Original

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- Management Science -
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End-Term Test
Production Management & Operations Research (5074)
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Last name: ..... **First name:** ..... **Matriculation No.:** .....

Examination: Production Management & Operations Research SS 2006
Examiner: Prof. Dr. G. Wäscher

General remarks:

1. Write your name and matriculation number on this cover sheet and on every other sheet that has been issued to you.
2. Leave a minimum of 4 cm as correction space on the outside margin of each page.
3. Make sure that you have a complete copy of the test. The test consists of **3 assignments**, all of which have to be dealt with. It is not permitted to remove the retaining clip; doing so will be treated as fraudulent behaviour.
4. Please write legibly and number the pages which have been used. For each assignment, put down your answers on a separate sheet. Only pens with permanent ink may be used, while correction pens or ink erasers are not permitted. Make sure that you don't write in red.
5. Always make clear how you have determined your solution (solution path). Isolated solutions without traceable origin will not be accepted.
6. The following aids may be used: writing utensils, non-programmable pocket calculators without communicating and/or data processing functions, dictionaries (without any added remarks only).

Assignment 1 (7 points)

Multiple Choice: Which is the correct answer to the following questions? Indicate your answer by marking the respective box! Only one answer per question is correct. (One point for each correct answer)

Short Questions: Answer the questions shortly! You do not need to write complete sentences – keywords are sufficient. (One point for each completed question)

1) The total slack of an activity is defined as the time period which is available for a possible delay and/ or extension of the activity, if the predecessors and successors are in the following positions:

   (1a) ☐ all predecessors are in earliest position and all successors are in earliest position
   (1b) ☐ all predecessors are in earliest position and all successors are in latest position
   (1c) ☐ all predecessors are in latest position and all successors are in earliest position
   (1d) ☐ all predecessors are in latest position and all successors are in latest position

2) If the independent slack of an activity has a value of five, you can conclude that

   (2a) ☐ the activity is on the critical path
   (2b) ☐ the free slack must be zero
   (2c) ☐ the free slack is greater than five
   (2d) ☐ the total slack is equal to or greater than five

3) If faithfulness to due dates is your most important goal in an order sequencing problem, what would be on the average the best priority rule to determine an order sequence?

   (3a) ☐ Shortest Operation Time
   (3b) ☐ Shortest Total Operation Time
   (3c) ☐ Slack-Rule
   (3d) ☐ Shortest Remaining Operation Time

4) The Helgeson and Bernie method for production line balancing starts from certain assumptions. One of the following premises is not correct. Indicate the wrong assumption!

   (4a) ☐ one-product line
   (4b) ☐ stochastic operation times
   (4c) ☐ given precedence relationships
   (4d) ☐ homogenous work stations

5) In general, capacity supply and demand may be balanced either by increasing the capacity supply or by reducing the capacity demand.
Name three short-term means for the reduction of capacity demand:

6) Information on decision-relevant costs are usually not available for decision making in production control. Instead auxiliary measures are used both in theory and practice. In order sequencing these measures can typically be attributed to one of three classes. Name the three classes of auxiliary goals for order sequencing!

7) For the production of the five orders (A,B,C,D and E) the same type of machine is needed. How many machines of this type do you need to produce the orders on time and with respect to the following activity schedule? Explain your answer!

	EST	EFT	LST	LFT
A	0	4	6	10
B	0	7	3	10
C	0	5	5	10
D	0	6	4	10
E	0	3	7	10

EST: earliest starting time
EFT: earliest finishing time
LST: latest starting time
LFT: latest finishing time

Assignment 2 (23 points)

Your company manufactures five product types in a four-stage production process. The operation times of the corresponding production orders (A, B, C, D and E) on the different stages are given in the table below (operation times are given in minutes).

production stage / production order	(1)	(2)	(3)	(4)	availability at production stage 1 at time
A	45	60	15	75	6:30 a.m.
B	30	60	15	60	6:00 a.m.
C	15	30	30	75	6:00 a.m.
D	45	45	30	90	6:00 a.m.
E	30	45	45	60	7:00 a.m.

The regular production shift starts at 6:00 a.m.. Due to maintenance, production stage 2 will be closed between 8:30 a.m. and 9:00 a.m..

The sequence of stages which the orders have to pass through is identical for all orders; overtaking of orders is not possible due to technical reasons.

a) Determine an order sequence by means of the Shortest Total Operation Time-Rule. Also give the corresponding finishing time of the last order!

b) Is the obtained solution an optimal one?

Now assume that the company had a technical update which permits orders overtaking each other.

c) Determine an order sequence by means of the Longest Remaining Operation Time-Rule. Again give the corresponding finishing time of the last order!

Your boss is not sure if in a case like this it is better for the company to minimize the cycle time or to maximize the capacity utilization. From your PMOR-lecture you remember that "in order sequencing, for a given set of orders, the minimization of the cycle time and the maximisation of the utilization are equivalent goals".

d) Give a general proof of the above statement!
Do not forget to define all the symbols properly you have to introduce!

Assignment 3 (15 points)

The following table lists the work elements that have to be performed on an assembly line in order to provide a final product. Furthermore, the corresponding operation times (in seconds) and the immediate predecessors of each work element (i.e. the list of work elements that have to be completed before a certain work element can be started) have been listed.

work element i	operation time t_i [sec]	direct predecessor(s)
1	10	-
2	15	-
3	8	1,2
4	4	2
5	25	1,3
6	16	3,4
7	12	6
8	10	5,7

The desired output rate is 120 units per hour and the goal is to minimize the number of work stations needed.

a) What is the maximal cycle time, which cannot be exceeded if 120 units are to be produced per hour?

b) What is the theoretical minimum number of work stations for the desired output rate?

c) For the precedence relationships given in the above table, plot the corresponding precedence diagram?

d) Assign the work elements to stations according to the method of Helgeson and Bernie!

e) How many work stations are necessary? Also determine the total idle time and the capacity utilization of this solution!

f) Is the solution an optimal one?