CHALMERS

CHALMERS UNIVERSITY OF TECHNOLOGY
Department of technology management and economics
MSc programme in Supply Chain Management

OPEN BOOK WRITTEN EXAM IN **OPERATIONS PLANNING AND CONTROL TEK 421**

March 17, 2020

Allowed aids: All kind of interaction in any form (internet, phone, etc.) with another person is completely forbidden during the entire exam.

Instructions:

You should write and submit your answer in a text document, i.e. Word.

- Create one text document for each exam problem.
- Name your text document Question_YY_Surname. *Example:* Problem_01_Jonsson.doc
- Submit your answers by uploading the text documents via Canvas before the due time.

Exam problem solutions involving calculations, figures, diagrams etc. should be solved on paper as in a normal exam.

- Make sure that each paper is clearly marked with your name, exam question number and page number.
- Scan or photograph your solutions.
- Name your image files Problem_YY_Page_XX_Surname. *Example:* Problem_01_Page_02_Jonsson.jpg.
- If you want, you can combine images for the same problem into a single document (e.g. Word) named Problem_YY_Surname.
- Submit your solutions by uploading the image files or documents via Canvas before the due time.

Problems: The exam includes seven problems.

Grades: Maximum result is 68 points. 28 points are needed for pass.
Language: You must answer in English.
Examiner: Patrik Jonsson (031-7721336)

Questions: Patrik Jonsson is available on phone during the exam but the line may be busy if many call. If uncertain about any problem formulation, then describe your interpretations/assumptions of the questions when answering so we know how you have understood the questions when marking.

Problem 1 (9 points)

All products manufactured by the company RainMan AB has seasonal demand. The company is introducing a new product and the management team needs to decide whether to use a levelled or chase production strategy. However, the number of employees available for the new product is limited. Thus, the management team also needs to decide whether to use overtime or subcontracting to cope with potential capacity shortages. The forecasts for the first year, as well as information about production costs, available capacity and inventory levels are provided in the tables below.

Quarter	Forecast
1	1 000
2	3 000
3	4 500
4	1 500

Production costs	
Regular time	750 SEK / unit
Overtime	950 SEK / unit
Subcontracting	1 050 SEK / unit
Inventory	50 SEK / unit / quarter
Backorder	500 SEK / unit / quarter

Available capacity	
Regular time	2 000 units / quarter
Overtime	2 000 units / quarter
Subcontracting	4 000 units / quarter

Inventory levels	
Starting	400 units
Ending	0 units

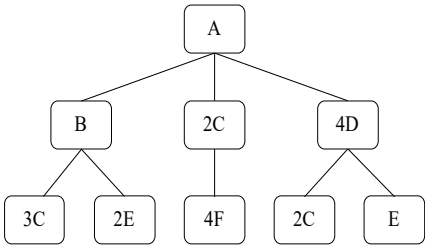
a) Provide recommendations to the management team of which production strategy and which type of additional capacity to use during the first year. Base your recommendations on the total costs of the different alternatives, but please note that it is not allowed to combine the alternatives.

b) After the first year, the actual demand for the new product is available, seen in the table below. Evaluate the forecasts that were used for the first year by calculating the mean error and mean absolute deviation and explain your interpretation of the results.

Quarter	Demand	Seasonal index
1	1198	0.5
2	2942	1.1
3	5116	1.7
4	1744	0.7

c) In its forecasting process, the company is using a seasonal index based on the aggregated demand of all its products, presented in the table above. For the second year, it is decided that the exponential smoothing method should be used to forecast the demand of the new product. Help the company to calculate the forecast for the first quarter of year 2 by using data from year 1 and taking the seasonal index into consideration. Use an α-value that corresponds to 3 quarters with the moving average method.

Problem 2 (9 points)
A company is producing special breathing masks, used for avoiding e.g. the Corona virus, according to the bill of material illustrated below. Information about the different items is also provided in the table below.



Item	Stock on hand	Scheduled receipts	Lot size	Safety stock	Lead time
A	300	400 in W1	400	100	3
B	200	500 in W1	500	200	1
C	700	1000 in W1	1000	250	1
D	400	800 in W1	800	150	2
E	800	1500 in W1	1500	300	1
F	600	1800 in W1	1800	300	1

MRP calculations for items B and D are already performed by the company and they show that planned order receipts of one lot of B is needed in weeks 2, 5 and 7 and one lot of D is needed in weeks 3, 4 and 7.

a) Develop an MRP record for item E and give advice on which weeks to release new production orders for this item in the next 8 weeks.

b) Data from the routing file is presented in the table below. What capacity requirement is needed to produce item E according to the MRP record developed in a)? Base your answer on capacity bill calculations for the associated work center.

Item	Work centre	Setup time / batch	Run time / unit
A	WC100	1 h	7 min
B	WC200	2 h	5 min
C	WC300	0.5 h	10 min
D	WC400	1.5 h	3 min
E	WC500	1 h	4 min
F	WC600	0.5 h	6 min

Another of the company's products is produced by three succeeding operations and the data for these operations is seen in the table below. Because of the Corona outbreak, the company has been told to speed up the production as much as possible, and by dividing the normal lot size into three equal sub-batches, the normal throughput time of one lot can be reduced by 3 hours when using overlapping.

c) Determine the normal lot size for this product, but note that setup preparation is not possible for any of the operations.

Setup time operation 1	1 hour
Run time operation 1	4 min/unit
Transport time 1-2	1.5 hours
Setup time operation 2	1.5 hours
Run time operation 2	5 min/unit
Transport time 2-3	1 hour
Setup time operation 3	1 hour
Run time operation 3	2 min/unit

Problem 3 (6 points)
A company is producing three different products. For one of the products, the company is currently using the EOQ method for determining an appropriate lot size.

a) What would be the difference (if any) in the number of orders needed during the following 8-week period if ERT was used instead? Motivate your answer by calculating the number of orders needed for the two alternatives, based on the data presented below.

On hand inventory: 1500 units
Safety stock: 150 units
Ordering cost: €160 / order
Product cost: €50 / unit
Inventory cost: €5 / unit / year

Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Requirement	710	960	520	650	860	740	840	720

For another of the products, the company receives four new customer orders:

(1) 70 units in week 5
(2) 40 units in week 3
(3) 60 units in week 1
(4) 80 unit in week 7

b) Based on the information below, develop a master production schedule, including available to promise and advise which of the orders that can be accepted without asking the production department. Note that the orders should be treated in the stated sequence.

On hand inventory: 180 units
Safety stock: 50 units
Lot size: 300 units
Release time fence: 1 week
Demand time fence: 2 weeks
Planning time fence: 6 weeks
Forecast time fence: 7 weeks

Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Forecast	100	100	100	100	100	100	100	100
Actual orders	120	75	80	115	95	70	55	40

For the third product, the company is about to determine an appropriate safety stock level. It is concluded that 95% of the demand should be satisfied directly from stock.

c) Based on below information, calculate the safety stock level.

Total demand	10 000 units / year
Order quantity	500 units
Mean absolute deviation of demand	40 units / week
Lead time	2 weeks
Standard deviation of lead time	0.5 weeks
Working weeks per year	50 weeks

Problem 4 (8 points)
Hiker Professionals is a manufacturing company that has serious financial problems and need to reduce the capital tied up in inventory. The board of the company has ordered the CEO to initiate a project with the objective to carry out a reduction of 30 % in less than six months.

1. What actions would you have taken to accomplish this in such a short time?
2. What's your opinion about reducing inventories in such a way?
3. What consequences may an initiative like this lead to?

Problem 5 (10 points)
What would be specific issues to consider when designing a sales & operations planning (S&OP) process in companies applying engineer-to-order manufacturing (in comparison to make-to-stock manufacturing companies)? I.e. how does the specific ETO context/environment affect the S&OP process, and what parameters in the S&OP process may be affected and how?

Problem 6 (10 points)
The following is a description of a master production scheduling process at Mechanical Fixes AB.

Weekly forecast quantities with 52 weeks planning horizon are updated by the sales organization with a weekly frequency. Based on these forecasts, capacity requirements for the demand are calculated by using capacity bills. These capacity bills express the total capacity requirement per product in terms of man hours needed per one hundred pieces in manufacturing as illustrated for one of the products below.

Manufacturing department	*Required man hours per 100 pieces*
Cutting	20
CNC-Milling	300
Grinding	100
Painting	40

The results of the calculations are weekly requirements of capacity in the various manufacturing departments. It constitutes a preliminary capacity requirements plan and represents capacity needed to manufacture what is needed to deliver according to the delivery plan.

When this calculation is carried out, a master planning meeting is held. Here, representatives from the planning and production departments review the capacity requirements and compare it with the capacity planned to be available. They also analyze the need for adjusting the capacity in order to produce the volumes requested by marketing.

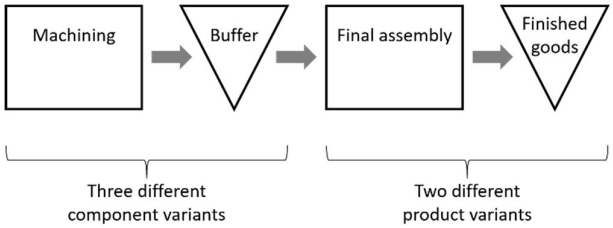
Examples of strategies used at the company for balancing capacity and capacity requirements, are to add another shift in critical resources or to produce in advance in order to even out periods with peak load, especially in the autumn before the winter season which is a high demand season for the company. In the latter case they move the quantities in the requirements plan. If these capacity and requirements adjustments are not enough for meeting the demand, reductions in the delivery plan, or longer delivery times for the web shop sales, has to be made. This step in the process is carried out together with representatives at the marketing department and includes decisions concerning allocation of limited quantities to prioritized markets. The outcome of the process is a master production schedule stating weekly quantities to produce during the coming 52 weeks.

Assess the used master production scheduling process at the company. (a) Identify and motivate strengths and weakness (b) If weaknesses, then suggest what to change and the expected effects of changing.

Problem 7 (16 points)
Consider a production setup with two overall production steps: a machining workshop and a final assembly workshop. The final assembly is organised in an assembly line with several consecutive assembly stations. The machining workshop is instead organised in a functional workshop comprising four different machining operations.

The final assembly produces two different products. The machining workshop produces three types of components which are used in different configurations in the different product types. Accordingly, depending on which product is being produced in the final assembly, the consumption of components will differ. All of the different component types take different routes through the machining workshop. Both the different product types and the different component types differ in value. Customer demand is stable for both product types. The capacity is more than sufficient in both the machining workshop and in the final assembly. The customers accept delivery lead times of up to two weeks, as long as the deliveries are punctual.

In both machining workshop and final assembly, setup times are very unpredictable and vary substantially from setup to setup, as there is no standard for how they should be performed. At their longest, the setups incur considerable standstills in the production. Therefore, both components and final products are currently produced in large batches. Throughput time in the machining workshop is currently around four days and in the assembly around two days. The machining and the final assembly are separated by a large buffer, which has the purpose of ensuring that the final assembly does not run out of components. There is a large number of products in finished goods inventory.



Task:
Your task is to prepare and present solutions for the execution and control of both machining and final assembly. **An important objective is to reduce the amount of capital that is tied up in the production, including the buffer between the machining workshop and the final assembly, as well as in the finished goods inventory. (Raw materials storage is not considered.) At the same time, it is important to ensure punctual and reliable deliveries to the customers.**

You should present two separate solutions for each of the production steps (machining and final assembly): one solution based on a traditional, centralised planning approach and one based on pull principles. In your solutions, you should explain the mechanisms by which production and transport activities are triggered. You should also explain the mechanisms by which the sequence of different orders is decided.

In order to achieve a well-performing production, it may not be sufficient to change the shop floor control approach alone, but supplementary changes may need to be made to the production setup. Therefore, if you find it applicable, you should indicate such supplementary changes that you think would support production performance. If you find it necessary, you may make assumptions, in which case you must clearly state which these are.

*In short, your task consists of the following: Present, **for each of the two workshops**, a solution based on a traditional **and** a pull-based approach. In your solutions, consider also the buffer between machining and final assembly as well as the finished goods inventory. Make sure to relate your solutions*

to the production performance in terms of tied-up capital as well as punctual and reliable deliveries to the customers.

Note that there is not necessarily a “correct” solution to the case. Instead, your solution will be assessed based on the understanding you display of the different underlying concepts and methods, as taught in the course. Therefore, in your answer, you should provide motives for the choices you make.