E-Supplement for Chapter 12 Production and Material Requirements Planning

Solved problems

Task S&OP

A producer of wood furniture has the following aggregate demand requirements and other data for the upcoming four quarters.

Quarter	Demand		
1	1300	Beginning inventory	200 units
2	1400	Stockout cost	$50 per unit
3	1500	Inventory holding cost	$10 per unit
4	1300	Hiring workers	$4 per unit
		Laying off workers	$8 per unit
		Unit cost	$30 per unit
		Overtime	$10 extra per unit

Your capacity is composed of 12 workers each of which has a productivity of 100 units per quarter.
Which of the following production plans is better: Plan A–chase demand by hiring and layoffs; or Plan B–produce at a constant rate of 1200 and obtain the remainder from overtime?

Answer:
Plan A:

Quarter	1	2	3	4	Total
Demand forecast	1300	1400	1500	1300	5500
Production:					
Regular	1100	1400	1500	1300	5300
Overtime	0	0	0	0	
Subcontract	0	0	0	0	
Shortage / Overage	0	0	0	0	0
Inventory:					

Beginning	200	0	0	0	200
Ending	0	0	0	0	
Average	100	0	0	0	100
Backlog	0	0	0	0	0
Costs:					
Production	33000	42000	45000	39000	
Inventory	1000	0	0	0	
Backlog	0	0	0	0	
Hiring/Laying-off	800	1200	400	1600	
Total costs	34800	43200	45400	40600	164.000

Plan B

Quarter	1	2	3	4	Total
Demand forecast	1300	1400	1500	1300	5500
Production:					
Regular	1200	1200	1200	1200	5300
Overtime	0	100	300	100	
Subcontract	0	0	0	0	
Shortage / Overage	0	0	0	0	0
Inventory:					
Beginning	200	100	0	0	
Ending	100	0	0	0	
Average	150	50	0	0	200
Backlog	0	0	0	0	0
Costs:					
Production	36000	36000	36000	36000	
Inventory	1500	500	0	0	
Backlog	0	0	0	0	
Hiring/Laying-off	0	4000	12000	4000	
Total costs	37500	40500	48000	40000	166.000

Plan A would cost $164,000, while Plan B would cost $165,000. In this case it is cheaper to vary work force than to use overtime. But negative effects of the chase strategy (e.g., loss of working skills and supporting economy of part-time work) should be taken into account.

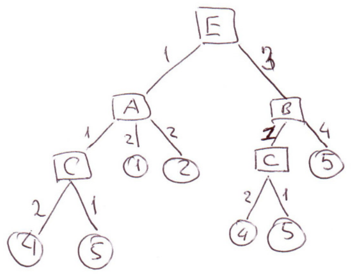
Task BOM/MRP

In firm, monthly production quantities in three consecutive periods amount to 60, 80, and 40 units respectively. There is no inventory on-hand or scheduled receipts. Lead time for each item is one period. The following indented BOM is given:

Level	Item	Quantity
0	E	1
1	A	1
2	C	1
3	4	2
3	5	1
2	1	2
2	2	2
1	B	3
2	C	1
3	4	2
3	5	1
2	5	4

1. Represent BOM in graphical form according to different levels
2. Represent BOM in table form subject to total amounts for each item
3. Calculate MRP (a) for each level and (b) for total demand for each item

1)



2.

Item	Quantity
E	1
A	1
B	3
C	4
1	2
2	2
4	8
5	16

3. MRP

a)

		1	2	3	4	5	6
0	E				60	80	40
1	A			60	80	40	
1	B			180	240	120	
2	C		240	320	160		
2	1		120	160	80		
2	2		120	160	80		
2	5		720	960	480		
3	4	480	640	320			
3	5	240	320	160			

b)

	1	2	3	4	5	6
E				60	80	40
A			60	80	40	
B			180	240	120	
C		240	320	160		
1		120	160	80		
2		120	160	80		
4	480	640	320			
5	240	1040	1120	480		

Task MRP

Kate, a Production Control Manager at an electronics company, was responsible for implementing time-phased material requirements planning. She decided to prepare an example to illustrate MRP.

Kate´s first step was to prepare a master production schedule (MPS) for one of the notebooks. The MPS indicates the number of units to be assembled during over the next nine days. From ERP system, Kate observed that the model A1 has demand of 16 units in day #9 and 15 units in day #7. Next, Kate decided to simplify MRP presentation example by considering only two of the many components which are needed to complete the assembly. These two components are the main block and a chip. One main block is needed for one notebook. Two chips are required for manufacturing of a main block. Finally, Kate got information from production and purchasing departments that lead time for notebook assembly is one day, lead time to get a chip from a supplier is one day, and lead time for main block assembly is two days.

Kate made the following assumptions:

- 8 main block and 15 chips are available on stock
- For notebooks, schedules receipts of 3 units are planned in the days #6 and #8 respectively.

Help Kate to calculate MRP!

First, we perform calculations for notebooks (lead time = 1):

Period	3	4	5	6	7	8	9
Gross requirement					15		16
On-hand inventory					3		3
Scheduled receipts				3		3	
Net requirement					12		13
Planned order release				12		13	

Consider the calculations for main block (lead time = 2):

Period	4	5	6	7	8	9	10
Gross requirement				12		13	
On-hand inventory				8	0	0	
Scheduled receipts							
Net requirement				4		13	
Planned order release		4		13			

Consider the calculations for chips (lead time = 1):

Period	4	5	6	7	8	9	10
Gross requirement		8		26			
On-hand inventory		15	7	7			
Scheduled receipts							
Net requirement		0		19			
Planned order release			19				

Task production planning (many periods, many products)

Products A and B are assembled of a module C (in-house production) and multiple sourcing components. Demand for A and B in different periods is given in Table:

	Month					
Product	1	2	3	4	5	6
A	120	120	220	280	160	300
B	150	80	120	50	40	100

Capacity in assembly is 30 units a day, and capacity for module C production is 14 units a day. Consider 20 working days a month. There is inventory of 20 units A, 10 units B, and 40 units C. Warehouse capacity of C is limited to 80 units. The monthly inventory holding costs of A,B,C is $1.2, 1.5, 0.8 respectively. Safety stock for C of 10 units hast to be held. Formulate this management problem as mathematical model with the objective of inventory costs minimization!

x_{jt}… production rate for product j in period t
L_{jt}… inventory of product j in periode t

Objective function

$ZF = \sum (1.2 * L_{At} + 1.5 * L_{Bt} + 0.8 * L_{Ct}) \rightarrow$ Min!

Constraints

Production capacity for A und B

$x_{At} + x_{Bt} \leq 15 * 20 * 1$
$x_{At} + x_{Bt} \leq 300$

2. Production capacity for C

$x_{Ct} \leq 7 * 20 * 2$
$x_{Ct} \leq 280$

3. Balance equations for A

$L_{A1} = 20 + x_{A1} - 120$
$L_{A2} = L_{A1} + x_{A2} - 120$
$L_{A3} = L_{A2} + x_{A3} - 220$
$L_{A4} = L_{A3} + x_{A4} - 280$
$L_{A5} = L_{A4} + x_{A5} - 160$
$L_{A6} = L_{A5} + x_{A6} - 300$

4. Balance equations for B

$L_{B1} = 10 + x_{B1} - 150$
$L_{B2} = L_{B1} + x_{B2} - 80$
$L_{B3} = L_{B2} + x_{B3} - 120$
$L_{B4} = L_{B3} + x_{B4} - 50$
$L_{B5} = L_{B4} + x_{B5} - 40$
$L_{B6} = L_{B5} + x_{B6} - 100$

5. Balance equations for C

$L_{C1} = 30 + x_{C1} - x_{A1} - x_{B1}$
$L_{Ct} = L_{C, t-1} + x_{Ct} - x_{At} - x_{Bt}$ for t = 2, 3, …., 6

6. Warehouse capacity for C

$L_{Ct} \leq 80 - 10 = 70$

7. Non-negativity constraint

$x_{jt}, L_{jt} \geq 0$