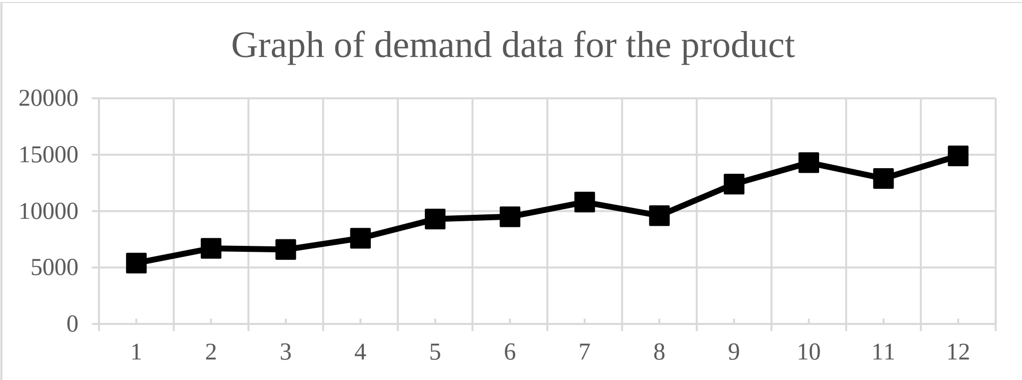
Answers to written exam in operations planning and control TEK 420 – January 16, 2016

Problem 1 (14 points)

a)

Plot the data:



Important characteristics to note:

- Strong, linear trend and significant variability
- Too short time series and too little information about product/market to say anything about seasonal variations

Choose number of periods and smoothing factor alpha:

- Higher number of periods required to smoothen variability → low alpha, high n
  - e.g. n=9 → alpha=0,2

Choose the trend smoothing factor beta:

- Linear trend with small variability in trend suggests a responsive/larger beta, but a smaller beta would on the other hand reduce the influence of random variation from the stable trend.
  - e.g. beta = 0,7 (but lower beta also OK)

Start iteration in month 6, with BF(6)=D(5)=9300 and T(6)=D(6)-D(5)=200

Period	D(t)	MA(t)	BF(t)	T(t)	F(t)		|PE| Exp.	|PE| MA	
1	5400								
2	6700								
3	6600								
4	7600								
5	9300								
6	9500	7120	9300	200					
7	10800	7940	9500	200	9700				
8	9600	8760	9920	354	10274		7,0	8,8	
9	12400	9360	10139	260	10399		16,1	24,5	
10	14300	10320	10799	540	11339		20,7	27,8	
11	12900	11320	11931	954	12885		0,1	12,2	
12	14900	12000	12888	956	13845		7,1	19,5	
13			14056	1104	15160				
14					16264				
15					17368				
					MAPE m. 8-12		10,2	18,6	

b)

Levelled production:

Production volume = closing inventory – opening inventory + demand volumes = 0 – 12’ + 120’ = 108’

Monthly production = 108’/12 = 9’

Max. regular time = 12 x 5 x 20 x 8 = 9600 (>9000 → no overtime)

Month		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**	
Demand (‘)		5,4	6,7	6,6	7,6	9,3	9,5	10,8	9,6	12,4	14,3	12,9	14,9	120	
Prod. (‘)		9	9	9	9	9	9	9	9	9	9	9	9	108	
Inv (’)	12	15,6	17,9	20,3	21,7	21,4	20,9	19,1	18,5	15,1	9,8	5,9	0		
Backlog		0	0	0	0	0	0	0	0	0	0	0	0	0	
Av. Inv.		13,8	16,8	19,1	21,0	21,6	21,2	20,0	18,8	16,8	12,5	7,9	3,0	192,5	

Production cost: 200 x 108 000 = € 21 600 000

Inventory cost: 20 x 192.5’ = € 3 850 000

Total cost = 21 600 000 + 3 850 000 = € 25 450 000

Chase production:

Month		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**	
Demand (‘)		5,4	6,7	6,6	7,6	9,3	9,5	10,8	9,6	12,4	14,3	12,9	14,9	120	
Prod. (‘)		0	0,1	6,6	7,6	9,3	9,5	10,8	9,6	12,4	14,3	12,9	14,9	108	
Inv (’)	12	6,6	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.		0	0.1	6.6	7.6	9.3	9,5	9,6	9,6	9,6	9,6	9,6	9,6	90.7	
Overtime								1,2	0	2,8	4,7	3,3	5,3	17.3	
Av. Inv.		9,3	3,3	0	0	0	0	0	0	0	0	0	0	12.6	

Production cost (regular time): 200 x 90.7 = € 18 140 000

Production cost (overtime): 400 x 17.3 = € 6 920 000

Inventory cost: 20 x 12.6 = € 252 000

Backlog costs: 0 €

Total costs: 18 140 000 + 6 920 000 + 252 000 = € 25 312 000

Recommendation should be to change to chase strategy (25.312 million compared to 25.450 million)

Problem 2 Solution (12 points)

a)

D=126.9; S=100; IxC=1.27

➔ EOQ=141

Week		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
Forecast		120	130	125	115	130	150	120	125	
Customer orders		115	135	117	105	95	83	54	39	
Scheduled rec.			100							
Inv.	200	85	50	67	94	106	98	120	137	
MPS				142	142	142	142	142	142	
ATP		85	-35	25	37	47	59	88	103	
ATP final		50	0	25	37	47	59	88	103	

a)

40 in week 2 → Yes, available from week 1

Week	1	2	3	4	5	6	7	8
ATP	10(1) ~~50~~(1)	0	25	37	47	59	88	103
Accepted orders		40(1)						

85 in week 3 → No, only 10 from week 1 and 25 from week 3 are available

80 in week 5 → Yes, use 10 from week 1, 25 from week 3, 37 from week 4 and 8 from week 5

Week	1	2	~~3~~	4	5	6	7	8
ATP	0(3) ~~10~~~~(1)~~(3) ~~50~~(1)	0	0 ~~25~~(3)	0 ~~37~~(3)	39 ~~47~~(3)	59	88	103
Accepted orders		40(1)			80(3)			

200 in week 7 → Yes, outside planning time fence

Week	1	2	~~3~~	4	5	6	7	8
ATP	0(3) ~~10~~~~(1)~~(3) ~~50~~(1)	0	0 ~~25~~(3)	0 ~~37~~(3)	39 ~~47~~(3)	58	0 ~~88~~(4)	102
Accepted orders		40(1)			80(3)		200(4)	

b)

Capacity requirements in WC02 for each MPS of 141 product X:

	Machine 1	Machine 2	Machine 3	
Setup time per batch [h]	1,5	1,2		
Run-time per unit [min]	14	7		
Quantity per week	142	284		
Total time required for MPS [h]	34,7	34,4		
Available time in WC02 per week [h]	40	40		
Run-time allocated to machine 3 [h]	None	None	None	
Setup in machine 3 [h]			N/A	
Total time in machine 3 [h]			None	
Available time in machine 3 [h]			20	

So, three lathes are sufficient given the MPS quantities of 141 units per week.

Problem 7 Solution (9 Points)

a)

SS_dfr=Z*sigma_ddlt

sigma_ddlt=sqrt(LT*sigma_d^2+sigma_lt^2*D^2)

LT=1
sigma_d=20
sigma_lt=0.9
D=100

➔ sigma_ddlt=92.195…

E(z)=(1-SL_dfr)*Q/sigma_ddlt

SL_dfr=0.95
Q=170
sigma_ddlt=92.195…

➔ E(z)=0.092…

➔ Z=0.94

SS_dfr=0.94*92.195…=86.6633=87 units

b)

MRP A

Week		1	2	3	4	5	6	7	8	
Forecast		100	100	100	100	100	100	100	100	
Sched. r.										
I	300	200	100	170	240	140	210	110	180	
Ord. r.				170	170		170		170	
Ord. s.			170	170		170		170		

MRP C

Week		1	2	3	4	5	6	7	8	
D(A)=2:1			340	340		340		340		
D_add		120	120	120	120	120	120	120	120	
Gross		120	460	460	120	460	120	460	120	
Sched. r.			500		500					
I	500	380	420	210	590	130	260	300	180	
Ord. r.				250			250	500		
Ord. s.			250			250	500			

MRP D

Week		1	2	3	4	5	6	7	8	
D(C)=2:1			500			500	1000			
D_add		120	120	120	120	120	120	120	120	
Gross		120	620	120	120	620	1120	120	120	
Sched. r.		200				700				
I	250	330	110	190	270	350	230	110	190	
Ord. r.			400	200	200		1000		200	
Ord. s.		400	200	200		1000		200		

We reach a capacity constraint in week 6, but since there is enough capacity available in earlier weeks (1000 units in total) and only 400 needs to be moved, we can plan production to those weeks to compensate for the demand peek in week 6. So YES, the company can meet the material requirements for the next 8 weeks.

Problem 4: Answers in Chapters 9 (9.1-9.2) and 10 (10.1-10.2).

Problem 4a (2 points)

- Similarities objectives, e.g.: balancing demand and supply resources. Generating feasible production plans. Decision about production volumes, capacity needs, inventories.
- Differences objectives, e.g.: S&OP on demand and Supply rates per product family, while MPS on anticipated build schedule. S&OP on overall capacity, while MPS on critical resources.

Problem 4b (4 points)

Similarities process, e.g. balancing demand and supply, and adjusting inventory/order stock levels.

Differences process, e.g.:

- S&OP always a process, while MPS could be only method (level 0 MRP).
- Planning object and unit (product – family), planning unit. Volume vs mix.
- Planning horizon (critical lead time vs budget horizon)
- Planning frequency. Monthly vs weekly/daily
- Interface with financial planning/budgeting (S&OP) not really MPS 1p
- Different order types in MPS – not in S&OP.

Problem 4c. Separate process (2 points)

- Different objectives. Difficult to focus on long-term issues if not a separate process for short-term balancing.
- Business planning focus and top-management perspective difficult if too short-term focus.
- Difficult to get a long-term focus if plans/data on mix details.

Problem 4d. Why combine processes (2 points)

- If planning environment and conditions allow: E.g. the small firm with stable and few products.
- In ETO firms where focus of MPS is on medium-term capacity planning.

Problem 5 (Changed max points to 10p)
Problem 5a: All methods defined in Chapter 13
Problem 5b (See Chapter 13 and answering ideas below):

- 3. Percentage of leadtime demand: When demand variations are stable/low or possible to segment products based on demand variation/forecast error. Requires simulation/follow-up to understand resulting fill-rate service. Need only simple software support/Excel and not much data.
- Demand fill rate: Requires software and data. Always applicable when at least medium level of volume.
- Cycle service (Poisson): When low volume demand e.g. spare parts. Requires simulation/follow up to understand resulting fill-rate service because it only calculated P of stockout per inventory cycle. Discrete so when rounding off not a problem.
- Cost optimization: When shortage costs can be calculated, which is difficult to find in practice, and especially when the inventory costs change incrementally. Must simulate to understand resulting fill-rate service.

Problem 6 (6 points)
Problem 6a: The calculation of a re-order point is based on expected average demand over a period. Accordingly it is basically impossible to consider seasonal variation in demand in re-order point systems. Material requirements planning is a more suitable method when dealing with seasonally varying demand. The method allows using seasonal indexes to make it possible to consider seasonal variation in demand when calculating net requirements as a basis for generating planned orders. 2p

Problem 6b: To some extent seasonal variation in demand could however be considered by for example using a lower re-order point during the low demand season and a higher re-order point during the high demand season.

Problem 6c: In re-order point systems, two quantities are compared when deciding whether to order or not; stock on hand and the re-order point. When using run-out time planning two lead times are compared to decide whether to order or not, the run-out time, i.e. the time that stock on hand is estimated to last, and the lead time to replenish stock plus possibly a safety time. Run-out time method can generate priority numbers which re-order point cannot.

Problem 7 (changed max points to 9p. Five improvements not required for full points)
NB. The answers have to focus on material planning.

- Differentiate service levels and safety stock levels for different products
- Safety stock allocation decision in the distribution network (up or downstream in distribution structure) (Chopra and Meindl, Chapter 12)
- Safety stock aggregation: Common safety stock for geographically close warehouses
- Distribution requirements planning to explode/derive requirements through a distribution network instead of local independent replenishment needs and decisions. DRP also allows generation of delivery schedules.
- Multi-echelon cycle stock policy (Chopra and Meindl, Chapter 11.7).

Problem 8 (10 points)
1b, 2b, 3a, 4a, 5b, 6b, 7b, 8a, 9a, 10b