter μ.

6.21 See the text in the book.

Computational Problems:

6.10 See the text in the book.

6.11 See the text in the book.

6.12 See the text in the book.

6.13 See the text in the book.

6.21 Consider the manufacturing operation described in Conceptual Problem 6.8 with arbitrary λ en μ, but with infinite capacity warehouse.

a) Classify the queueing model for this manufacturing operation according to the standard nomenclature described in paragraph 6.1.

b) Give the rate diagram for the model.

c) Formulate a set of balance and normalizing equations.

d) Give the condition for stability.

e) Take the data from this exercise. Make the tasks as given in the text of this exercise in the book.

6.27 See the text in the book.

6.28 Consider the parking system as described in the text of this exercise.

a) Classify the queueing model for this parking system according to the standard nomenclature described in paragraph 6.1.

b) Give the rate diagram for the model.

c) Formulate a set of balance and normalizing equations.

d) Calculate the limiting distribution without using MAXIM.
Hints:

- Show that the limiting probability p_i on state $i = 0, 1, \ldots$ cars at the parking place is equal to $p_i = (\frac{(120)^i}{i!})p_0$ and calculate p_0 with the normalizing equation.
- To calculate p_0, use the following series: $\sum_{i=0}^{\infty} \frac{x^i}{i!} = e^x$.

e) Determine the following steady state performance measures without using MAXIM. Verify your result afterwards with MAXIM:

- The mean number of cars in the parking lot and the mean waiting time of cars
- The mean number of occupied parking places and the mean parking time of a car.

- The mean number of cars in the queue, waiting for a available parking place and the mean queueing time of a car.
- The fraction of time a certain parking place on the parking lot is occupied.
- The probability that all places are occupied.
- The throughput, the expected number of cars that leave the parking lot per hour.

6.32 Consider the service system as described in the text of this exercise.

a) Classify the queueing model for this service system according to the standard nomenclature described in paragraph 6.1.

b) Determine the following steady state performance measures without using MAXIM. Verify your result afterwards with MAXIM:
   - The mean number of customers in the service system and the mean waiting time of customers.
   - The mean number of occupied servers and the mean service time of a customer.
   - The mean number of customers in the queue, waiting for a available server and the mean queueing time of customers.
   - The fraction of time the server is occupied.
   - The throughput, the expected number of customers that leave the system per hour.

6.33 See the text in the book.

6.35 See the text in the book.

6.36 Consider the queueing system as described in the text of Conceptual Problem 6.20. Use the asumptions and data from this exercise.

a) The servers are considered separately. Each server is modelled as a $G|M|1$ queue. Determine for each server the following steady state performance measures without using MAXIM. Verify your result afterwards with MAXIM:
   - The mean number of customers and the mean waiting time of customers who are assigned to the server.
   - The mean number of occupied servers and the mean service time of a customer.
   - The mean number of customers in the queue, waiting for an available server and the mean queueing time of customers.
   - The fraction of time the server is occupied.
   - The throughput, the expected number of customers that are served by the server per hour.

b) The service system is changed: entering customers form a single queue served "First Come First Served" by the two identical servers. Determine for the changed system the mean number of customers in the system.

c) Answer the question as given in the text of this exercise in the book.

6.40 See the text in the book.