CHAPTER 9
MATERIAL REQUIREMENTS PLANNING

Discussion Questions

1. What do we mean when we say that MRP is based on dependent demand?

   Decisions in MRP are directly driven by decisions made elsewhere in planning end-item production. The order quantities depend *on the plans for end-item production. Without end-item production there is no need for an MRP system.*

2. Discuss the importance of the master production schedule in an MRP system.

   The master production schedule "drives" the system. It states the planned due dates for end items. Material requirements planning computer runs, however, involve an iterative process. The master production schedule "proposes" or "hypothesizes" a tentative schedule. After the MRP run with this schedule, the shop scheduler examines the MRP plan for impractical loads on the productive system—either by stating excessive demands on personnel or equipment, or in excessive idle time. Then the master production schedule is revised and the program is run again.

   Because the entire MRP system is geared to satisfying the master production schedule, it is critical that the master production schedule be correct at the start of the first MRP run. The production scheduler then knows what effects any changes he makes on the schedule will have on the original MRP schedule. He can then take appropriate action as necessary, such as requesting that customers be contacted to try to extend promised dates if they are too close, or to arrange for early delivery or additional storage space if products will be completed prior to the promised delivery date.

3. Explain the need for *time fences* in the master production schedule.

   Time fences allow for some certainty in the planning of production resources and the execution of the MRP system. Since most items ordered in an MRP system have some lead time, the MPS must be firmed up early enough to allow for the lead times needed in ordering needed materials through the MRP system. If the MPS is allowed to change up until the last minute there will not be enough time to order everything needed to support it.

4. "MRP just prepares shopping lists. It does not do the shopping or cook the dinner." Comment.

   An MRP system generates schedules to meet material needs. It starts with the master schedule and develops a time phased schedule which specifies what, when, and how many units of each material are required. Whether this schedule is adhered to, depends first on the master scheduler who may change the schedule. Then an inventory control personnel may choose to change order quantities or timing. Then the purchasing department may make further modifications to a purchase order, and finally the production scheduler may actually release the work to production—(which may be at some time other than that called for in the MRP schedule).

5. What are the sources of demand in an MRP system? Are these dependent or independent, and how are they used as inputs to the system?

   An MRP system has both dependent and independent item demands. The major demands on the system occur through the master production schedule (these are usually of independent origin). From here on throughout the system, the demands are then dependent on the master production schedule.

   Orders for spare parts and repair parts normally do not go through the master production schedule unless their amounts are large enough to place a significant load on the productive system. These demands (which are usually independent) are fed into the inventory records file by-passing the master production schedule. Once there, they are then exploded into the required parts and materials needed during the normal course of the MRP run. The parts and materials needed to make the spares and repair parts are, therefore, dependent demand.

6. State the types of data that would be carried in the bill-of-materials file and the inventory record file.

   The Bill-of-materials file contains information about the product, including a listing of parts numbers, quantities needed per unit or product, and the assembly or process flow stipulating how the unit is structured. Engineering design changes that affect the product structure are placed into the Bill-of-materials file. Also, parts or material changes that occur through a change of vendors or material composition are also added to update the file.

   The Inventory Record file contains a great deal of information about each inventory item. At a minimum, the file would contain the number of units on hand and on order, the number reserved for prior commitments, the cost of the item, the name and address of the vendor, the lead time needed to obtain a shipment, and any shipment size restrictions. Additional information may be added as desired, such as that contained in Exhibit 21.7.

7. Discuss the meaning of MRP terms such as *planned order release* and *scheduled order receipts*.

   A planned order release is an order currently planned to be released. It has not been released. Consequently, the planned order release can be changed based upon changes in demand as one example.

   A scheduled order receipt, on the other hand, reflects an order that has already been released. The scheduled order receipt indicates the anticipated arrival of the released order. Due to variations in delivery times, it may not arrive exactly at the planned arrival time.

8. Why is the MRP process referred to as an "explosion?"

   Dependent demand for items managed in an MRP system is driven by production orders for the independent demand end item. As end item orders are entered, the MRP system evaluates the impact on demand for all of the dependent demand items. The system calculates the dependent demand by examining the end item product structure tree one level at a time. For complex items, a small order for a single end item could result in inventory calculations and planned orders for hundreds of component parts and assemblies. One small order "explodes" into a very complex series of orders.

9. Many practitioners currently update MRP weekly or biweekly. Would it be more valuable if it were updated daily? Discuss.

   The performance of any operation will naturally vary from day to day. When the observed time period in which performance is measured is a week or two, the daily variations are smoothed; that is, the variations in performance are averaged. For example, below-average performance in one day may be offset by a higher-than-average performance the next day. Daily MRP runs monitor performance too closely and may even create an exception report calling a normal variation an abnormal deviation from expected output.

10. Should safety stock be necessary in an MRP system with dependent demand? If so, why? If not, why do firms carry it anyway?

    In most systems, there are some reasons to carry safety stock, even for items that only have dependent demand. Most reasons stem from uncertainty in the system and its environment. Some of these include:
    a. *Possible short-notice increase in the production order quantity for the parent independent demand item.*
    b. *Rush orders for the parent independent demand item.*
    c. *Potential quality or yield issues with the MRP orders*
    d. *Lead time variation with the MRP orders*
    e. *Scrapped items in the MRP system*

11. Contrast the significance of the term *lead time* in the traditional EOQ context and in an MRP system.

    In the traditional context, lead time is fixed—either as a discrete time or as a probability distribution. Such lead time constancy or variation is outside of the inventory model.

    Lead time in an MRP system is assumed to be a variable. While specific lead times are stated for planning purposes, these times may be speeded up or delayed as conditions warrant. Indeed, it is this ability to detect needed changes in lead times—either by expediting or de-expediting—that many users cite as one of the most valuable features of MRP.

12. Planning orders on a lot-for-lot is commonly done because it is simple and intuitive. It also helps to minimize holding costs as you are only ordering what is needed when it is needed. So far it sounds like a good idea. Are there any disadvantages to this approach?

    The main problem lies in its simplicity – there is no analysis of the costs involved. It will work well when setup costs are extremely low and lead times are dependable. These are traits needed to

implement a JIT system, and lot-for-lot is a very JIT-type logic. When setup costs are high, as in Solved Problem 4, lot-for-lot ordering is not appropriate and can be quite expensive compared to other methods.

13. What is meant when we say that the least total cost (LTC) and least unit cost (LUC) methods are *dynamic* lot-sizing techniques?

Dynamic means that the order sizes are always changing as our needs change across time. In the EOQ approach, the order quantity is the same every time. In lot-for-lot ordering, the quantities do change, but they are always exactly what is needed in a period. In LTC and LUC we consider the effect of cumulative needs across time to determine best ordering quantities. Order quantities change throughout time, and the number of periods we order for each time will change too. Also, as we roll through time and new demand requirements are known, previously developed planned orders may end up changing. These methods are dynamic indeed!

Objective Questions

1. Match the industry type to the expected benefits from an MRP system, as High, Medium, or Low.

Industry Type	Expected Benefit (High, Medium, or Low)
Assemble-to-stock	***High***
Assemble-to-order	***High***
Make-to-stock	***Low***
Make-to-order	***Low***
Engineer-to-order	***High***
Process	***Medium***

2. MRP is based on what type of demand?

   Dependent demand

3. Which scheduling process drives requirements in the MRP process?

   Master production scheduling

4. What term is used to identify the difference between the number of units of an item listed on the master schedule and firm customer orders?

   Available to promise

5. What are the three primary data sources used by the MRP system?

   Master production schedule, bill-of-materials, inventory records file

6. What is another common name for the bill-of-materials?

   Product structure tree -or- *product tree*

7. What is the process to ensure that all of the needs for a particular item are calculated at the same time in the MRP process?

   Low-level coding

8. What is the MRP term for the time periods used in planning?

   Time buckets

9. Semans is a manufacturer that produces bracket assemblies. Demand for bracket assemblies (X) is 130 units. The following is the BOM in indented form:

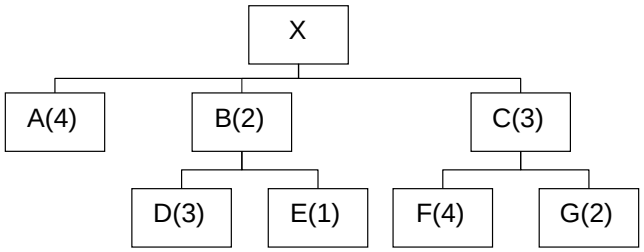
Item	Description	Usage
X	Bracket assembly	1
A	Wall board	4
B	Hanger subassembly	2
D	Hanger casting	3
E	Ceramic knob	1
C	Rivet head screw	3
F	Metal tong	4
G	Plastic cap	2

Below is a table indicating current inventory levels:

Item	X	A	B	C	D	E	F	G
Inventory	25	16	60	20	180	160	1,000	100

a. Using Excel, create the MRP using the information provided.

b. What are the net requirements of each item?



X	A	B	C	D	E	F	G
105	404	150	295	270	0	180	490

(Sample MRP schedule worksheet)

	Period:	1	2	3	4	5	6	7	8	9	10
Item:	Gross requirements										
OH:	Scheduled receipts										
LT:	Projected available balance										
SS:	Net requirements										
Q:	Planned order receipts										
	Planned order releases										
Item:	Gross requirements										
OH:	Scheduled receipts										
LT:	Projected available balance										
SS:	Net requirements										
Q:	Planned order receipts										
	Planned order releases										
Item:	Gross requirements										
OH:	Scheduled receipts										
LT:	Projected available balance										
SS:	Net requirements										
Q:	Planned order receipts										
	Planned order releases										
Item:	Gross requirements										
OH:	Scheduled receipts										
LT:	Projected available balance										
SS:	Net requirements										
Q:	Planned order receipts										
	Planned order releases										

10. In the following MRP planning schedule for Item J, indicate the correct net requirements, planned order receipts, and planned order releases to meet the gross requirements. Lead time is one week.

	Week Number					
Item J	0	1	2	3	4	5
Gross requirements			75		50	70
On hand	40					
Net requirements						
Planned order receipt						
Planned order release						

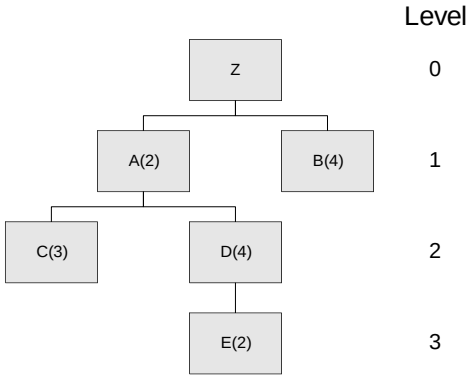
	Period:	1	2	3	4	5	
Item: J	Gross requirements		75		50	70	
OH: 40	Scheduled receipts						
LT: 1	Projected available balance	40	0	0	0	0	
SS: 0	Net requirements		35		50	70	
Q: L4L	Planned order receipts		35		50	70	
	Planned order releases	35		50	70		

11. Assume that Product Z is made of two units of A and four units of B. A is made of three units of C and four of D. D is made of two units of E.

    Lead times for purchase or fabrication of each unit to final assembly are: Z takes two weeks; A, B, C, and D take one week each; and E takes three weeks.

    Fifty units are required in Period 10. (Assume that there is currently no inventory on hand of any of these items.)

    a. Show the bill-of-materials (product structure tree).



    b. Develop an MRP planning schedule showing gross and net requirements and order release and order receipt dates.

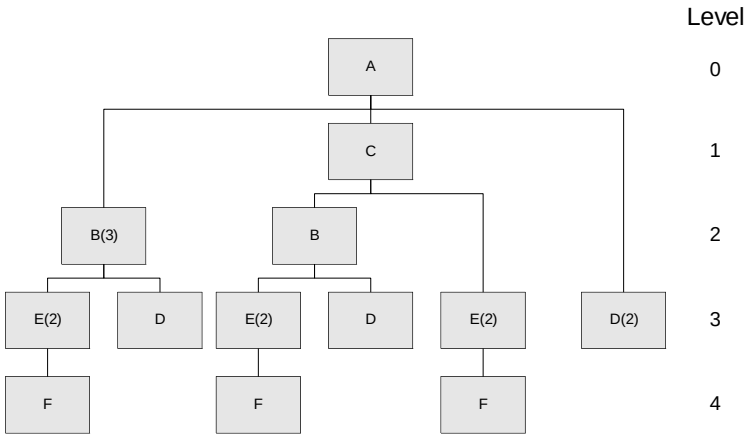
Solution is on next page

		Period:	1	2	3	4	5	6	7	8	9	10
Item:	Z	Gross requirements										50
OH:	0	Scheduled receipts										
LT:	2	Projected available balance	0	0	0	0	0	0	0	0	0	0
SS:	0	Net requirements										50
Q:	L4L	Planned order receipts										50
		Planned order releases								50		
Item:	A	Gross requirements								100		
OH:	0	Scheduled receipts										
LT:	1	Projected available balance	0	0	0	0	0	0	0	0	0	0
SS:	0	Net requirements								100		
Q:	L4L	Planned order receipts								100		
		Planned order releases							100			
Item:	B	Gross requirements								200		
OH:	0	Scheduled receipts										
LT:	1	Projected available balance	0	0	0	0	0	0	0	0	0	0
SS:	0	Net requirements								200		
Q:	L4L	Planned order receipts								200		
		Planned order releases							200			
Item:	C	Gross requirements							300			
OH:	0	Scheduled receipts										
LT:	1	Projected available balance	0	0	0	0	0	0	0	0	0	0
SS:	0	Net requirements							300			
Q:	L4L	Planned order receipts							300			
		Planned order releases						300				
Item:	D	Gross requirements							400			
OH:	0	Scheduled receipts										
LT:	1	Projected available balance	0	0	0	0	0	0	0	0	0	0
SS:	0	Net requirements							400			
Q:	L4L	Planned order receipts							400			
		Planned order releases						400				
Item:	E	Gross requirements						800				
OH:	0	Scheduled receipts										
LT:	3	Projected available balance	0	0	0	0	0	0	0	0	0	0
SS:	0	Net requirements						800				
Q:	L4L	Planned order receipts						800				
		Planned order releases			800							

12. One unit of A is made of three units of B, one unit of C, and two units of D. B is composed of two units of E and one unit of D. C is made of one unit of B and two units of E. E is made of one unit of F.

    Items B, C, E, and F have one-week lead times; A and D have lead times of two weeks.

    Assume that lot-for-lot (L4L) lot sizing is used for Items A, B, and F; lots of size 50, 50, and 200 are used for Items C, D, and E, respectively. Items C, E, and F have on hand (beginning) inventories of 10, 50, and 150, respectively; all other items have zero beginning inventory. We are scheduled to receive 10 units of A in Week 2, 50 units of E in Week 1, and also 50 units of F in Week 1. There are no other scheduled receipts. If 30 units of A are required in Week 8, use the low-level-coded bill-of-materials to find the necessary planned order releases for all components.



Plan is shown on following page.

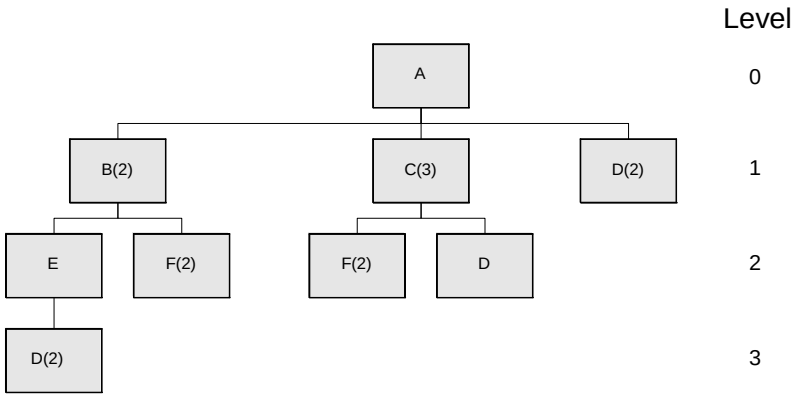
		Period:	1	2	3	4	5	6	7	8	9	10
Item:	A	Gross requirements								30		
OH:	0	Scheduled receipts		10								
LT:	2	Projected available balance	0	10	10	10	10	10	10	0		
SS:	0	Net requirements								20		
Q:	L4L	Planned order receipts								20		
		Planned order releases						20				
Item:	C	Gross requirements						20				
OH:	10	Scheduled receipts										
LT:	1	Projected available balance	10	10	10	10	10	40	40	40		
SS:	0	Net requirements						10				
Q:	50	Planned order receipts						50				
		Planned order releases					50					
Item:	B	Gross requirements					50	60				
OH:	0	Scheduled receipts										
LT:	1	Projected available balance	0	0	0	0	0	0	0	0		
SS:	0	Net requirements					50	60				
Q:	L4L	Planned order receipts					50	60				
		Planned order releases				50	60					
Item:	D	Gross requirements				50	60	40				
OH:	0	Scheduled receipts										
LT:	2	Projected available balance	0	0	0	0	40	0	0	0		
SS:	0	Net requirements				50	60	0				
Q:	50	Planned order receipts				50	100					
		Planned order releases		50	100							
Item:	E	Gross requirements				100	220					
OH:	50	Scheduled receipts	50									
LT:	1	Projected available balance	100	100	100	0	180	180	180	180		
SS:	0	Net requirements				0	220					
Q:	200	Planned order receipts					400					
		Planned order releases				400						
Item:	F	Gross requirements				400						
OH:	150	Scheduled receipts	50									
LT:	1	Projected available balance	200	200	200	0	0	0	0	0		
SS:	0	Net requirements				200						
Q:	L4L	Planned order receipts				200						
		Planned order releases			200							

13. One unit of A is made of two units of B, three units of C, and two units of D. B is composed of one unit of E and two units of F. C is made of two units of F and one unit of D. E is made of two units of D. Items A, C, D, and F have one-week lead times; B and E have lead times of two weeks. Lot-for-lot (L4L) lot sizing is used for Items A, B, C, and D; lots of size 50 and 180 are used for Items E and F, respectively. Item C has an on-hand (beginning) inventory of 15; D has an on-hand inventory of 50; all other items have zero beginning inventories. We are scheduled to receive 20 units of Item E in Week 2; there are no other scheduled receipts.

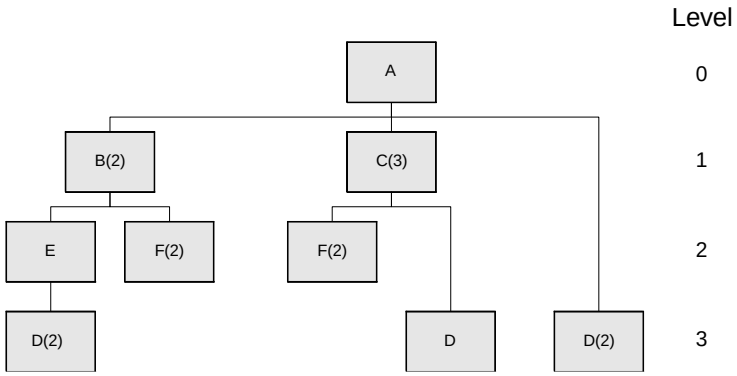
    Construct simple and low-level-coded bill-of-materials (product structure tree) and indented and summarized parts lists.

    If 20 units of A are required in Week 8, use the low-level-coded bill-of-materials to find the necessary planned order releases for all components.

Product structure tree



Low-level coded product structure tree



Bills-of-material

Indented bill-of-materials

A
B(2)
E
D(2)
F(2)
C(3)
F(2)
D
D(2)

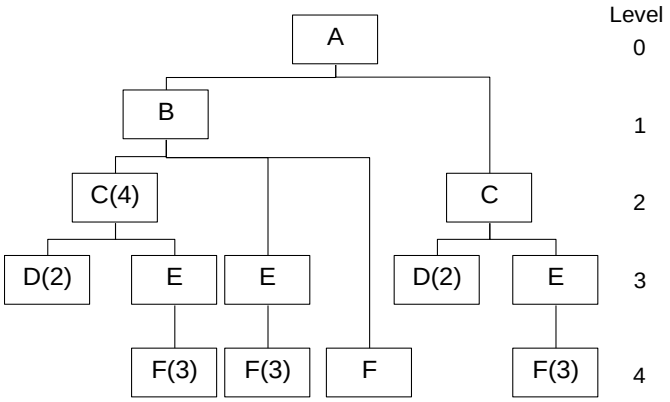
Single level bill-of-materials

A
B(2)
C(3)
D(2)
B
E
F(2)
C
D
F(2)
E
D(2)

		Period:	1	2	3	4	5	6	7	8	9	10
Item:	A	Gross requirements								20		
OH:	0	Scheduled receipts										
LT:	1	Projected available balance	0	0	0	0	0	0	0	0		
SS:	0	Net requirements								20		
Q:	L4L	Planned order receipts								20		
		Planned order releases							20			
Item:	B	Gross requirements							40			
OH:	0	Scheduled receipts										
LT:	2	Projected available balance	0	0	0	0	0	0	0	0		
SS:	0	Net requirements							40			
Q:	L4L	Planned order receipts							40			
		Planned order releases					40					
Item:	C	Gross requirements							60			
OH:	15	Scheduled receipts										
LT:	1	Projected available balance	15	15	15	15	15	15	0	0		
SS:	0	Net requirements							45			
Q:	L4L	Planned order receipts							45			
		Planned order releases						45				
Item:	E	Gross requirements					40					
OH:	0	Scheduled receipts		20								
LT:	2	Projected available balance	0	20	20	20	30	30	30	30		
SS:	0	Net requirements					20					
Q:	50	Planned order receipts					50					
		Planned order releases			50							
Item:	F	Gross requirements					80	90				
OH:	0	Scheduled receipts										
LT:	1	Projected available balance	0	0	0	0	100	10	10	10		
SS:	0	Net requirements					80					
Q:	180	Planned order receipts					180					
		Planned order releases				180						
Item:	D	Gross requirements			100			45	40			
OH:	50	Scheduled receipts										
LT:	1	Projected available balance	50	50	0	0	0	0	0	0		
SS:	0	Net requirements			50			45	40			
Q:	L4L	Planned order receipts			50			45	40			
		Planned order releases		50			45	40				

14. One unit of A is made of one unit of B and one unit of C. B is made of four units of C and one unit each of E and F. C is made of two units of D and one unit of E. E is made of three units of F. Item C has a lead time of one week; Items A, B, E, and F have two-week lead times; and Item D has a lead time of three weeks. Lot-for-lot (L4L) lot sizing is used for Items A, D, and E; lots of size 50, 100, and 50 are used for Items B, C, and F, respectively. Items A, C, D, and E have on-hand (beginning) inventories of 20, 50, 100, and 10, respectively; all other items have zero beginning inventory. We are scheduled to receive 10 units of A in Week 1, 100 units of C in Week 1, and 100 units of D in Week 3; there are no other scheduled receipts. If 50 units of A are required in Week 10, use the low-level-coded bill-of-materials (product structure tree) to find the necessary planned order releases for all components.

Product structure tree

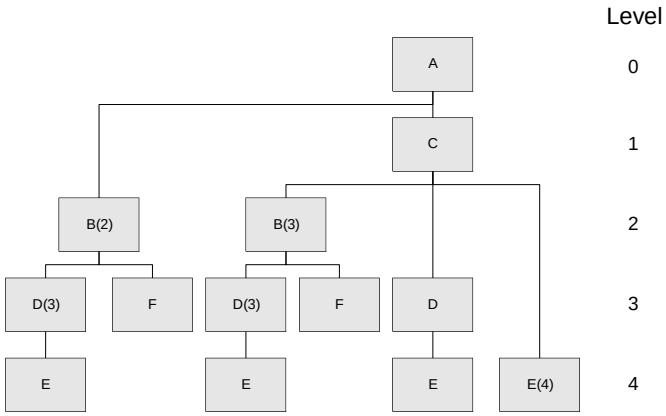


Plan is shown on following page.

		Period:	1	2	3	4	5	6	7	8	9	10
Item:	A	Gross requirements										50
OH:	20	Scheduled receipts	10									
LT:	2	Projected available balance	30	30	30	30	30	30	30	30	30	0
SS:	0	Net requirements										20
Q:	L4L	Planned order receipts										20
		Planned order releases								20		
Item:	B	Gross requirements								20		
OH:	0	Scheduled receipts										
LT:	2	Projected available balance	0	0	0	0	0	0	0	30	30	30
SS:	0	Net requirements								20		
Q:	50	Planned order receipts								50		
		Planned order releases						50				
Item:	C	Gross requirements						200		20		
OH:	50	Scheduled receipts	100									
LT:	1	Projected available balance	150	150	150	150	150	50	50	30	30	30
SS:	0	Net requirements						50				
Q:	100	Planned order receipts						100				
		Planned order releases					100					
Item:	D	Gross requirements					200					
OH:	100	Scheduled receipts			100							
LT:	3	Projected available balance	100	100	200	200	0	0	0	0	0	0
SS:	0	Net requirements					0					
Q:	L4L	Planned order receipts										
		Planned order releases										
Item:	E	Gross requirements					100	50				
OH:	10	Scheduled receipts										
LT:	2	Projected available balance	10	10	10	10	0	0	0	0	0	0
SS:	0	Net requirements					90	50				
Q:	L4L	Planned order receipts					90	50				
		Planned order releases			90	50						
Item:	F	Gross requirements			270	150		50				
OH:	0	Scheduled receipts										
LT:	2	Projected available balance	0	0	30	30	30	30	30	30	30	30
SS:	0	Net requirements			270	120		20				
Q:	50	Planned order receipts			300	150		50				
		Planned order releases	300	150		50						

15. One unit of A is made of two units of B and one unit of C. B is made of three units of D and one unit of F. C is composed of three units of B, one unit of D, and four units of E. D is made of one unit of E. Item C has a lead time of one week; Items A, B, E, and F have two-week lead times; and Item D has a lead time of three weeks. Lot-for-lot (L4L) lot sizing is used for Items C, E, and F; lots of size 20, 40, and 160 are used for Items A, B, and D, respectively. Items A, B, D, and E have on-hand (beginning) inventories of 5, 10, 100, and 100, respectively; all other items have zero beginning inventories. We are scheduled to receive 10 units of A in Week 3, 20 units of B in Week 7, 40 units of F in Week 5, and 60 units of E in Week 2; there are no other scheduled receipts. If 20 units of A are required in Week 10, use the low-level-coded bill-of-materials (product structure tree) to find the necessary planned order releases for all components.

Product structure tree



Plan is shown on following page.

		Period:	1	2	3	4	5	6	7	8	9	10
Item:	A	Gross requirements										20
OH:	5	Scheduled receipts			10							
LT:	2	Projected available balance	5	5	15	15	15	15	15	15	15	15
SS:	0	Net requirements										5
Q:	20	Planned order receipts										20
		Planned order releases								20		
Item:	C	Gross requirements								20		
OH:	0	Scheduled receipts										
LT:	1	Projected available balance	0	0	0	0	0	0	0	0	0	0
SS:	0	Net requirements								20		
Q:	L4L	Planned order receipts								20		
		Planned order releases							20			
Item:	B	Gross requirements							60	40		
OH:	10	Scheduled receipts							20			
LT:	2	Projected available balance	10	10	10	10	10	10	10	10	10	10
SS:	0	Net requirements							30	30		
Q:	40	Planned order receipts							40	40		
		Planned order releases					40	40				
Item:	D	Gross requirements					120	120	20			
OH:	100	Scheduled receipts										
LT:	3	Projected available balance	100	100	100	100	140	20	0	0	0	0
SS:	0	Net requirements					20		0			
Q:	160	Planned order receipts					160					
		Planned order releases		160								
Item:	F	Gross requirements					40	40				
OH:	0	Scheduled receipts					40					
LT:	2	Projected available balance	0	0	0	0	0	0	0	0	0	0
SS:	0	Net requirements					0	40				
Q:	L4L	Planned order receipts						40				
		Planned order releases				40						
Item:	E	Gross requirements		160					80			
OH:	100	Scheduled receipts		60								
LT:	2	Projected available balance	100	0	0	0	0	0	0	0	0	0
SS:	0	Net requirements		0					80			
Q:	L4L	Planned order receipts							80			
		Planned order releases					80					

16. One unit of A is composed of two units of B and three units of C. Each B is composed of one unit of F. C is made of one unit of D, one unit of E, and two units of F. Items A, B, C, and D have 20, 50, 60, and 25 units of on-hand inventory, respectively. Items A, B, and C use lot-for-lot (L4L) as their lot-sizing technique, while D, E, and F require multiples of 50, 100, and 100, respectively, to be purchased. B has scheduled receipts of 30 units in Period 1. No other scheduled receipts exist. Lead times are one period for Items A, B, and D, and two periods for Items C, E, and F. Gross requirements for A are 20 units in Period 1, 20 units in Period 2, 60 units in Period 6, and 50 units in Period 8. Find the planned order releases for all items.

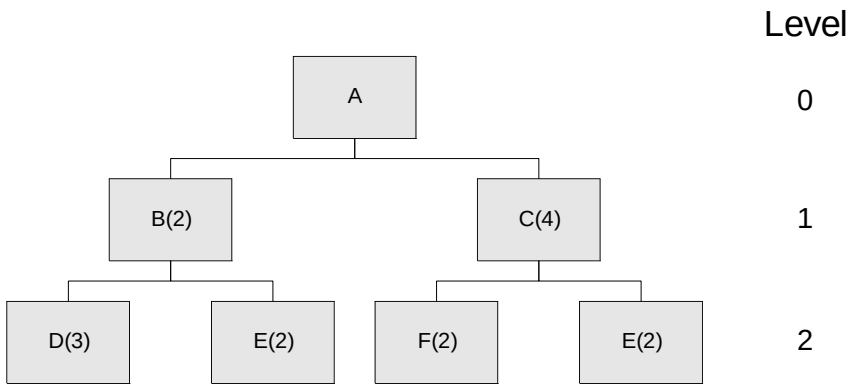
		Period:	1	2	3	4	5	6	7	8	9	10
Item:	A	Gross requirements	20	20				60		50		
OH:	20	Scheduled receipts										
LT:	1	Projected available balance	0	0	0	0	0	0	0	0		
SS:	0	Net requirements	0	20				60		50		
Q:	L4L	Planned order receipts		20				60		50		
		Planned order releases	20				60		50			
Item:	B	Gross requirements	40				120		100			
OH:	50	Scheduled receipts	30									
LT:	1	Projected available balance	40	40	40	40	0	0	0	0		
SS:	0	Net requirements					80		100			
Q:	L4L	Planned order receipts					80		100			
		Planned order releases				80		100				
Item:	C	Gross requirements	60				180		150			
OH:	60	Scheduled receipts										
LT:	2	Projected available balance	0	0	0	0	0	0	0	0		
SS:	0	Net requirements	0				180		150			
Q:	L4L	Planned order receipts					180		150			
		Planned order releases			180		150					
Item:	D	Gross requirements			180		150					
OH:	25	Scheduled receipts										
LT:	1	Projected available balance	25	25	45	45	45	45	45	45		
SS:	0	Net requirements			155		105					
Q:	50	Planned order receipts			200		150					
		Planned order releases		200		150						
Item:	E	Gross requirements			180		150					
OH:	0	Scheduled receipts										
LT:	2	Projected available balance	0	0	20	20	70	70	70	70		
SS:	0	Net requirements			180		130					
Q:	100	Planned order receipts			200		200					
		Planned order releases	200		200							
Item:	F	Gross requirements			360	80	300	100				
OH:	0	Scheduled receipts										
LT:	2	Projected available balance	0	0	40	60	60	60	60	60		
SS:	0	Net requirements			360	40	240	40				
Q:	100	Planned order receipts			400	100	300	100				
		Planned order releases	400	100	300	100						

17. Each unit of A is composed of one unit of B, two units of C, and one unit of D. C is composed of two units of D and three units of E. Items A, C, D, and E have on-hand inventories of 20, 10, 20, and 10 units, respectively. Item B has a scheduled receipt of 10 units in Period 1, and C has a scheduled receipt of 50 units in Period 1. Lot-for-lot (L4L) lot sizing is used for Items A and B. Item C requires a minimum lot size of 50 units. D and E are required to be purchased in multiples of 100 and 50, respectively. Lead times are one period for Items A, B, and C, and two periods for Items D and E. The gross requirements for A are 30 in Period 2, 30 in Period 5, and 40 in Period 8. Find the planned order releases for all items.

		Period:	1	2	3	4	5	6	7	8	9	10
Item:	A	Gross requirements		30			30			40		
OH:	20	Scheduled receipts										
LT:	1	Projected available balance	20	0	0	0	0	0	0	0		
SS:	0	Net requirements		10			30			40		
Q:	L4L	Planned order receipts		10			30			40		
		Planned order releases	10			30			40			
Item:	B	Gross requirements	10			30			40			
OH:	0	Scheduled receipts	10									
LT:	1	Projected available balance	0	0	0	0	0	0	0	0		
SS:	0	Net requirements	0			30			40			
Q:	L4L	Planned order receipts				30			40			
		Planned order releases			30			40				
Item:	C	Gross requirements	20			60			80			
OH:	10	Scheduled receipts	50									
LT:	1	Projected available balance	40	40	40	30	30	30	0	0		
SS:	0	Net requirements				20			50			
Q:	50	Planned order receipts				50			50			
		Planned order releases			50			50				
Item:	D	Gross requirements	10		100	30		100	40			
OH:	20	Scheduled receipts										
LT:	2	Projected available balance	10	10	10	80	80	80	40	40		
SS:	0	Net requirements			90	20		20				
Q:	100	Planned order receipts			100	100		100				
		Planned order releases	100	100		100						
Item:	E	Gross requirements			150			150				
OH:	10	Scheduled receipts										
LT:	2	Projected available balance	10	10	10	10	10	10	10	10		
SS:	0	Net requirements			140			140				
Q:	50	Planned order receipts			150			150				
		Planned order releases	150			150						

18. Product A is an end item and is made from two units of B and four of C. B is made of three units of D and two of E. C is made of two units of F and two of E. A has a lead time of one week. B, C, and E have lead times of two weeks, and D and F have lead times of three weeks.

    a. Show the bill-of-materials (product structure tree).



b. If 100 units of A are required in Week 10, develop the MRP planning schedule, specifying when items are to be ordered and received. There are currently no units of inventory on hand.

		Period:	1	2	3	4	5	6	7	8	9	10
Item:	A	Gross requirements										100
OH:	0	Scheduled receipts										
LT:	1	Projected available balance	0	0	0	0	0	0	0	0	0	0
SS:	0	Net requirements										100
Q:	L4L	Planned order receipts										100
		Planned order releases									100	
Item:	B	Gross requirements									200	
OH:	0	Scheduled receipts										
LT:	2	Projected available balance	0	0	0	0	0	0	0	0	0	0
SS:	0	Net requirements									200	
Q:	L4L	Planned order receipts									200	
		Planned order releases							200			
Item:	C	Gross requirements									400	
OH:	0	Scheduled receipts										
LT:	2	Projected available balance	0	0	0	0	0	0	0	0	0	0
SS:	0	Net requirements									400	
Q:	L4L	Planned order receipts									400	
		Planned order releases							400			
Item:	D	Gross requirements							600			
OH:	0	Scheduled receipts										
LT:	3	Projected available balance	0	0	0	0	0	0	0	0	0	0
SS:	0	Net requirements							600			
Q:	L4L	Planned order receipts							600			
		Planned order releases				600						
Item:	E	Gross requirements							1200			
OH:	0	Scheduled receipts										
LT:	2	Projected available balance	0	0	0	0	0	0	0	0	0	0
SS:	0	Net requirements							1200			
Q:	L4L	Planned order receipts							1200			
		Planned order releases					1200					
Item:	F	Gross requirements							800			
OH:	0	Scheduled receipts										
LT:	3	Projected available balance	0	0	0	0	0	0	0	0	0	0
SS:	0	Net requirements							800			
Q:	L4L	Planned order receipts							800			
		Planned order releases				800						

Assumes all items are ordered L4L

19. Audio Products, Inc., produces two AM/FM/CD players for cars. The radio/CD units are identical, but the mounting hardware and finish trim differ. The standard model fits intermediate and full-size cars, and the sports model fits small sports cars.

Audio Products handles the production in the following way. The chassis (radio/ CD unit) is assembled in Mexico and has a manufacturing lead time of two weeks. The mounting hardware is purchased from a sheet steel company and has a three-week lead time. The finish trim is purchased as prepackaged units consisting of knobs and various trim pieces from a Taiwan electronics company with offices in Los Angeles. Trim packages have a two-week lead time. Final assembly time may be disregarded because adding the trim package and mounting are performed by the customer.

Audio Products supplies wholesalers and retailers, which place specific orders for both models up to eight weeks in advance. These orders, together with enough additional units to satisfy the small number of individual sales, are summarized in the following demand schedule:

	Week							
Model	1	2	3	4	5	6	7	8
Standard model				300				400
Sports model					200			100

There are currently 50 radio/CD units on hand but no trim packages or mounting hardware.

Prepare a material requirements plan to meet the demand schedule exactly. Specify the gross and net requirements, on-hand amounts, and the planned order release and receipt periods for the radio/CD chassis, the standard trim and sports car model trim, and the standard mounting hardware and the sports car mounting hardware.

	Period:	1	2	3	4	5	6	7	8	9	10
	Standard Model Demand:				300				400		
	Sports Model Demand:					200			100		
Radio/CD	Gross requirements				300	200			500		
OH: 50	Scheduled receipts										
LT: 2	Projected available balance	50	50	50	0	0	0	0	0		
SS: 0	Net requirements				250	200			500		
Q: L4L	Planned order receipts				250	200			500		
	Planned order releases		250	200			500				
Standard Trim	Gross requirements				300				400		
OH: 0	Scheduled receipts										
LT: 2	Projected available balance	0	0	0	0	0	0	0	0		
SS: 0	Net requirements				300				400		
Q: L4L	Planned order receipts				300				400		
	Planned order releases		300				400				
Standard HW	Gross requirements				300				400		
OH: 0	Scheduled receipts										
LT: 3	Projected available balance	0	0	0	0	0	0	0	0		
SS: 0	Net requirements				300				400		
Q: L4L	Planned order receipts				300				400		
	Planned order releases	300				400					
Sport Trim	Gross requirements					200			100		
OH: 0	Scheduled receipts										
LT: 2	Projected available balance	0	0	0	0	0	0	0	0		
SS: 0	Net requirements					200			100		
Q: L4L	Planned order receipts					200			100		
	Planned order releases			200			100				
Sport HW	Gross requirements					200			100		
OH: 0	Scheduled receipts										
LT: 3	Projected available balance	0	0	0	0	0	0	0	0		
SS: 0	Net requirements					200			100		
Q: L4L	Planned order receipts					200			100		
	Planned order releases		200			100					

Assumes all items are order L4L

20. The MRP gross requirements for Item A are shown here for the next 10 weeks. Lead time for A is three weeks and setup cost is $10. There is a carrying cost of $0.01 per unit per week. Beginning inventory is 90 units.

	Week									
	1	2	3	4	5	6	7	8	9	10
Gross requirements	30	50	10	20	70	80	20	60	200	50

Use the least total cost or the least unit cost lot-sizing method to determine when and for what quantity the first order should be released.

Least Total Cost										
Period	1	2	3	4	5	6	7	8	9	10
Gross Requirements	30	50	10	20	70	80	20	60	200	50
Projected available balance	60	10	0	230	160	80	60	0	50	0
Net requirements				20					200	
Planned order receipts				250					250	
Planned order releases	250					250				
Least Unit Cost										
Period	1	2	3	4	5	6	7	8	9	10
Gross Requirements	30	50	10	20	70	80	20	60	200	50
Projected available balance	60	10	0	430	360	280	260	200	0	0
Net requirements				20						50
Planned order receipts				450						50
Planned order releases	450						50			

Calculations

Weeks	Quantity ordered	Carrying cost	Order cost	Total cost	Unit cost
4	20	$0.00	$10.00	$10.00	$0.500
4 to 5	90	0.70	10.00	10.70	0.119
4 to 6	170	2.30	10.00	12.30	0.072
4 to 7	190	2.90	10.00	12.90	0.068
4 to 8	250	5.30	10.00	15.30	0.061
4 to 9	450	15.30	10.00	25.30	0.056
4 to 10	500	18.30	10.00	28.30	0.057
9	200	0.00	10.00	10.00	
9 to 10	250	0.50	10.00	10.50	

For Least Total Cost, order for periods 4 through 8, since carrying cost is the closest to ordering cost. For Least Unit Cost, order for periods 4 through 9, since this has the lowest unit cost.

21. The MRP gross requirements for Item X are shown here for the next 10 weeks. Lead time for A is two weeks, and setup cost is $9. There is a carrying cost of $0.02 per unit per week. Beginning inventory is 70 units.

	Week									
	1	2	3	4	5	6	7	8	9	10
Gross requirements	20	10	15	45	10	30	100	20	40	150

Use the least total cost or the least unit cost lot-sizing method to determine when and for what quantity the first order should be released.

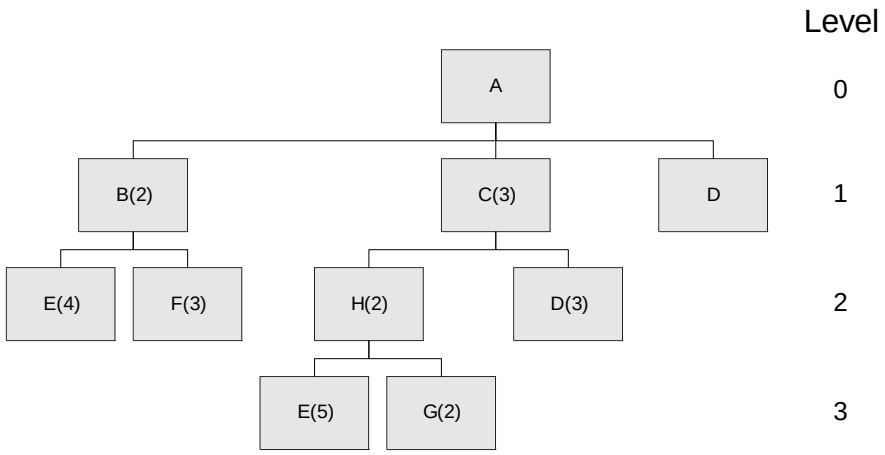
Period	1	2	3	4	5	6	7	8	9	10
Gross Requirements	20	10	15	45	10	30	100	20	40	150
Projected available balance	50	40	25	160	150	120	20	0	150	0
Net requirements				20				0	40	0
Planned order receipts				180					190	
Planned order releases		180					190			

Weeks	Quantity ordered	Carrying cost	Order cost	Total cost	Unit cost
4	20	$0.00	$9.00	$9.00	$0.450
4 to 5	30	0.20	9.00	9.20	0.307
4 to 6	60	1.40	9.00	10.40	0.173
4 to 7	160	7.40	9.00	16.40	0.103
4 to 8	180	9.00	9.00	18.00	0.100
4 to 9	220	13.00	9.00	22.00	0.100
4 to 10	370	31.00	9.00	40.00	0.108

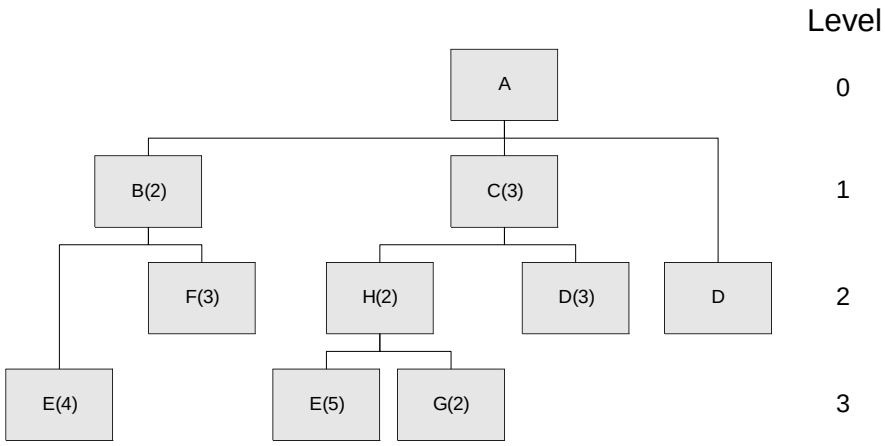
Least Total Cost method indicates that 180 units should be ordered to cover the needs for periods 4 through 8, since the carrying cost is equal to the order cost ($9). Least Unit Cost it tied at $.100 for ordering for periods 4 through 8 and 4 through 9. Therefore, order either 180 or 220 units in period 2.

22. Product A consists of two units of Subassembly B, three units of C, and one unit of D. B is composed of four units of E and three units of F. C is made of two units of H and three units of D. H is made of five units of E and two units of G.

a. Construct a simple bill-of-materials (product structure tree).



b. Construct a product structure tree using low-level coding.



c. Construct an indented parts list.

Indented bill-of-materials	Single level bill-of-materials
A	A
B(2)	B(2)
E(4)	C(3)
F(3)	D
C(3)	B
D(3)	E(4)
H(2)	F(3)
E(5)	C
G(2)	D(3)
D	H(2)
	H
	E(5)
	G(2)

d. To produce 100 units of A, determine the number of units of B, C, D, E, F, G, and H required.

Level 0	*100 units of A*
Level 1	*200 units of B*
	300 units of C
Level 2	*600 units of F*
	600 units of H
	1000 units of D (3x3x100 + 1x100)
Level 3	*3800 units of E (4x2x100 + 5x2x3x100)*
	1200 units of G

ANALYTICS EXERCISE: An MRP Explosion – Brunswick Motors

Recently, Phil Harris, the Production Control Manager at Brunswick, read an article on Time-Phased Requirements Planning. He was curious about how this technique might work in scheduling Brunswick's engine assembly operations, and decided to prepare an example to illustrate the use to Time-Phased Requirements Planning.

Phil's first step was to prepare a master schedule for one of the engine types produced by Brunswick - the Model 1000 engine. This schedule indicates the number of units of the Model 1000 engine to be assembled each week during the past twelve weeks, and is shown below. Next, Phil decided to simplify his requirements planning example by considering only two of the many components that are needed to complete the assembly of the Model 1000 engine. These two components, the Gear Box and the Input Shaft, are shown in the Product Structure Diagram shown below. Phil noted that the Gear Box is assembled by the Sub-Assembly Department, and is subsequently sent to the main engine assembly line. The Input Shaft is one of several component parts manufactured by Brunswick that are needed to produce a Gear Box sub-assembly. Thus, levels 0, 1, and 2 are included in the Product Structure Diagram to indicate the three manufacturing stages that are involved in producing an engine: the Engine Assembly Department, the Sub-Assembly Department, and the Machine Shop.

The manufacturing lead times required to produce the Gear Box and Input Shaft components are also indicated in the Product Structure Diagram. Note that two weeks are required to produce a batch of Gear Boxes, and that all of the Gear Boxes must be delivered to the assembly line parts stockroom before Monday morning of the week in which they are to be used. Likewise, it takes three weeks to produce a lot of Input Shafts, and all of the shafts that are needed for the production of Gear Boxes in a given week must be delivered to the Sub-Assembly Department stockroom before Monday morning of the week.

In preparing the MRP example Phil planned to use the worksheets shown on the next page and make the following assumptions:

1. Seventeen gear boxes are on hand at the beginning of week 1, and five gear boxes are currently on order to be delivered at the start of week 2.
2. Forty input shafts are on hand at the start of week 1, and 22 are scheduled for delivery at the beginning of week 2.

Solution/Teaching Note

This is a simple case that can be used as an in-class exercise or a group assignment. To start the class, quickly explain the basics of calculating net requirements. Then, distribute this case, have the students read the case, and give a brief explanation or what they are expected to do. It is probably best to have students work in pairs or small teams for this exercise.

1. Initially, assume that Phil wants to minimize his inventory requirements. Assume that each order will be only for what is required for a single period. Using the following forms, calculate the net requirements and planned order releases for the gear boxes and input shafts. Assume that lot sizing is done using lot-for-lot.

Engine Assembly Master Schedule

Week	1	2	3	4	5	6	7	8	9	10	11	12
Demand	15	5	7	10		15	20	10		8	2	16

Gear Box Requirements

Week:	1	2	3	4	5	6	7	8	9	10	11	12
Gross Requirements	15	5	7	10	0	15	20	10	0	8	2	16
Scheduled Receipts		5										
Projected Available Balance	2	2	0	0	0	0	0	0	0	0	0	0
Net Requirements			5	10	0	15	20	10	0	8	2	16
Planned Order Receipt			5	10		15	20	10		8	2	16
Planned Order Release	5	10		15	20	10		8	2	16		

Input Shaft Requirements

Week:	1	2	3	4	5	6	7	8	9	10	11	12
Gross Requirements	10	20		30	40	20		16	4	32		
Scheduled Receipts		22										
Projected Available Balance	30	32	32	2	0	0	0	0	0	0	0	0
Net Requirements					38	20	0	16	4	32	0	0
Planned Order Receipt					38	20		16	4	32		
Planned Order Release		38	20		16	4	32					

2. Phil would like to consider the costs that his accountants are currently using for inventory carrying and setup for the gearbox and input shafts. These costs are as follows:

Part	Cost
Gear Box	Setup = $90/order
	Inventory Carrying Cost = $2/unit/period
Input Shaft	Setup = $45/order
	Inventory Carrying Cost = $1/unit/period

Gear Box
- Setup Cost = 8 orders x $90 = $720
- Inventory = (2+2) x 2 = $8
- Total = $728

Input Shaft
- Setup Cost = 5 orders x $45 = $225
- Inventory = (30+32+32+2) x 1 = $96
- Total = $321

Total Cost = $1,049

3. Find a better schedule by reducing the number of orders and carrying some inventory. What are the savings with this new schedule?

Engine Assembly Master Schedule

Week	1	2	3	4	5	6	7	8	9	10	11	12
Demand	15	5	7	10		15	20	10		8	2	16

Gear Box Requirements

Week:	1	2	3	4	5	6	7	8	9	10	11	12
Gross Requirements	15	5	7	10	0	15	20	10	0	8	2	16
Scheduled Receipts		5										
Projected Available Balance	2	2	10	0	0	30	10	0	0	18	16	0
Net Requirements			5	0	0	15		0	0	8		0
Planned Order Receipt			15			45		0		26		
Planned Order Release	15			45				26				

Input Shaft Requirements

Week:	1	2	3	4	5	6	7	8	9	10	11	12
Gross Requirements	30			90				52				
Scheduled Receipts		22										
Projected Available Balance	10	32	32	0	0	0	0	0	0	0	0	0
Net Requirements				58				52				
Planned Order Receipt				58				52				
Planned Order Release	58				52							

Gear Box

Setup Cost = 3 orders x $90 = $270
Inventory = 88 x $2 = $176
Total = $446

Input Shaft

Setup Cost = 2 orders x $45 = $90
Inventory = 74 x 1 = $74
Total = $164

Total Cost = $610

Total cost of this solution is $439 less than the initial solution, a reduction of about 42%.

Note: Inventory carrying costs in parts 2 and 3 are figured based on ending inventory levels (projected available balance).