Exam Modeling of Business Processes
10th December 1999, 13.30-16.30, Q1.05

This exam consists of **5** problems, each consisting of several questions.
All answers should be motivated, including calculations, formulas used, etc.

1. A project has the following activities:

Activity	Preceding activities	Duration
A	-	2
B	A	3
C	A	2
D	C	1
E	B,D,G	2
F	-	3
G	C,F	2

Assume for the moment that there are enough resources.
a. Make a graph representation of this project.
b. Compute the earliest finish time of the project and all earliest and latest starting times of the activities. (Hint: renumber first the activities.)
c. Give the definitions of slack, critical activity, and critical path.
d. Compute in the example project the slack of each activity. What is the critical path?
Suppose that activities B and C use the same resource. Therefore they cannot be scheduled at the same time.
e. What is now the earliest finish time of the project?
f. Prove that the solution to d. gives indeed the earliest finish time possible.

2. Consider two production lines, each consisting of two consecutive production steps. The production lines share the same resource for the second production step (but not the first). Production planning is on a MTO basis, and orders arrive according to a Poisson process. Assume that service times are exponential. The order arrival and service rates are given in the following table:

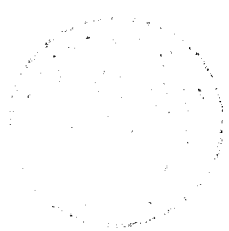
	Order arrival rate	Stage 1	Stage 2
Type 1	1	2	3
Type 2	1.5	2	α

Let the processing order at all stages be FIFO.
a. Calculate the expected total waiting and response time for both product types, for $\alpha = 3$.
b. Calculate the expected total waiting and response time for both product types, for $\alpha = 2$.
c. The same question as b., but now if type 1 has priority over type 2.
(Hint: The following formula might be helpful (in the notation of the lecture notes):

$$\mathbb{E}W_Q(HOL) = \sum_{i=1}^{p} \frac{\lambda_p \mathbb{E}R}{\lambda(1-\sigma_p)(1-\sigma_{p-1})},$$

with $\mathbb{E}R = \lambda \mathbb{E}S^2/2$ and $\sigma_p = \sum_{i=1}^{p} \rho_i = \sum_{i=1}^{p} \lambda_i \mathbb{E}S_i$.)

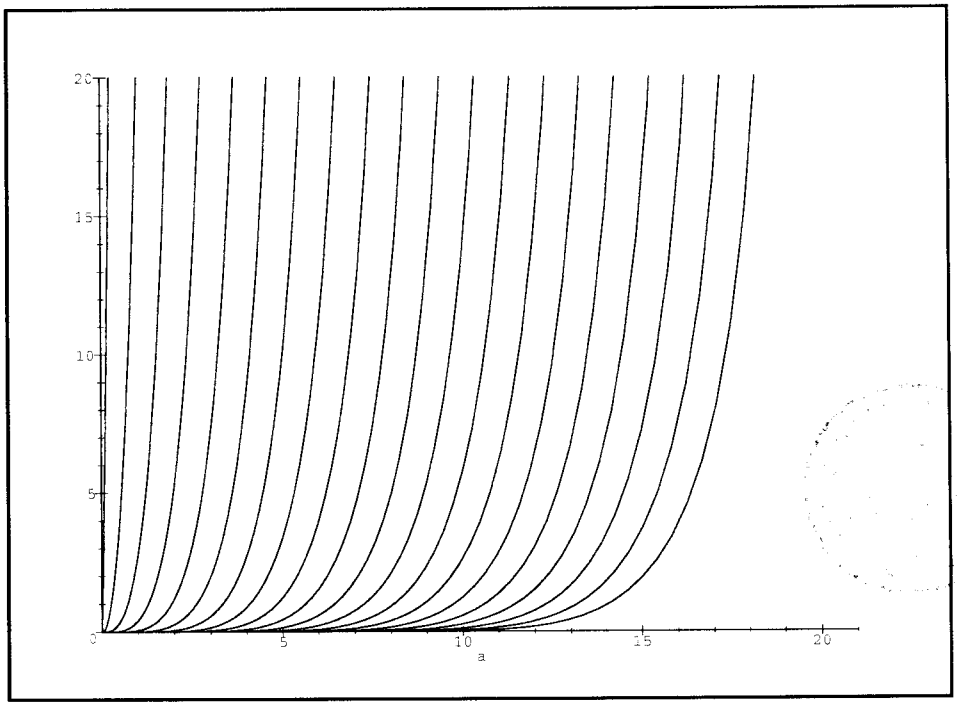
3. A person receives a monthly salary S on a bank account. Each month is assumed to have 30 days. From this bank account she pays each day her daily expenses d. We assume that $30d \leq S$. She has the option to put money on a savings account. The savings account has a daily interest rate r, there is no interest rate on the account where her salary arrives, unless the amount is negative: then she pays an interest rate of p, $p > r$. Interest is payed at the end of the month (the same day the salary arrives). The day the salary arrives she decides how much money to put on the savings account.
a. Model this problem as an inventory model: classify the model and determine the necessary parameters.
b. Calculate the amount to put on the savings account that maximizes the interest at the end of the month.
c. Give the definitions of safety stock, cycle stock, and seasonal stock.
d. What type of stock is the money on the standard account?
She uses the money on the savings account to pay for her summer holidays.
e. What type of stock is the money on the savings account?



4. A company is changing its call centers operations. Instead of a regional approach (there are currently 3 regional call centers), they decide to build a single call center with skill-based routing. A model for the new call center is needed to determine the consequences for the workforce. Based on the model outcomes decisions are taken with regard to the possible employment of new agents and with regard to the training of agents for specific skills.
a. Give the definition of strategic, tactical, and operational decisions.
b. Classify the decisions to change the call center structure and the decision with respect to the training of agents.
The average call duration β is 2 minutes, independent of call center and call type. In the next table the number of agents in the regional call centers and the expected waiting times during peak hours are given. The arrival rates are not known.

Call center	1	2	3
Number of agents	12	9	7
Expected waiting time (seconds)	27	78	5.5

c. Determine the arrival rates, using the table below.
There will be 2 call types, approximately 1 out of three calls is type 1. The average waiting time for both types should not exceed the current overall waiting time.
d. Determine the current average waiting time.
e. Determine the right number of agents for the two skills.



Values of $\mathbb{E}W$ as a function of the load a for (from left to right) $s = 1$ t/m 20 and $\beta = 60$.

5. A bank is considering installing a new computer system to handle all financial transactions of the bank. It is not clear whether the system proposed by the supplier has the processing capacity that is needed to deal quickly enough with the transactions. A simulation study is called for by management.

a. Can a simulation study be helpful in this case?

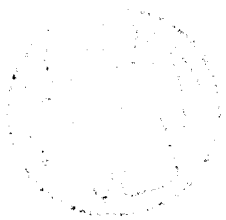
b. How would you implement the simulation (Arena/C++/...)?

c. What are the types of data that is needed and from who can it be obtained?

d. Discuss the role of the simulation in the whole decision process.

e. Name another type of decision for which this model could also be useful.

f. A manager thinks that queueing theory might also be helpful. Discuss advantages and disadvantage with respect to using a simulation study (including implementation time, level of detail, ease of use, presentation).



Do not forget to motivate **all** answers.

The final note is determined as follows: all questions give 1/3 points if well answered, except for 2b and 2c, they count for 2/3. Adding 1 to this gives the note.