Answers to written exam in TEK 420 Operations Planning & Control (1501)

Problem 1 (18p)

a) OPC supports decisions of how much to deliver, manufacture and produce. Its purpose is to improving performance in a company by making business processes such as manufacturing, purchasing and sales efficient. It help in coordinating the different functions in the company and aligning the business strategies and goals with operations and as such achieves a good balance of demand and supply. (5p)

b) Planning from a material perspective means establishing what product/items need to be delivered, what quantities of these products/items need to be delivered and when. Planning from a capacity perspective means what establishing what capacity is required to manufacturer the quantities needed and what capacity that is available. We do need both sides in order to achieve the purpose of planning, i.e. making a good balance between the need to be able to deliver and the possibility of being able to produce. Planning from both the material and capacity perspective is relevant at all levels although the relative importance of planning from the material perspective and the capacity perspective depends on the planning horizon. (5p)

c) OPC affects and is affected by the different levels of control. Typically one distinguishes between three levels of control, i.e. strategic, tactical and operative. The relationships are as follows: strategic control ⇔ S&OP, tactical control ⇔ MPS, operative control ⇔ order planning, (execution ⇔ execution and control).
Strategic control is aimed at positioning the company in the business environment and decisions here are concerned with goals and overall allocating of resources. Examples of issues which are include in or have a connection to OPC are choice between manufacturing strategies (MTO, MTS etc.), decision on supplier structure, goals for delivery times and service levels, choice between having all production in one factory or separately for each market.
Tactical control is about the structure of the company within the framework established at the strategic control level. Examples of issues which are include in or have a connection to OPC are choice of manufacturing layout, choice of centralised or decentralised planning organisation, rules for determining order quantities and safety stock.
Operative control is concerned with on-going activities and daily decisions. Examples of issues which are include in or have a connection to OPC assigning priorities to production in the factory, stock accounting, delivery monitoring, workload planning. (4p)

d) Time fences is a policy or a guideline established to note where various restrictions or changes in operating procedure takes place. In S&OP time fences are typically used to decide when changes may be carried out and percentages for how much may be changed. In MPS time fences are used to gain control over how and when rescheduling is supposed to be executed. E.g. demand and forecast time fences are used to balance order backlog and forecast when calculating delivery plans, release time fence and planning time fences are used to control the processing of manufacturing orders. (4p)

Problem 2 (16 p)
a) (7 p)
Process and decisions: S&OP (aggregated requirement per product group in monthly buckets to determine production programme volumes), MPS (requirement per manufactured product type, mainly to plan purchase of special items and human resources during the critical leadtime of 4-6 months), campaigns (categorizing types of campaigns and forecast the expected sales effect of a campaign activity), delivery schedules to suppliers with long-term agreements (the product forecast used to generate MPS indirectly results in delivery schedules through BOM explosion in MRP)

In addition to the above MPC processes, there is also a need for an annual financial/business planning forecast.

Object and horizon: Retailer assortment on aggregated level for months 7 to at least month 12; Own assortment on item/SKU level for months 1 to about 6 (to the MPS planning horizon), and on aggregated level for months 7 to at least 12.

b) (9 p)
Different arguments/motives could give points, e.g.:

- Exponential smoothing, combined with grass root approach to forecast the own assortment during months 1 to 6. There are different ways of combing the two approaches, e.g. exponential smoothing as a base line forecast which sales reps are changing, an analytical (formula) mix of the two approaches, or grass root forecast in the short term and exp. smoothing in the long term, etc. The answer had to present a motivate a relevant strategy for combining methods.
- Sales management and exponential smoothing to validate/modify the 6 months delivery schedule information of the retailer assortment (depending on the length of the frozen delivery schedule period).
- Regression analysis, sales management or grass root approach to forecast campaign effects on sales – could present motives for any of these. However, the possibility of regression had to be mentioned.
- Sales management, grass root or exponential smoothing for long term aggregated (6 to at least 12 months) forecast, depending on what approach is resulting in the best accuracy.
- Sales management approach for financial and annual business planning, which is used in pyramid forecasting with for example quarterly frequency.

Problem 3 (16 p)

a) (12 p)

Re-order point: + independent RWs, decentralized decision making, reacts directly on market demand/pull, simple; - disconnected replenishment decisions, downstream requirement not visible, cannot generate planned order information (delivery schedules), decentralized safety stocks may result in larger total stock level, large bullwhip risk.

MRP (time-phased order point): + independent DCs, decentralized decision making, reacts on local planned future requirements, generates planned order information (delivery schedules); -: decentralized safety stocks may result in large total stock levels, forecast dependency (depending on planning horizon), bullwhip risk.

Distribution requirements planning: +integrates inventory replenishment decisions for the total system, downstream requirement visible and generates planned order information (delivery schedules), safety stock can be consolidated; -: lack of local knowledge/input, requires central planning organization, distribution planning software, data quality, forecast dependent

Important to outline +/- for all methods and then present arguments for any of them. DRP should be suitable for this distribution network but it is possible to argue for any of the methods. Important to note that planning (especially if utilizing the benefits of TPOP/DRP) is difficult if longer planning horizon than 6 months. It is therefore important with frequent replenishments to the CW and RWs to keep the throughput time short.

b) (4 p) High stock levels in combination with shortages is a signal of inappropriate item differentiation and safety stock policy (The policy could include what target service levels to have per item group, where to store the respective item group – only CW or both CW/RW?, other strategies than safety stocks to meet customer demand for specific item groups).

Problem 4 (16 p)

a) In total 7 point. One get maximum 3 point if one is able of comparing the two methods in terms of capacity consideration, links with material planning and dependency on job reporting. One get maximum 4 points for giving plus and minus of the different methods.

Example of answers for comparing the methods:

Property variables	Supervisor managed priority control	Priority control by dispatch list
Capacity consideration	Capacity consideration in own work center	Capacity consideration if based on finite capacity scheduling
Links with material planning	No consideration taken of material situation	Consideration taken to material situation
Dependency on job reporting	Not required	Times and final reporting is required

Example of answer for plus and minus with the methods

Supervisor managed priority control	Simple, positive effect on motivation, suitable in small workshops, few operations, short throughput times, sequent dependent set up time	Manufacturing sequence may be very random from a material planning perspective Sub-optimizing
Priority control by dispatch list	Relatively simple to use, manufacturing is run in a sequence that reflect the current material planning situation, suitable in all types of environments (but best in job shop according to Jonsson and Mattsson)	Requires system support Requires high discipline by operators (need to report a lot) High data quality is needed Is not suitable if having sequence dependent set up time

b) In total 5 point. Need to identify challenges in the environment such as uncertainties, complexity and a lot of flexibility for the operators to make something about the situation as well as identifying problem with the requirement the method is placing such as high discipline among its user, high data quality etc. Could also be good to put out that operators are used of doing things by themselves and with a dispatch list the motivation may be lost.

c) In total 4 point. Important to point out the importance of simplifying the problem, i.e. creating the best possible planning environment by reducing complexity and uncertainty in different ways (simplifying the planning environment). Also to point out issues connected to change management.

Problem 5 a) (7 p)

Analysis:

- Small variations outside of trend, especially in latter half of the year → (small n, large alpha. E.g. n=3 → alpha = 0.5)
- Clear trend (exp. sm. with trend correction)
- Stable trend (more weight on actual trend, mid-large beta. E.g. beta = 0.5)
- Start e.g. 3 months prior to month 9, in month 6, for trend and forecast to "settle"

Month	Demand	Basic forecast (alpha=0.5)	Trend (beta=0.5)	Forecast with trend	Absolute error
1	6000				
2	6200				
3	6600				
4	6400				
5	6800				
6	7000	6800,0	200,0	7000,0	
7	7400	7000,0	200,0	7200,0	
8	7400	7300,0	250,0	7550,0	
9	7600	7475,0	212,5	7687,5	87,5
10	7800	7643,8	190,6	7834,4	34,4
11	8200	7817,2	182,0	7999,2	200,8
12	8600	8099,6	232,2	8331,8	268,2
		8465,9	299,3	8765,2	
		8765,2		9064,5	
		9064,5		9363,7	
Total	86000				
MAD					147,7

Problem 5 b) (7 p)

Production volume = 0 – 2000 + 86000 = 84000

Monthly production = 84000/12 = 7000

Max. regular time = 9 x 8 x 20 x 5 = 7200 (7000 → no overtime)

Month	1	2	3	4	5	6	7	8	9	10	11	12	Total
Demand	6'	6.2'	6.6'	6.4'	6.8'	7'	7.4'	7.4'	7.6'	7.8'	8.2'	8.6'	86'
Production	7'	7'	7'	7'	7'	7'	7'	7'	7'	7'	7'	7'	84'
Inv. (2')	3'	3.8'	4.2'	4.8'	5'	5'	4.6'	4.2'	3.6'	2.8'	1.6'	0	
Backlog													
Av. Inv.	2.5'	3.4'	4'	4.5'	4.9'	5'	4.8'	4.4'	3.9'	3.2'	2.2'	.8'	43.6'

Production cost: 120 x 84 000 = 10.08 million

Inventory cost: 30 x 43 600 = 1.31 million

Total cost = 10.08+1.308 = 11.39 million

Month	1	2	3	4	5	6	7	8	9	10	11	12	Total
Demand	6'	6.2'	6.6'	6.4'	6.8'	7'	7.4'	7.4'	7.6'	7.8'	8.2'	8.6'	86'
Production	4'	6.2'	6.6'	6.4'	6.8'	7'	7.4'	7.4'	7.6'	7.8'	8.2'	8.6'	84'
Inv. (2')	0	0	0	0	0	0	0	0	0	0	0	0	
Backlog	0	0	0	0	0	0	0	0	0	0	0	0	
Regular t.	4'	6.2'	6.6'	6.4'	6.8'	7'	7.2'	7.2'	7.2'	7.2'	7.2'	7.2'	80.2'
Overtime							.2'	.2'	.4'	.6'	1'	1.4'	3.8'
Av. Inv.	1'	0	0	0	0	0	0	0	0	0	0	0	1'

Production cost (regular time): 120 x 80.2 = 9.62 million

Production cost (overtime): 200 x 3.8 = 760 thousand

Inventory cost: 30 x 1 = 30 thousand

Backlog costs: 0 €

Total costs: 9.62+0.76+0.03 = 10.41 million

Recommendation should be to change to a chase strategy (10.41 compared to 11.39 million)

Problem 6 a) (2 p)

The economic order quantity (EOQ) is calculated as:

$$\text{EOQ} = \sqrt{\frac{2 \times 40 \times 65}{30/52}} = 94.9\ldots \rightarrow 95 \text{ units}$$

Problem 6 b) (4 p)

$$\sigma_{\text{DDLT}} = \sqrt{15^2 \times 1 + 0.5^2 \times 40^2} = 25$$

Service level 97% → k=1.88

SS = 25 × 1.88 = 47 units

Problem 6 c) (6 p)

Product A		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Gross requirement		40	40	40	40	40	40	40	40
Scheduled receipt									
Inventory	150 (47)	110	70	125	85	140	100	60	115
Planned order delivery				95		95			95
Planned order start			95		95			95	
Item C		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Part of A 2:1			190		190			**190**	
Other products		**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**
Gross requirement		20	210	20	210	20	20	210	20
Scheduled receipt			120						
Inventory	170 (55)	150	60	100	70	110	90	60	100
Planned order delivery				60	180	60		180	60
Planned order start		60	180	60		180	60		
Item D		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Gross requirement (Cx2)		120	360	120		360	120		
Scheduled receipt			80						
Inventory	250 (70)	130	90	130		90	130		
Planned order delivery			240	160		320	160		
Planned order start		240	160		320	160			

Problem 7 a) (3 p)

Week		1	2	3	4	5	6	7	8
Forecast		100	110	105	90	100	115	110	105
Customer orders		92	101	83	106	91	81	73	54
Inventory	100	8	107	2	96	196	81	171	66
MPS			200		200	200		200	
ATP		8	16		94	28		73	
Cumulative ATP		8	24	24	118	146	146	219	219

Problem 7 b) (2 p)

Week	1	2	3	4	5	6	7	8
ATP	4 (-4)	0	0	94	28		73	

Week 3 – 20 units – YES

Week	1	2	3	4	5	6	7	8
ATP	4	0	0	82 (-12)	0		73	

Week 5 – 40 units – YES

Week	1	2	3	4	5	6	7	8
ATP	0 (-4)	0		82			73	

Week 2 – 4 units - YES

Week	1	2	3	4	5	6	7	8
ATP	0	0		75 (-7)		0	0 (-73)	

Week 7 – 80 units – YES

Problem 7 c) (3 p)

Part Y

Set-up time = 4 x 1 h = 4 h

Run time = 200 x 4 x 6 = 4800 min = 80 h

Total time = 1890 min = 84 h

Part Z

Set-up time = 4 x 1.5 = 6 h

Run time = 200 x 4 x 2 x 2.5 = 4000 min = 66.67 h

Total time = 72.67 h

Time req./batch:

156.67/4 → 39.17h/batch → 1 shift (40h/week) enough