Otto-von-Guericke-University Magdeburg
Faculty of Economics and Management
- Management Science -
Prof. Dr. Gerhard Wäscher

End-Term Test
Production Management & Operations Research (11072)
July 9, 2010

Last name: ..... **First name: .....** **Matriculation No.: .....**

Examination: Production Management & Operations Research SS 2010
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 (18 points)

A production manager is about to plan the sequence according to which five orders (A, B, C, D, E) should be manufactured on four production stages (#1, #2, #3, #4). The following table represents the corresponding operation times on each production stage, as well as the total operation time and the total remaining operation times after each production stage (all data given in time units):

production order	operation time at production stage				total operation time	total remaining operation time		
	#1	#2	#3	#4		after stage #1	after stage #2	after stage #3
A	4	3	4	5	16	12	9	5
B	3	6	4	10	23	20	14	10
C	2	3	6	4	15	13	10	4
D	2	3	10	3	18	16	13	3
E	5	7	2	3	17	12	5	3

The sequence of production stages (#1, #2, #3, #4) is identical for all orders. Splitting of orders is not permitted.

Assume that the orders C, D and E are available when manufacturing will be started at t = 0! The orders A and B will become available at t = 5! Further assume that orders can pass each other! Due to maintenance activities the production stage #3 will be closed for five time units from t = 15 until t = 20!

a) Determine an order sequence for the sequencing problem by means of the Longest Remaining Operation Time-Rule (LROT)! Plot the corresponding GANTT-Chart!

b) Determine the corresponding cycle time, the capacity utilization, the idle time of stage #2 and the waiting time of order A!

c) Consider the following statement:

"In order sequencing, for a given set of orders, the minimization of the cycle time and the minimization of the total idle time are equivalent goals."

Give a general proof for this statement! Do not forget to define all the symbols properly which you have to introduce!

Assignment 2 (18 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 minutes) and the immediate predecessors of each work element have been listed.

work element i	operation time t_i [min]	direct predecessor(s)
1	6	-
2	8	1
3	10	1
4	3	2
5	6	3
6	7	3
7	5	5
8	5	5, 6
9	8	4, 7
10	9	8, 9

The desired output rate is 4 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 4 units are to be produced per hour?

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

c) Plot the corresponding precedence diagram for the precedence relationships given in the above table!

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

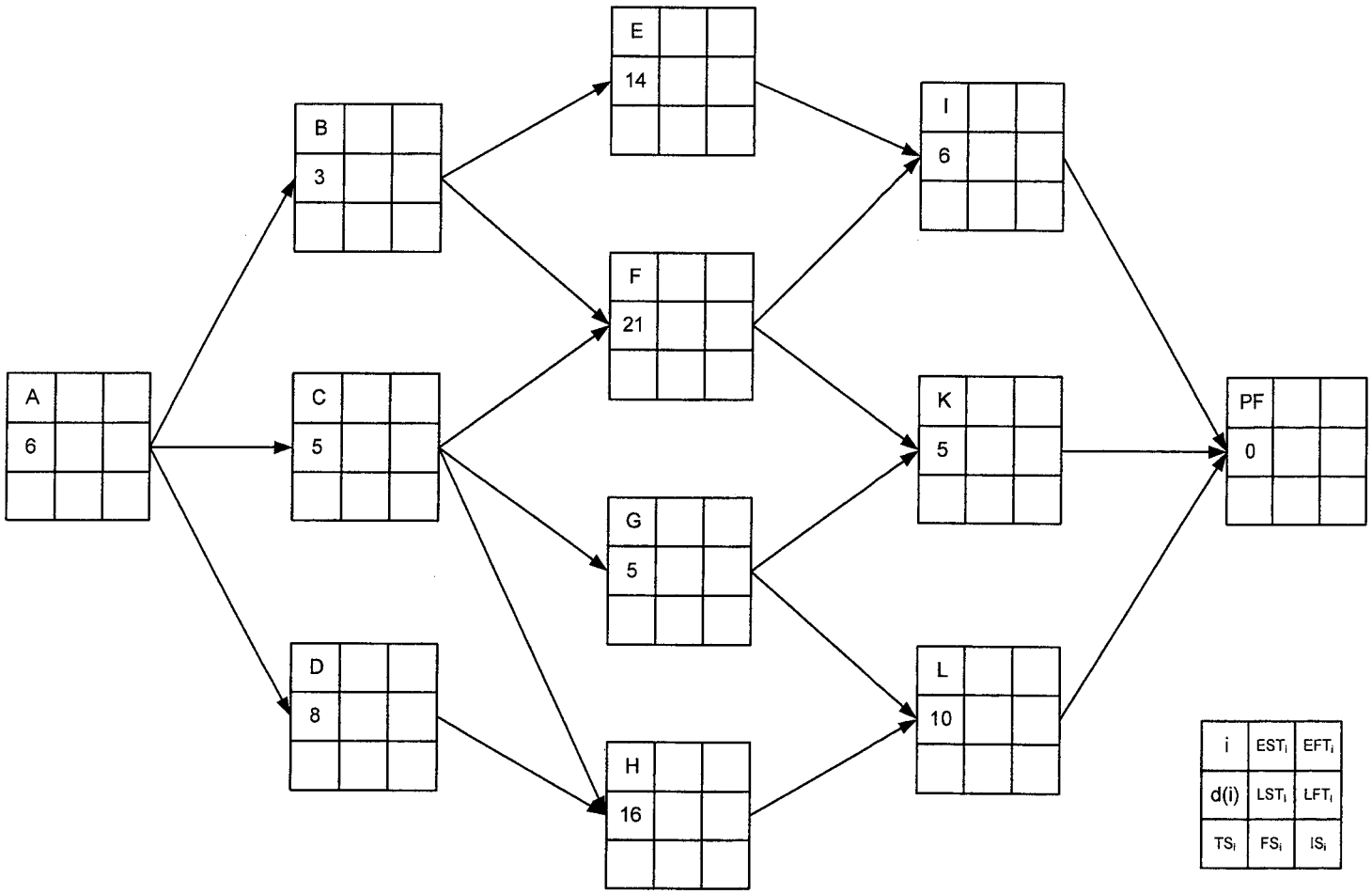
e) How many work stations are necessary? Also determine the total idle time and the capacity utilization of this solution!

f) What can be said about the optimality of the obtained solution? Explain your answer!

g) As known from the mathematical formulation of the assembly line balancing problem, every feasible solution has to fulfill the sequencing restrictions. Formulate the necessary sequencing restrictions for the relationship between the work element number 5 and its direct successors! Demonstrate that the obtained solution from d) complies with these restrictions!

Assignment 3 (14 points)

The following activity-on-node network represents a project.



a) For each activity, determine the earliest and latest start time, the earliest and latest finish time, and the total, free and independent slack!
Use the network given above to present your results!

b) Identify the critical path(s)! Why is it important to know the critical path(s)?

c) Transform the activity-on-node network given above into an activity-on-arc network! Do **not** perform the calculations again!