Worksheet Four: Materials Requirement Planning

Please attempt the questions before the session and be prepared to share your solutions.

Question One

Company OLDCO manufactures product Y. The demand for Y is stationary over time, but with a seasonal effect. The weekly demand for product Y is shown in Table 4.

Table: Weekly demands for product Y

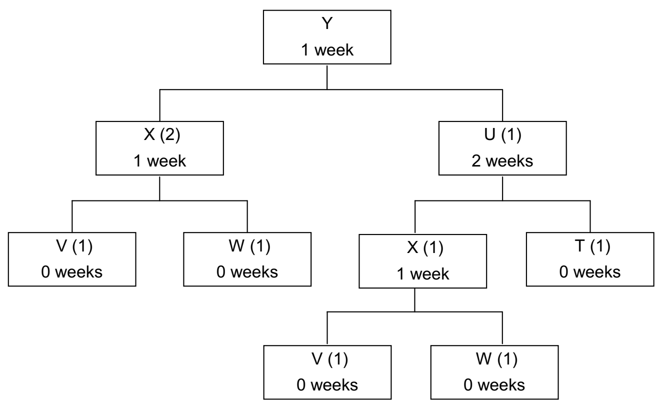
Week	5	6	7	8	9	10	11	12
Demand	30	55	80	30	65	90	25	70

Product Y is made of two units of X and one unit of U. Component X consists of one unit of V and one unit of W. Component U is made of one unit of X and one unit of T. Production and assembly of Y and X each take one week; assembly of U takes two weeks. All other assembly times or lead times may be assumed to be negligible. At the end of period 4, 15 units of Y are expected to be in stock, and 10 units of X will be available in period 2. The inventory holding costs for X and W are £1 per unit per week and £0.01 per unit per week, respectively. The machine producing X appears to be critical in the entire process. The setup cost to start producing X is therefore high – estimated at £300 per setup.

(a) Draw the product structure diagram for product Y

Solution

The product structure diagram for Y can be shown as:



(b) Using the demand for product Y given in the table above, determine the planned order release (lot-for-lot) for X using an MRP approach. Organise your calculations in an appropriate table and explain your approach.

We first note our maximum lead time is give 4 weeks. (Lead time Y + Lead time X + Lead time U)

To find the planned order release (lot-for-lot) for X we began at the first (highest) level, with product Y and note the demand for product Y = Gross requirement Y.

- ⇒ Inventory: We note that at the end of period 4, 15 units of Y are expected to be in stock.
- ⇒ Net requirements: subtract any on hand inventory from gross requirement
- ⇒ Time phased: the lead time for Y is given as one week, so bring net requirement forward by one week.
- ⇒ Planned order release: As we are using lot-for-lot approach, the planned order release for Y = the time phased net requirement for Y

We move to the next level and consider component U

- ⇒ Gross requirement U = POR Y as one component U is required for one unit of Y
- ⇒ Net requirement: we have no inventory on hand for U so net requirement = gross requirement
- ⇒ Time phased: the lead time for U is given as two weeks, so bring net requirement forward by two weeks
- ⇒ Planned order release: Using lot-for-lot approach, planned order release for U = time phased net requirement for U

Next, consider component X

- ⇒ Gross requirement: here one unit of Y requires two units of X, **and** one unit of U requires one unit of X.
    - o Thus, total gross requirement of X= gross requirement X from Y + gross requirement X from U
- ⇒ Inventory: 10 units of X will be available in period 2
- ⇒ Net requirement: subtract on hand inventory from gross requirement
- ⇒ Time phased: the lead time for X is given as one week, so bring net requirement forward by one week.
- ⇒ Planned order release: Using lot-for-lot approach, planned order release for X = time phased net requirement for X

Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Gross requirements Y	0	0	0	0	30	55	80	30	65	90	25	70
End inventory Y				15	0							
Net requirements Y	0	0	0	0	15	55	80	30	65	90	25	70
Time phased net requirements Y	0	0	0	15	55	80	30	65	90	25	70	
Planned order release (L4L) Y	0	0	0	15	55	80	30	65	90	25	70	
Gross requirements U	0	0	0	15	55	80	30	65	90	25	70	
Net requirements U	0	0	0	15	55	80	30	65	90	25	70	
Time phased net requirements U	0	15	55	80	30	65	90	25	70			
Planned order release (L4L) U	0	15	55	80	30	65	90	25	70			
Gross requirements 2 X (from Y)	0	0	0	15 *2 = 30	55* 2 = 110	80*2= 160	30*2 = 60	65*2 = 130	90*2 = 180	25*2 = 50	70*2 = 140	
Gross requirements 1 X (from U)	0	15	55	80	30	65	90	25	70			
Total gross requirements X	0	15+0 = 15	55+0 = 55	30+80 = 110	110+30 = 140	160+65 = 225	60+90 = 150	130+25 = 155	180+70 = 250	50+0 = 50	140+0 = 140	
Inventory X		10										
Net requirements X	0	15-10 = 5	55	110	140	225	150	155	250	50	140	
Time phased net requirements X	5	55	110	140	225	150	155	250	50	140		

Question Two

A manufacturing company produces two products, A and B, which have a common component Y (see Figure 1). Table 3 shows the MPS for A and B for the next eight weeks. The projected inventory levels for A and B at the end of week 3 are 30 and 25 units, respectively. In addition, 5 units of component X will be available in week 4, while 50 units of component Y are expected to arrive in week 5.

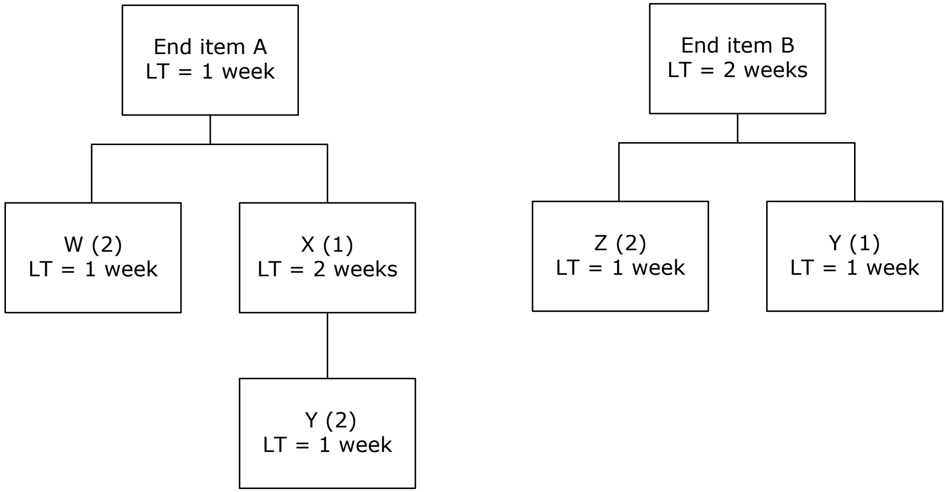


Figure 1: Product structure diagram for A and B

Table 3: MPS: weekly demand for A and B

Week	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Demand A	65	55	30	95	40	25	30	35
Demand B	55	75	40	55	85	80	85	95

(a) Determine the planned order release (lot-for-lot) for Y. Describe briefly your approach and arrange your calculations in an appropriate table.

Solution

First, we need to calculate the time phased net requirements for A and B (taking into account the inventory at period 3).

Next, we calculate the time phased net requirements for X, taking into account that 5 units of X will arrive in period 4.

The gross requirements for X are the same as the time phased net req for A.

Next, we calculate the total gross requirements for Y:

- Which are: twice the time phased net req for X plus once the time phased net req for B.

Accounting for the scheduled receipts in week 5, we obtain the total net req for Y.

By shifting everything one week earlier we get the time phased net req for Y (= lot for lot).

Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Gross requirement A				65	55	30	95	40	25	30	35
Inventory A			30		0						
Net requirement A				65-30 = 35	55	30	95	40	25	30	35
Time phased Net A			35	55	30	95	40	25	30	35	
Gross requirement B			35	55	75	40	55	85	80	85	95
Inventory B			25	0							
Net requirement B				55-25 = 30	75	40	55	85	80	85	95
Time phased Net B		30	75	40	55	85	80	85	95		
Gross requirement X			35	55	30	95	40	25	30	35	
Scheduled receipts				5							
Net requirement X			35	50	30	95	40	25	30	35	
Time phased Net X	35	50	30	95	40	25	30	35			
Gross requirement Y (from X)	35*2= 70	50*2 = 100	30*2 = 60	95*2 = 190	40*2 = 80	25*2 = 50	30*2 = 60	35*2 = 70			
Gross requirement Y (from B)		30	75	40	55	85	80	85	95		

Total gross requirement Y		100+30 = 130	60+75 = 135	190+40 = 230	80+55 = 135	50+85 = 135	60+80 = 140	70+85 = 155	95		
Scheduled receipts					50						
Net requirement Y	70	130	140	60	85	110	40	125	70		
Time phased net Y = lot-for lot	130	140	60	85	110	40	125	70			

We need to ensure that we have 70 units in inventory at the end of the previous planning horizon!

(b) Suppose that the capacity to produce Y is 120 units per week. The production setup cost for Y is £150 and the holding cost is £0.50 per unit per week. Is the Planned order release for Y from part (a) capacity feasible? If not, try to obtain your best possible capacity feasible plan for Y.

<u>Solution</u>

If capacity = 120 then we have the following:

Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Original POR Y	130	135	230	85	135	140	150	95
Capacity	120	120	120	120	120	120	120	120

We note that in weeks 2, and 7 our POR is greater than our capacity of 120 units. Therefore, the plan identified in part (a) is not feasible.

However, we can use our feasibility check to see **if** a feasible plan exists.

The feasibility check states a feasible plan exists IF cumulative capacity is greater than cumulative demand

Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Original POR Y	130	135	230	85	135	140	150	95
Capacity	120	120	120	120	120	120	120	120
Cumulative requirement	140	130+135= 265	265+230 = 495	495+85 = 580	580+135 = 715	715+140 = 855	855+150 = 1005	1005+95 = 1100

Cumulative capacity	120	120+120 = 240	240+120 = 360	360+120 = 480	480+120 = 600	600+120 = 720	720+120 = 840	840+120 = 960

Here we see that our cumulative capacity in each period is **less** than our cumulative demand.

Therefore, there **IS NOT** a feasible solution.

Alternative scenario

Suppose that our POR is instead:

Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
POR	90	140	60	85	110	40	125	70

Is there a feasible plan in this scenario?

To find a feasible plan we look for the first week whereby capacity < demand:

In week 2:

- Requirement (140) is 20 units greater than capacity (120).
- We can backshift additional 20 units to week 1 where there is capacity

In week 7:

- Requirement (125) is 5 units greater than capacity (120)
- We can backshift additional 5 units to week 6

Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Original POR Y	90	140	60	85	110	40	125	70	0	0	0
Capacity	120	120	120	120	120	120	120	120	0	0	0

Cumulative requirement	90	230	290	375	485	525	650	720	0	0	0
Cumulative capacity	120	240	360	480	600	720	840	960	0	0	0
Modified POR	90+20 = 110	140-20 = 120	60	85	110	40+5 = 45	125 – 5 = 120	70			
Inventory	110-90 = 20	20+120–140 = 0	0+60-60 = 0	0+85-85 = 0	0+110-110 = 0	0+45-40 = 5	5+120-125 = 0	0+70-70 = 0			

The cost of this plan is calculated as order cost + inventory cost

= (8*150) + (25*0.5)

= £1,212.50

Recall that lot shifting will give find a feasible plan (if one exists), but not necessarily an optimal plan.

We can use the improvement procedure to find an improved plan.

First, find the excess capacity:

Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Modified POR	110	120	60	85	110	45	120	70
Excess capacity	10	0	60	35	10	75	0	50

Starting with the last period, week 8, is it possible to backshift the entire demand (70 units)? Yes, week 6 has capacity of 75 units.

Now, check whether the additional holding cost is less than the fixed order cost:

Holding cost £0.50 per week £0.50*70*2 = £70 < £150

Thus, we want to backshift week 8 (70 units) to week 6

Result:

Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Modified POR	110	120	60	85	110	45	120	70
Modified POR	110	120	60	85	110	115	120	0
Excess capacity	120-110 =10	120-120 = 0	120-60 = 60	120-85= 35	120-110 = 10	120-115 = 5	120-120 = 0	120-0 = 120
Inventory	20	0	0	0	0	5	0	0

Total cost of this plan = 7*150 + (0.5*25) = £1,062.5

Is this a better plan? **Yes** £1,062.5 < £1,212.50

Question Three

Office Supplies ltd. produces office equipment. Their most popular item is the Soft Chair. The demand for the chair over an eight-week period is shown below:

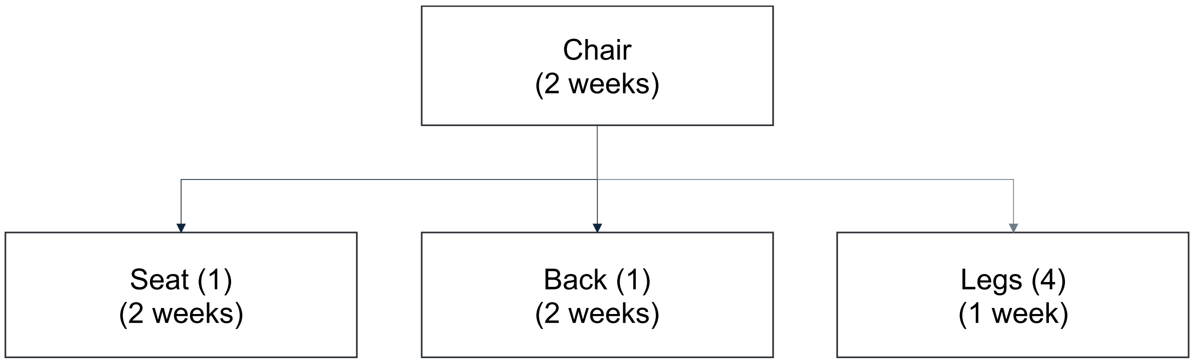
Week	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Demand	150	70	190	80	60	100	85	120

The lead times are given as follows: two weeks for the chairs, seat and back and one week for the legs. The company is expecting a receipt of 50 seat units in week two and 20 back units in week 5.

At the end of week 2 the company expects to have 260 chair units in inventory. In week one, the company expects to have 70 seat units, 35 back units and 60 leg units in inventory.

(a) Draw the product structure diagram (bill of materials) for the chair

The bill of materials is shown below. It is not mentioned but we assume each chair has 4 legs.



(b) Using the demand for the chairs given in the table above, determine the planned order release (lot-for-lot) for the chairs and component parts using an MRP approach.

Chair:

week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Gross Demand (Chair)			150	70	190	80	60	100	85	120
Inventory (Chair)		260	260-150 = 110	110-70 =40	0					
Net demand (Chair)			0	0	190-40 = 150	80	60	100	85	120
Time phased (chair)			150	80	60	100	85	120		
planned order release (chair)			150	80	60	100	85	120		

Seat:

gross demand (seat)	0	0	150	80	60	100	85	120		
inventory (seat)	70	70	70+50 = 120	0						
scheduled receipts		50	0	0	0					
net demand	0	0	150-120 = 30	80	60	100	85	120		
time phased	30	80	60	100	85	120				

Back:

gross demand	0	0	150	80	60	100	85	120	0	0
inventory	35	35	40							
scheduled receipts		5	0	0	20	0	0	0		
net demand		0	150-40 = 110	80	60-20 = 40	100	85	120		
time phased	110	80	40	100	85	120				

Legs:

gross demand	0	0	600	320	240	400	340	480		
inventory	60	60	60							
scheduled receipts			0	0	0	0	0	0		
net demand			540	320	240	400	340	480		
Time phased net demand		540	320	240	400	340	480	0		

Summary

Summary	**week 1**	**week 2**	**week 3**	**week 4**	**week 5**	**week 6**	**week 7**	**week 8**	**week 9**	**week 10**
chair	0	0	135	90	60	100	85	120	0	0
seat	30	80	60	100	85	120	0	0	0	0
back	115	90	55	100	85	120	0	0	0	0
legs	0	540	320	240	400	340	480	0	0	0

(c) Compare the cost of the lot for lot lotsizing POR for the seat with EOQ lotsizing. Assume the setup cost is £275 and the holding cost is £1.50 per unit per week.

The cost of the plan in part (b) is given as:

$$Total\ cost = (number\ of\ orders\ *\ order\ holding\ cost) + (inventory\ units * inventory\ holding\ cost)$$

In this plan, no inventory is held, but the maximum number of orders is made:

$$\Rightarrow total\ cost = 6 * 275 = £1650$$

Recall EOQ formula: $Q^* = \sqrt{\frac{2K\lambda}{h}}$

Here we have our fixed cost K = £275 and holding cost h = £1.50 per unit per week.

We need to find average demand λ

$$\lambda = \frac{30 + 80 + 60 + 100 + 85 + 25}{6}$$

= 89.167

Thus, EOQ gives

$$Q^* = \sqrt{\frac{2 * 275 * 89.167}{1.5}}$$

= 180.816 = 190 units

Seat	**week 1**	**week 2**	**week 3**	**week 4**	**week 5**	**week 6**
Original POR	30	80	60	100	85	120
EOQ POR	190			180		180
inventory	160	80	20	100	15	75

Cost associated with EOQ plan:

Set up cost: 3*275 = 825
Inventory cost: (160+80+20+100+15+75)*3 = 675
Total cost = £1,500 less than our cost of £1,650 for the lot for lot plan