CHAPTER 14

Material Requirements Planning (MRP) and ERP

DISCUSSION QUESTIONS

1. The difference between a gross requirements plan and a net requirement plan is that a net plan adjusts for on-hand inventory and scheduled receipts at each level.

2. Once the MRP system is in place, it provides information to assist decision makers in other functional areas such as the amounts of labor required, cash needs, purchase requirements, and timing.

3. The similarities between material requirements planning (MRP) and distribution resource planning (DRP) are that the procedures and logic are analogous.

4. The difference between material requirements planning (MRP) and material resource planning II (MRP II) is that MRP II includes or integrates functions within the firm in addition to the management of dependent demand inventories. Examples of these additional functions include: Order entry, invoicing, billing, purchasing, production scheduling, capacity planning, and warehouse management.

5. There is no one "ideal" lot sizing technique that should be used by all manufacturing organizations. Lot-for-lot is the goal to be sought. However, where setup costs are significant and demand is not particularly lumpy, EOQ is a simple method and typically provides satisfactory results. Too much concern with lot sizing yields spurious results because of MRP dynamics.

6. In a DRP system, inventory residing within the system is moved within the system, rather than entering or leaving the system. Therefore, although effort should be made to reduce total inventory to minimize overall carrying cost, carrying cost per se does not have a significant effect on appropriate lot size.

7. MRP is usually a part of the overall production planning process. Its most important capability is including the timing/scheduling factor in inventory planning. MRP II, of course, addresses the timing/scheduling of other resources in addition to inventory.

8. (a) When a work center is only over capacity for one week (or a short time), the production planner has a number of options, including:

- Splitting an order to an earlier or later week
- Requesting overtime, an alternate (perhaps more expensive) production process
- Subcontracting

(b) A consistent lack of capacity suggests a capital investment to increase capacity, add a shift, or develop an outside source. Redesign of the product may also be an alternative.

9. The master schedule is expressed in terms of:

(1) End items in a continuous (make-to-stock) company;
(2) Customer orders in a job shop (make-to-order) company; and
(3) Modules in a repetitive (assemble-to-stock) company.

10. Virtually all functions of the firm impact an MRP system. For instance, purchasing performance affects delivery, changes in capacity (i.e., labor, maintenance, breakdowns) impact throughput, sales impact the master schedule as do financial issues such as capital expenditure for capacity, engineering performance such as meeting schedules and preference (or flexibility) for particular approaches to design/processing.

11. The rationale for: (a) A phantom bill of material is a subassembly that exists only on the production line—say a mixture/glue that only exists a few minutes and then must be used or discarded. Such items are never inventoried. (b) A planning bill of material may be used to issue a mixture of parts that only makes sense to reduce material handling—say the hardware for a washing machine assembly. (c) A pseudo bill of material is another name for planning bill to meet the same conditions.

12. An effective MRP system requires:

- A good schedule of what is to be made
- An accurate BOM
- Accurate inventory records
- Accurate purchases data
- Lead times that will be met

13. The benefits of ERP include:

- Provides integration of the production, supply chain, and administrative functions.
- Increases collaboration between functions and locations
- Often has a common database
- Can add effectiveness and efficiency to the organization.

14. Distinctions between MRP, DRP, and ERP, are: MRP is a set of software programs designed to schedule material requirements. These programs include an integrated set of programs that determine an item master for each part, a bill of material, an

explosion scheme, a lead-time file, an inventory status file, and vendor information. DRP is a time-phased stock-replenishment plan for all levels of the distribution network. Its focus is on retail and wholesale distribution network. On the other hand, enterprise resource planning (ERP) systems are systems that often integrate MRP and a variety of other accounting systems, human resource management, and communication with vendors and suppliers.

15. In MRP, demand need not be constant. Also, in an MRP system, the demand for one item depends on the demand for others—in particular, the end item. (There are exceptions such as spare parts and maintenance orders.)

16. The disadvantages of ERP include:

- Is very expensive to purchase and even more costly to customize.
- Implementation may require major changes in the company and its processes.
- Is so complex that many companies cannot adjust to it.
- Involves an ongoing process for implementation, which may never be completed.
- Expertise in ERP is limited, with staffing an ongoing problem.

17. (a) The Web sites of most of the major ERP vendors will include "successful solutions" using their software. See Web pages of the major vendors:

American Software: www.amsoftware.com
JD Edwards: www.jdedwards.com
The Baan Company: www.baan.com
Oracle: www.oracle.com
SAP: www.sap.com
IQMS: www.iqms.com

(b) The poor ERP efforts or installations may take a little more digging, but a look at www.CIO.com and www.Information Week.com should get students started.

18. (a) PeopleSoft includes the following in its CRM offerings (see http://www.oracle.com/applications/peoplesoft/CRM/ent/index.html):

Supplier Relationship Management Manage supplier relationships including indirect and direct goods, as well as services procurement with:

- Partner relationship management solution
- Sales solution
- Service solution
- CRM analytics
- CRM industry solutions
- Marketing solution

(b) **SAP's Supply Chain Management product includes:**

- *Supply strategy development*
- *Supplier qualification*
- *Supplier selection*
- *Contract negotiation and management*

(c) **SAP's Product Lifecycle Management product includes:**

- *Life-cycle data management*
- *Asset life-cycle management*
- *Program & project management*
- *Life-cycle collaboration*
- *Quality management*
- *Environment health & safety*

(See www.sap.com/solutions.)

19. Moving toward JIT and kanban suggest that the traditional weekly "buckets" (or even daily buckets) in an MRP system may be inadequate. MRP systems may need to move to hourly buckets for some items. Some MRP systems now deliver to "positions" in the production process—a "flow" criterion rather than a bucket criteria.

Additionally, if tracking of small lots is necessary (and it may not be) then not only will such "buckets" be necessary, but ease of inputs via bar codes or other automated means may be necessary.

ETHICAL DILEMMA

ERP is going to cost more than expected.

What do you do? Certainly, any sense of fairness and decency suggest that the customer must be told the truth. However, a sales representative can be expected to try to solve the problem for his customer. This may mean that:

- The first stop is the sales representative's manager to see if another customer or pending customer may have dealt with this problem and solved the problem or may be willing to share development costs.
- A second option is to ask the manager "Is there any budget or pending budget for this type of enhancement or can we help the customer out by paying for part of the enhancement?"

The bottom line is that not telling the customer the truth and/or selling the customer something that will not do the job is not only unethical, but also probably bad business—certainly bad business in the long run.

ACTIVE MODEL EXERCISE

ACTIVE MODEL 14.1: Order Releases

1. Suppose that item B must be ordered in multiples of dozens. Which items are affected by this change?

Items D and E

2. Suppose that the minimum order quantity for item C is 200 units. Which items are affected by this change?

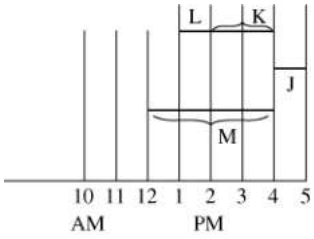
Items E, F, G, and D

END-OF-CHAPTER PROBLEMS

14.1 An exploded bill yields the following:

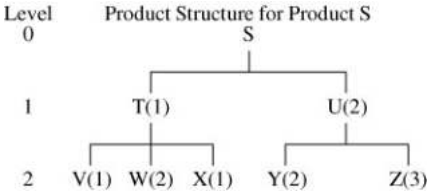
Item J: 200 units; Item K: 200 × 1 = 200 units; Item L: 200 × 4 = 800 units; Item M: 200 × 2 = 400 units.

14.2 The time-phased assembly plan for the gift bags is:

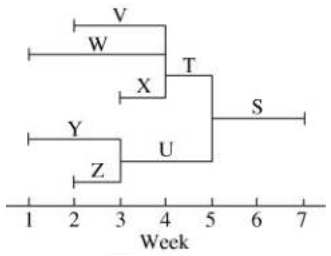


Someone should start on item M by noon.

14.3 (a) Product structure:



(b)



14.4 Gross material requirements plan:

		Week								Lead Time
Item		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**(weeks)**
S	Gross req							100		
	Order release					100				2
T	Gross req					100				
	Order release				100					1
U	Gross req					200				
	Order release			200						2
V	Gross req				100					
	Order release		100							2
W	Gross req				200					
	Order release	200								3
X	Gross req				100					
	Order release			100						1
Y	Gross req			400						
	Order release	400								2
Z	Gross req			600						
	Order release		600							1

14.5 Net material requirements plan:

		Week								Lead Time
Item		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**(weeks)**
S	Gross req							100		
	On hand							20		
	Net req							80		2
	Order receipt							80		
	Order release					80				
T	Gross req					80				
	On hand					20				
	Net req					60				1
	Order receipt					60				
	Order release				60					
U	Gross req					160				
	On hand					40				
	Net req					120				2
	Order receipt					120				
	Order release			120						
V	Gross req				60					
	On hand				30					
	Net req				30					2
	Order receipt				30					
	Order release		30							
		Week								Lead Time
Item		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**(weeks)**
W	Gross req				120					
	On hand				30					
	Net req				90					3
	Order receipt				90					
	Order release	90								
X	Gross req				60					
	On hand				25					
	Net req				35					1
	Order receipt				35					
	Order release			35						
Y	Gross req			240						
	On hand			240						
	Net req			0						2
	Order receipt			0						
	Order release									
Z	Gross req			360						
	On hand			40						
	Net req			320						1
	Order receipt			320						
	Order release		320							

14.6 Gross material requirements plan, modified to include the 20 units of U required for maintenance purposes:

		Week								Lead Time
Item		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**(weeks)**
S	Gross req							100		
	Order release					100				2
T	Gross req					100				
	Order release				100					1
U	Gross req					200	20*			
	Order release			200	20					2
V	Gross req				100					
	Order release		100							2
W	Gross req				200					
	Order release	200								3
X	Gross req				100					
	Order release			100						1
Y	Gross req			400	40					
	Order release	400	40							2
Z	Gross req			600	60					
	Order release		600	60						1

*needed for maintenance.

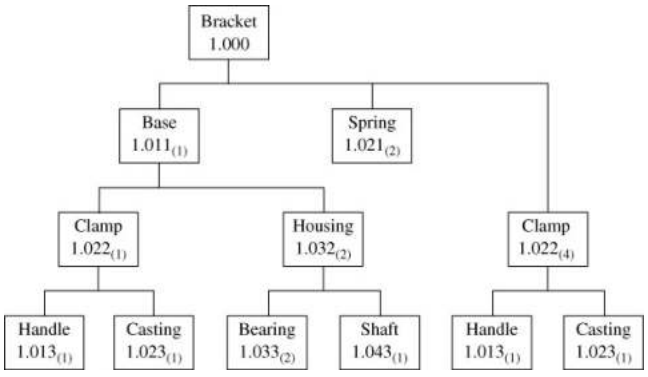
14.7 Net material requirements plan, modified to include the 20 units of U required for maintenance:

		Week								Lead Time
Item		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**(weeks)**
S	Gross req							100		
	On hand							20		
	Net req							80		2
	Order receipt							80		
	Order release					80				
T	Gross req					80				
	On hand					20				
	Net req					60				1
	Order receipt					60				
	Order release				60					

Item		Week 1	2	3	4	5	6	7	8	Lead Time (weeks)
U	Gross req					160	20*			
	On hand					40	0			
	Net req					120	20			2
	Order receipt					120	20			
	Order release			120	20					
V	Gross req				60					
	On hand				30					
	Net req				30					2
	Order receipt				30					
	Order release		30							
W	Gross req				120					
	On hand				30					
	Net req				90					3
	Order receipt				90					
	Order release	90								
X	Gross req				60					
	On hand				25					
	Net req				35					1
	Order receipt				35					
	Order release			35						
Y	Gross req			240	40					
	On hand			240	0					
	Net req				40					2
	Order receipt				40					
	Order release		40							
Z	Gross req			360	60					
	On hand			40	0					
	Net req			320	60					1
	Order receipt			320	60					
	Order release		320	60						

* To achieve these results in POM for Windows, add Part U as a new BOM line, level O, so that the software will recognize an additional independent demand, not scheduled receipts.

14.8 (a)

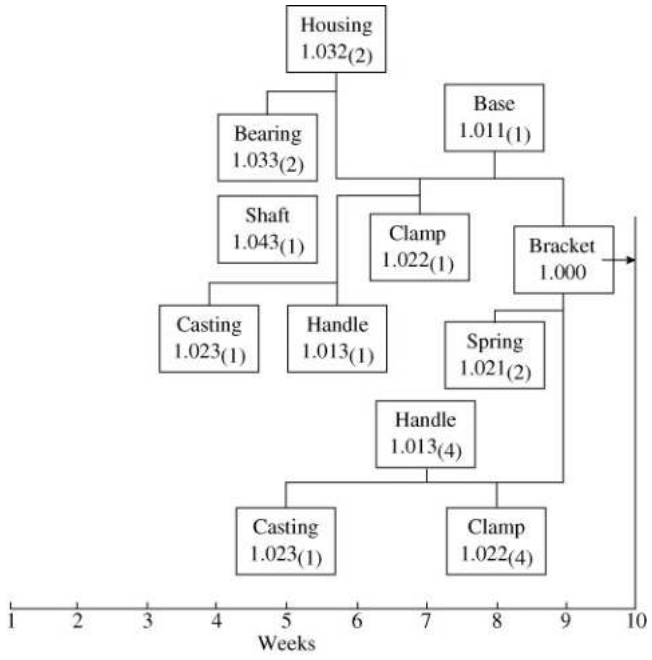


Level
0
1
2
3

(b) For 50 brackets, the gross requirements are for 50 bases, 100 springs, 250 clamps, 250 handles, 250 castings, 100 housings, 200 bearings, and 100 shafts.

(c) For 50 brackets net requirements are: 25 bases, 100 springs, 125 clamps, 125 handles, 125 castings, 50 housings, 100 bearings, and 50 shafts.

14.9 (a) Time-phased product structure for bracket with start times:



(b) Castings need to start in week 4.

14.10 (a) Gross material requirements plan:

Note: Elements have been listed in the gross material requirements plan in the order of level, and within a level, from left to right as viewed in the product structure.

		Week											
Item		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
X_1	Gross req								50		20		100
	Order rel							50		20		100	
B_1	Gross req							50		20		100	
	Order rel					50		20		100			
B_2	Gross req							100		40		200	
	Order rel					100		40		200			
A_1	Gross req					50		20		100			
	Order rel				50		20		100				
C	Gross req					200		80		400			
	Order rel				200		80		400				
D	Gross req					100		40		200			
	Order rel				100		40		200				
E	Gross req				200	50	80	20	400	100			
	Order rel	200	50	80	20	400	100						

(b) Net material requirements (planned order release) plan:

Level: 0		**Parent:—**							**Quantity:**				
Item: X1		**Lead Time: 1**							**Lot Size: L4L**				
Week No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Gross requirement								50		20		100
Scheduled receipt												
On hand	50							50		0		0
Net requirement								0		20		100
Planned order receipt										20		100
Planned order release									20		100	

Level: 1		**Parent: X1**						**Quantity: 1X**					
Item: B1		**Lead Time: 2**						**Lot Size: L4L**					
Week No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Gross requirement									20		100	
Scheduled receipt												
On hand	20								20		0	
Net requirement									0		100	
Planned order receipt											100	
Planned order release									100			

Level: 1		**Parent: X1**						**Quantity: 2X**					
Item: B2		**Lead Time: 2**						**Lot Size: L4L**					
Week No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Gross requirement									40		200	
Scheduled receipt												
On hand	20								20		0	
Net requirement									20		200	
Planned order receipt									20		200	
Planned order release							20		200			

Level: 2		**Parent: B1**						**Quantity: 1X**					
Item: A1		**Lead Time: 1**						**Lot Size: L4L**					
Week No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Gross requirement									100			
Scheduled receipt												
On hand	5								5			
Net requirement									95			
Planned order receipt									95			
Planned order release								95				

Level: 2		**Parent: B2**						**Quantity: 2X**					
Item: C		**Lead Time: 1**						**Lot Size: L4L**					
Week No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Gross requirement							40		400			
Scheduled receipt												
On hand							0		0			
Net requirement							40		400			
Planned order receipt							40		400			
Planned order release						40		400				

Level: 2		Parent: B2					Quantity: 1X					
Item: D		Lead Time: 1					Lot Size: L4L					
Week No.	1	2	3	4	5	6	7	8	9	10	11	12
Gross requirement							20		200			
Scheduled receipt												
On hand							0		0			
Net requirement							20		200			
Planned order receipt							20		200			
Planned order release						20		200				

Level: 2&3		Parent: B1 & D					Quantity: 1X & 2X					
Item: E		Lead Time: 2					Lot Size: L4L					
Week No.	1	2	3	4	5	6	7	8	9	10	11	12
Gross requirement						40		400	100			
Scheduled receipt												
On hand						10		0	0			
Net requirement 10						30		400	100			
Planned order receipt						30		400	100			
Planned order release			30		400	100						

14.11 (a)

		Week											
Item		1	2	3	4	5	6	7	8	9	10	11	12
A	Gross req								100		50		150
	Order rel							100		50		150	
H	Gross req									100		50	
	Order rel								100		50		
C	Gross req							100	100	50	50	150	
	Order rel					100	100	50	50	150			

(b)

Level: 0		Parent: —					Quantity:					
Item: A		Lead Time: 1					Lot Size: L4L					
Week No.	1	2	3	4	5	6	7	8	9	10	11	12
Gross requirement								100		50		150
Scheduled receipt												
On hand								0		0		0
Net requirement								100		50		150
Planned order receipt								100		50		150
Planned order release							100		50		150	

Level: 0		Parent: —					Quantity:					
Item: H		Lead Time: 1					Lot Size: L4L					
Week No.	1	2	3	4	5	6	7	8	9	10	11	12
Gross requirement									100		50	
Scheduled receipt												
On hand									0		0	
Net requirement									100		50	
Planned order receipt									100		50	
Planned order release								100		50		

Level: 1		Parent: A, H					Quantity: 1X					
Item: C		Lead Time: 2					Lot Size: L4L					
Week No.	1	2	3	4	5	6	7	8	9	10	11	12
Gross requirement							100	100	50	50	150	
Scheduled receipt												
On hand							50	0	0	0	0	
Net requirement 50							50	100	50	50	150	
Planned order receipt							50	100	50	50	150	
Planned order release					50	100	50	50	150			

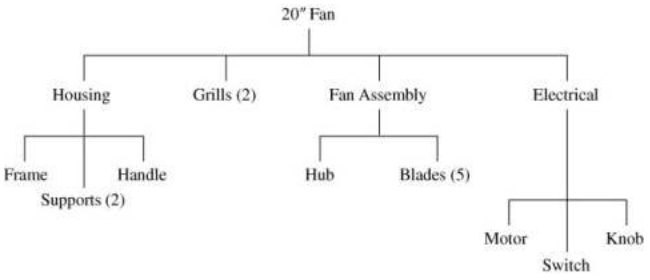
14.12 (a) Net material requirements plan:

Item			Week 1	2	3	4	5	6	7	8	9	10	11	12
A	Gross requirement									100		50		150
	On hand: —	0								0		0		0
	Net requirement									100		50		150
	Order receipt									100		50		150
	Order release								100		50		150	
H	Gross requirement										100		50	
	On hand: —	0									0		0	
	Net requirement										100		50	
	Order receipt										100		50	
	Order release									100		50		
B	Gross requirement								100		50		150	
	On hand:	100							100		0		0	
	Net requirement										50		150	
	Order receipt										50		150	
	Order release								50		150			
C	Gross requirement								100	100	50	50	150	
	On hand:	50							50	0	0	0	0	
	Net requirement								50	100	50	50	150	
	Order receipt								50	100	50	50	150	
	Order release						50	100	50	50	150			
J	Gross requirement									100		50		
	On hand:	100								100		0		
	Net requirement									0		50		
	Order receipt									0		50		
	Order release									50				
K	Gross requirement									100		50		
	On hand:	100								100		0		
	Net requirement									0		50		
	Order receipt									0		50		
	Order release									50				
D	Gross requirement								50		150			
	On hand:	50							50		0			
	Net requirement										150			
	Order receipt										150			
	Order release									150				
E	Gross requirement								50	100	150			
	On hand:	75							75	25	0			
	Net requirement									75	150			
	Order receipt									75	150			
	Order release							75	150					
F	Gross requirement						50	100	50	100	150			
	On hand:	75					75	25	0	0	0			
	Net requirement							75	50	100	150			
	Order receipt							75	50	100	150			
	Order release					75	50	100	150					
G	Gross requirement						50	100	50	100	150			
	On hand:	75					75	25	0	0	0			
	Net requirement							75	50	100	150			
	Order receipt							75	50	100	150			
	Order release						75	50	100	150				

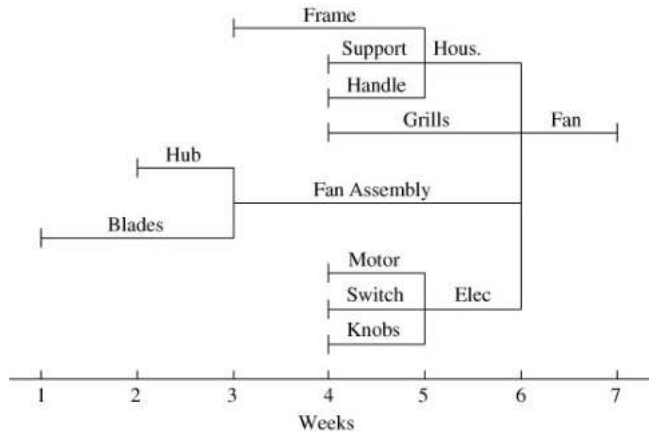
(b)

Item		Period (week) 1	2	3	4	5	6	7	8	9	10	11	12	13
A	Gross requirement								100		50		150	
	Scheduled receipt													
	Projected on hand 0								0		0		0	
	Net requirement								100		50		150	
	Planned order receipt								100		50		150	
	Planned order release							100		50		150		
H	Gross requirement									100		50		
	Scheduled receipt													
	Projected on hand 0									0		0		
	Net requirement									100		50		
	Planned order receipt									100		50		
	Planned order release								100		50			
B	Gross requirement							200		100		300		
	Scheduled receipt													
	Projected on hand 100							100		0		0		
	Net requirement							100		100		300		
	Planned order receipt							100		100		300		
	Planned order release					100		100		300				
C	Gross requirement							200	200	100	100	300		
	Scheduled receipt													
	Projected on hand 50							50	0	0	0	0		
	Net requirement							150	200	100	100	300		
	Planned order receipt							150	200	100	100	300		
	Planned order release					150	200	100	100	300				
J	Gross requirement								100		50			
	Scheduled receipt													
	Projected on hand 100								100		50			
	Net requirement								0		50			
	Planned order receipt										50			
	Planned order release								50					
K	Gross requirement								100		50			
	Scheduled receipt													
	Projected on hand 100								100		50			
	Net requirement								0		50			
	Planned order receipt										50			
	Planned order release								50					
D	Gross requirement					100		100		300				
	Scheduled receipt													
	Projected on hand 50					50		100		300				
	Net requirement					50		100		300				
	Planned order receipt					50		100		300				
	Planned order release				50		100		300					
E	Gross requirement					100		100	100	300				
	Scheduled receipt													
	Projected on hand 75					75		100	100	300				
	Net requirement					25		100	100	300				
	Planned order receipt					25		100	100	300				
	Planned order release			25		100	100	300						
F	Gross requirement					300	400	200	300	600				
	Scheduled receipt													
	Projected on hand 75					225	400	200	300	600				
	Net requirement					225	400	200	300	600				
	Planned order receipt					225	400	200	300	600				
	Planned order release			225	400	200	300	600						
G	Gross requirement					150	200	100	150	300				
	Scheduled receipt													
	Projected on hand 75					75	200	100	150	300				
	Net requirement					75	200	100	150	300				
	Planned order receipt					75	200	100	150	300				
	Planned order release				75	200	100	150	300					

14.13 (a)



(b)



(c)

Level: 0		**Parent: —**					**Quantity:**					
Item: 20″ fan		**Lead Time: 1**					**Lot Size:**					
Week No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Gross requirement							1,000					
Scheduled receipt												
On hand 100							100					
Net requirement							900					
Planned order receipt							900					
Planned order release						900						

Level: 1		**Parent: 20″ fan**					**Quantity: 1X**					
Item: housing		**Lead Time: 1 week**					**Lot Size: L4L**					
Week No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Gross requirement						900						
Scheduled receipt												
On hand 100						100						
Net requirement						800						
Planned order receipt						800						
Planned order release					800							

Level: 1		**Parent: 20″ fan**					**Quantity: 2X**					
Item: grills		**Lead Time: 2 weeks**					**Lot Size: 500**					
Week No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Gross requirement						1,800						
Scheduled receipt												
On hand 200						200	400					
Net requirement						1,600						
Planned order receipt						2,000						
Planned order release				2,000								

Level: 1	Parent: 20″ fan						Quantity: 1X					
Item: fan assembly	Lead Time: 3 weeks						Lot Size: L4L					
Week No.	1	2	3	4	5	6	7	8	9	10	11	12
Gross requirement						900						
Scheduled receipt												
On hand 150						150						
Net requirement						750						
Planned order receipt						750						
Planned order release			750									

Level: 1	Parent: 20″ fan						Quantity: 1X					
Item: electrical unit	Lead Time: 1 week						Lot Size: L4L					
Week No.	1	2	3	4	5	6	7	8	9	10	11	12
Gross requirement						900						
Scheduled receipt												
On hand												
Net requirement						900						
Planned order receipt						900						
Planned order release					900							

Level: 2	Parent: housing						Quantity: 1X					
Item: frame	Lead Time: 2 weeks						Lot Size: L4L					
Week No.	1	2	3	4	5	6	7	8	9	10	11	12
Gross requirement					800							
Scheduled receipt												
On hand												
Net requirement					800							
Planned order receipt					800							
Planned order release			800									

Level: 2	Parent: housing						Quantity: 2X					
Item: supports	Lead Time: 1 week						Lot Size: 100					
Week No.	1	2	3	4	5	6	7	8	9	10	11	12
Gross requirement					1,600							
Scheduled receipt												
On hand					50							
Net requirement					1,550							
Planned order receipt					1,600							
Planned order release				1,600								

Level: 2	Parent: housing						Quantity: 1X					
Item: handle	Lead Time: 1 week						Lot Size: 500					
Week No.	1	2	3	4	5	6	7	8	9	10	11	12
Gross requirement					800							
Scheduled receipt												
On hand					400	100						
Net requirement					400							
Planned order receipt					500							
Planned order release				500								

Level: 2	Parent: fan assembly						Quantity: 1X					
Item: hub	Lead Time: 1 week						Lot Size: L4L					
Week No.	1	2	3	4	5	6	7	8	9	10	11	12
Gross requirement			750									
Scheduled receipt												
On hand												
Net requirement			750									
Planned order receipt			750									
Planned order release		750										

Level: 2	Parent: fan assembly						Quantity: 5X					
Item: blades	Lead Time: 2 weeks						Lot Size: 100					
Week No.	1	2	3	4	5	6	7	8	9	10	11	12
Gross requirement			3,750									
Scheduled receipt												
On hand				50								
Net requirement			3,750									
Planned order receipt			3,800									
Planned order release	3,800											

Level: 2	Parent: electrical unit						Quantity: 1X					
Item: motor	Lead Time: 1 week						Lot Size: L4L					
Week No.	1	2	3	4	5	6	7	8	9	10	11	12
Gross requirement					900							
Scheduled receipt												
On hand												
Net requirement					900							
Planned order receipt					900							
Planned order release				900								

Level: 2	Parent: electrical unit						Quantity: 1X					
Item: switch	Lead Time: 1 week						Lot Size: 12					
Week No.	1	2	3	4	5	6	7	8	9	10	11	12
Gross requirement					900							
Scheduled receipt												
On hand 20					20	8						
Net requirement					880							
Planned order receipt					888							
Planned order release				888								

Level: 2	Parent: electrical unit						Quantity: 1X					
Item: knob	Lead Time: 1 week						Lot Size: 25					
Week No.	1	2	3	4	5	6	7	8	9	10	11	12
Gross requirement					900							
Scheduled receipt		200										
On hand			200	200	200							
Net requirement												
Planned order receipt					700							
Planned order release				700								

14.14 (a)

Level	Component	Quantity
0 A		1
1	B	1
2	C	1
2	D	1
3	E	1
1	F	1
2	G	1
2	H	1
3	E	1
3	C	1

Note: with low-level coding, C would be a level 3 code.

(b)

Lot Size	Lead Time	On Hand	Safety Stock	Allocated	Low Level Code	Item ID		Period (week) 1	2	3	4	5	6	7	8
Lot for Lot	1	0	—	—	0	A	Gross requirement								10
							Scheduled receipt								
							Projected on hand								0
							Net requirement								10
							Planned receipt								10
							Planned release							10	

Lot Size	Lead Time	On Hand	Safety Stock	Allocated	Low Level Code	Item ID		Period (week) 1	2	3	4	5	6	7	8
Lot for Lot	1	2	—	—	1	B	Gross requirement							10^{A}	
							Scheduled receipt								
							Projected on hand	2	2	2	2	2	2	2	0
							Net requirement							8	
							Planned receipt							8	
							Planned release						8		

Lot Size	Lead Time	On Hand	Safety Stock	Allocated	Low Level Code	Item ID		Period (week) 1	2	3	4	5	6	7	8
Lot for Lot	1	5	—	—	1	F	Gross requirement							10^{A}	
							Scheduled receipt								
							Projected on hand	5	5	5	5	5	5	5	0
							Net requirement							5	
							Planned receipt							5	
							Planned release						5		

Lot Size	Lead Time	On Hand	Safety Stock	Allocated	Low Level Code	Item ID		Period (week) 1	2	3	4	5	6	7	8
Lot for Lot	1	5	—	—	2	D	Gross requirement						8^{B}		
							Scheduled receipt								
							Projected on hand	5	5	5	5	5	5	0	0
							Net requirement						3		
							Planned receipt						3		
							Planned release					3			

Lot Size	Lead Time	On Hand	Safety Stock	Allocated	Low Level Code	Item ID		Period (week) 1	2	3	4	5	6	7	8
Lot for Lot	3	1	—	—	2	G	Gross requirement						5^{F}		
							Scheduled receipt								
							Projected on hand	1	1	1	1	1	1	0	0
							Net requirement						4		
							Planned receipt						4		
							Planned release			4					

Lot Size	Lead Time	On Hand	Safety Stock	Allocated	Low Level Code	Item ID		Period (week) 1	2	3	4	5	6	7	8
Lot for Lot	1	10	—	—	2	H	Gross requirement						5^{F}		
							Scheduled receipt								
							Projected on hand	10	10	10	10	10	10	5	5
							Net requirement						0		
							Planned receipt						0		
							Planned release					0			

Lot Size	Lead Time	On Hand	Safety Stock	Allocated	Low Level Code	Item ID		Period (week) 1	2	3	4	5	6	7	8
Lot for Lot	2	10	—	—	3	C	Gross requirement					0^{H}	8^{B}		
							Scheduled receipt								
							Projected on hand	10	10	10	10	10	10	2	2
							Net requirement					0	0		
							Planned receipt					0	0		
							Planned release			0	0				

Lot Size	Lead Time	On Hand	Safety Stock	Allocated	Low Level Code	Item ID		Period (week) 1	2	3	4	5	6	7	8
Lot for Lot	1	4	—	—	3	E	Gross requirement					$3^{H,D}$			
							Scheduled receipt								
							Projected on hand	4	4	4	4	4	1	1	1
							Net requirement					0			
							Planned receipt					0			
							Planned release				0				

14.15 (a) Ten units are required for production, and 10 each of B and F for field service repair

Component	Quantity
A	10
B	20
C	40
D	20
E	40
F	20
G	20
H	20

(b)

Lot Size	Lead Time	On Hand	Safety Stock	Allocated	Low Level Code	Item ID		Period (week) 1	2	3	4	5	6	7	8
Lot for Lot	1	0	—	—	0	A	Gross requirement								10
							Scheduled receipt								
							Projected on hand	0	0	0	0	0	0	0	10
							Net requirement								10
							Planned receipt								10
							Planned release							10	

Lot Size	Lead Time	On Hand	Safety Stock	Allocated	Low Level Code	Item ID		Period (week) 1	2	3	4	5	6	7	8
Lot for Lot	1	2	—	—	1	B	Gross requirement						10^{M}	10^{A}	
							Scheduled receipt								
							Projected on hand	2	2	2	2	2	2	0	0
							Net requirement						8	10	
							Planned receipt						8	10	
							Planned release					8	10		

Lot Size	Lead Time	On Hand	Safety Stock	Allocated	Low Level Code	Item ID		Period (week) 1	2	3	4	5	6	7	8
Lot for Lot	1	5	—	—	1	F	Gross requirement						10^{M}	10^{A}	
							Scheduled receipt								
							Projected on hand	5	5	5	5	5	5	0	0
							Net requirement						5	10	
							Planned receipt						5	10	
							Planned release					5	10		

Lot Size	Lead Time	On Hand	Safety Stock	Allocated	Low Level Code	Item ID		Period (week) 1	2	3	4	5	6	7	8
Lot for Lot	1	5	—	—	2	D	Gross requirement					8^{B}	10^{B}		
							Scheduled receipt								
							Projected on hand	5	5	5	5	5	0	0	0
							Net requirement					3	10		
							Planned receipt					3	10		
							Planned release				3	10			

Lot Size	Lead Time	On Hand	Safety Stock	Allocated	Low Level Code	Item ID		Period (week) 1	2	3	4	5	6	7	8
Lot for Lot	3	1	—	—	2	G	Gross requirement					5^{F}	10^{F}		
							Scheduled receipt								
							Projected on hand	1	1	1	1	1	0	0	0
							Net requirement					4	10		
							Planned receipt					4	10		
							Planned release		4	10					

Note: M (in items B and F) means a repair or maintenance item.

Lot Size	Lead Time	On Hand	Safety Stock	Allocated	Low Level Code	Item ID		Period (week) 1	2	3	4	5	6	7	8
Lot for Lot	1	10	—	—	2	H	Gross requirement					5^{F}	10^{F}		
							Scheduled receipt								
							Projected on hand	10	10	10	10	10	5	0	0
							Net requirement						5		
							Planned receipt						5		
							Planned release					5			

Lot Size	Lead Time	On Hand	Safety Stock	Allocated	Low Level Code	Item ID		Period (week) 1	2	3	4	5	6	7	8
Lot for Lot	2	10	—	—	3	C	Gross requirement					$13^{H,B}$	10^{B}		
							Scheduled receipt								
							Projected on hand	10	10	10	10	10	0	0	0
							Net requirement					3	10		
							Planned receipt					3	10		
							Planned release			3	10				

Lot Size	Lead Time	On Hand	Safety Stock	Allocated	Low Level Code	Item ID		Period (week) 1	2	3	4	5	6	7	8
Lot for Lot	1	4	—	—	3	E	Gross requirement				3^{D}	$15^{H,D}$			
							Scheduled receipt								
							Projected on hand	4	4	4	4	1	0	0	0
							Net requirement					14			
							Planned receipt					14			
							Planned release				14				

14.16 (a) Only item G has changed because it has no subassemblies or components.

(b) If week 1 on the production plan is now, then an increase in the lead time for G means only one unit of G will be available for component F in week 5. Therefore, F and consequently four units of "A" will be delayed one week.

(c) As production planner, several options are possible:

- Tell the customer that the four units (which are probably "spares") are going to be delayed one week.
- Ask the supplier of G to expedite production or delivery.
- Reduce the production time for item F or A.

14.17 Lot-for-Lot Ordering Policy:

	Week											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Gr req	30		40		30	70	20		10	80		50
Beg inv	40	10	10	0	0	0	0	0	0	0	0	0
End inv	10	10	0	0	0	0	0	0	0	0	0	0
Ord rcpt			30		30	70	20		10	80		50
Ord rel		30		30	70	20		10	80		50	

CT = Order cost + holding cost = 7 orders × \$150/order + 20 units × \$2.50/unit/period = \$1,100

14.18 Economic order quantity:

$$Q = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2 \times 330 \times 150}{2.50 \times 12}} = 57.4, \text{ or } 57 \text{ units}$$

where D = period demand, S = setup or order cost, H = holding cost.

Reorder point:

$$\text{Reorder point} = \text{Demand during lead time} = \frac{330}{12}\text{units/week} \times 1 \text{ week}$$

$$= 27.5, \text{ or } 28 \text{ units}$$

Level:			**Parent:**					**Quantity:**						
Item:			**Lead Time: 1**					**Lot Size: EOQ**						
Week No.		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	
Gross requirement		30		40		30	70	20		10	80		50	
Scheduled receipt														
On hand	40	40	10	10	27	27	54	41	21	21	11	45	45	52
Net requirement		0		30		3	16				69		5	
Planned order receipt				57		57	57				114		57	
Planned order release			57		57	57				114		57		

Setups: 5 × 150 = \$750

Holding: (allowing for 12 time periods) 2.50 × 352 = \$880

Setup + holding = total cost = \$1,630

Theoretical total cost:

$$C_T = \text{Order cost} + \text{Holding cost} = \frac{DS}{Q} + \frac{QH}{2}$$

$$= \frac{330 \times 150}{57} + \frac{57 \times (12 \times 2.50)}{2}$$

$$= 868.42 + 855.00 = \$1{,}723.42$$

Note: Order and carrying costs are not equal due to rounding of the EOQ to a whole number. *Actual* total cost:

$$\begin{aligned} C_T &= \text{Order cost} + \text{Holding cost} + \text{Stockout cost} \\ &= 5 \text{ orders} \times \$150/\text{order} + 454 \text{ units} \\ &\quad \times \$2.50/\text{unit/period} + 33 \text{ units} \times \$10/\text{unit stockout} \\ &= 750 + 1{,}135 + 330 \\ &= \$2{,}215 \end{aligned}$$

Note: The actual cost of using the EOQ policy under this case of varying demand is more than the theoretical cost. In addition, we were forced to use backorders when stockouts occurred. The poor performance with respect to stockout is due to the fact that "average demand during lead time" is not a particularly good measure of the necessary reorder point.

Note that the present versions of the Excel OM and POM for Windows software do not consider reorder points, stockouts, or backorder costs.

You may wish to make use of the following:

EOQ ordering policy, modified for delayed order placement:

	Week											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Gross requirement	30		40		30	70	20		10	80		50
Beginning inventory	40	0	67	27	84	54	–16	21	78	68	–12	–12
Ending inventory	10	10	27	27	54	–16*	21	21	68	–12*	–12	–5*
Order receipts			57		57		57		57			57
Order release		57		57		57		57			57	57

* Stockouts = 16 + 12 + 5 = 33

Total inventory = 10 + 10 + 27 + 27 + 54 + 21 + 21 + 68 = 238

Actual total cost:

$$\begin{aligned} C_T &= \text{Order cost} + \text{Holding cost} + \text{Stockout cost} \\ &= 6 \text{ orders} \times \$150/\text{order} + 238 \text{ units} \\ &\quad \times \$2.50/\text{unit/period} + 33 \text{ units} \times \$10/\text{unit stockout} \\ &= 900.00 + 595.00 + 330.00 = \$1{,}825.00 \end{aligned}$$

Thus, if we are able to "time" order placement in an optimal fashion, the *EOQ* ordering policy can be made more efficient. Note, however, that this optimal timing requires that we *accurately* forecast demand—something that for varying demand we are usually unable to do. Note, also, that this "optimal" timing does not reduce the likelihood of a stockout and, by increasing the customer "wait" period, may contribute to additional customer dissatisfaction. The elimination of stockouts can only be accomplished by using a higher reorder point (reorder + safety stock).

EOQ ordering policy, modified to include safety stock:

	Week											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Gr req	30		40		30	70	20		10	80		50
Beg inv	40	10	67	84	84	54	41	78	78	68	45	102
End inv	10	67	84	84	54	41	78	78	68	45	102	52
Ord rcpt		57	57			57	57			57	57	
Ord rel	57	57			57	57			57	57		57

Reorder when ending inventory <70

Combined reorder + safety stock:

Demand during Lead Time	Frequency	Probability	Cumulative Probability
0	4	0.333	0.333
10	1	0.083	0.417
20	1	0.083	0.500
30	2	0.167	0.667
40	1	0.083	0.750
50	1	0.083	0.833
60	0	0.000	0.833
70	1	0.083	0.917
80	1	0.083	1.000

To reduce the likelihood of a stockout to approximately 10%, we must use a combined reorder point/safety stock of 70 units. Note that this "reorder" point is approximately two and one half times the reorder point calculated using the measure of "average demand over lead time."

Actual total cost:

C_T = Order cost + Holding cost + Stockout cost

= 6 orders × \$150/order + 763 units × \$2.50/unit/period + 0 units × \$10/unit stockout

= 900.00 + 1907.50 + 0 = \$2,807.50

Note that as we might expect, the holding cost has increased.

14.19 Solution with lead time = 1: Holding cost = \$2.50; Setup cost = \$150. PPB ordering policy:

	Week											
	1	2	3	4	5	6	7	8	9	10	11	12
Gr req	30		40		30	70	20		10	80		50
Beg inv	40	10	10	30	30	0	30	10	10	0	50	50
End inv	10	10	30	30	0	30	10	10	0	50	50	0
Ord rcpt			60			100				130		
Ord rel		60			100				130			

Calculating EPP:

$$\text{EPP} = \frac{\text{Setup cost}}{\text{Holding cost}} = \frac{150}{2.50} = 60$$

Periods Combined	Cumulative Net Req.	Part Periods	Costs Order	Hold
1	0		0 +	25
1, 2	0		0 +	25
1, 2, 3	30		150 +	75
1, 2, 3, 4	30		150 +	75
1, 2, 3, 4, 5*	60	30 × 0 + 30 × 2 = 60	150	
1, 2, 3, 4, 5, 6	130	30 × 0 + 30 × 2 + 70 × 3 = 270	150	

* The part periods for an order encompassing periods 1, 2, 3, 4, and 5 most nearly approximates the EPP of 60.

Note: (1) We have assumed that: (a) a product ordered during a calendar week is available at the beginning of the following week; (b) shipments during a week take place at the beginning of the week. (2) POM for Windows will produce the same answer. Excel OM will produce the same answer when lead time is zero.

Periods Combined	Cumulative Net Req.	Part Periods	Costs Order	Hold
6	70	70 × 0 = 0	150 +	0
6, 7	90	70 × 0 + 20 × 1 = 20		50
6, 7, 8	90	70 × 0 + 20 × 1 = 20		50
6, 7, 8, 9*	100	70 × 0 + 20 × 1 + 10 × 3 = 50		125
6, 7, 8, 9, 10	180	70 × 0 + 20 × 1 + 10 × 3 + 80 × 4 = 370		

* The part periods for an order encompassing periods 6, 7, 8, and 9 most nearly approximates the EPP of 60.

Periods Combined	Cumulative Net Req.	Part Periods	Costs Order	Hold
10	80	80 × 0 = 0	150 +	0
10, 11	80	80 × 0 = 0		0
10, 11, 12*	130	80 × 0 + 50 × 2 = 100		250

* The part periods for an order encompassing periods 10, 11, 12 most nearly approximates the EPP of 60.

Calculate total cost:

C_T = Order cost + Holding cost

= 3 orders × \$150/order + 230 units × \$2.50/unit/period

= \$1,025.00

14.20 Always order 100 units; fixed order quantity (FOQ) = 100

		1	2	3	4	5	6	7	8	9	10
Gross requirement		35	30	40	0	10	40	30	0	30	55
Scheduled receipt											
Projected on hand	35	35	0	70	30	30	20	80	50	50	20
Net requirement		0	30	0	0	0	20	0	0	0	35
Planned order receipt			100				100				100
Planned order release		100				100				100	

3 setups at $100 each + 350 units @ $1 = $650.

14.21 Periodic order quantity (POQ)—3 periods; Every three weeks, order for 3 wks ahead.

		1	2	3	4	5	6	7	8	9	10
Gross requirement		35	30	40	0	10	40	30	0	30	55
Scheduled receipt											
Projected on hand	35	35	0	40	0	0	70	30	0	85	55
Net requirement		0	30	0	0	10	0	0	0	30	0
Planned order receipt			70			80			85		
Planned order release		70			80			85			

3 setups each at $100 + 280 units @ $1 = 580

14.22 A modification of the part-period balancing shown in the text yields the following costs:

		1	2	3	4	5	6	7	8	9	10
Gross requirement		35	30	40	0	10	40	30	0	30	55
Scheduled receipt											
Projected on hand	35	35	0	50	10	10	0	30	0	0	55
Net requirement		0	30	0	0	0	40	30	0	30	0
Planned order receipt			80				70	0		85	
Planned order release		80				70			85		

3 setups each at $300 + 155 units @ $1 = $455

14.23 The firm has 22,500 minutes available to produce 330 units, which require 21,450 minutes of work. One possible solution is:

Week	Units	Capacity Required (Time)	Capacity Available (Time)	Over/ (Under)	Production Scheduler's Action
1	0	0	2,250	(2,250)	
2	40	2,600	2,250	350	Lot split. Use 350 minutes in week 1.
3	30	1,950	2,250	(300)	
4	40	2,600	2,250	350	Lot split. Use 300 minutes in week 3. Use 50 minutes on another machine or in week 1 or 5.
5	10	650	2,250	(1,600)	
6	70	4,550	2,250	2,300	Lot split. Use 1900 minutes in week 1. Operations split. Use 400 minutes on another machine, overtime, or subcontract.
7	40	2,600	2,250	350	Overlap operations so that next operation can begin. Lot split. Use 350 minutes in week 5.
8	10	650	2,250	(1,600)	
9	30	1,950	2,250	(300)	
10	60	3,900	2,250	1,650	Lot split. 1250 minutes in Week 8 and 300 minutes in week 9. Operations split. 100 minutes on another machine, overtime, or subcontract.

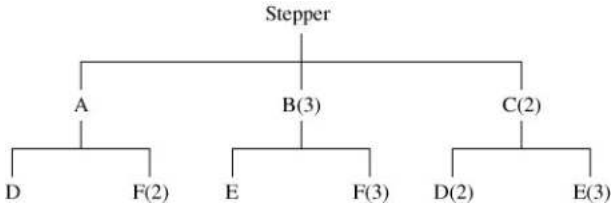
There are other possible solutions.

14.24

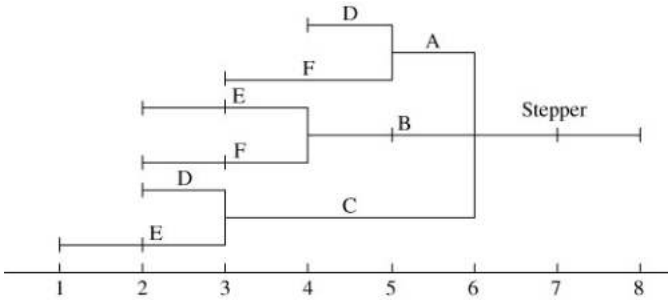
Week	Units	Capacity Required (Time)	Capacity Available (Time)	Over/ (Under)	Production Scheduler's Action
1	60	3,900	2,250	1,650	Lot split. Move 300 minutes (4.3 units) to week 2 and 1350 minutes to week 3.
2	30	1,950	2,250	(300)	
3	10	650	2,250	(1,600)	
4	40	2,600	2,250	350	Lot split. Move 250 minutes to week 3. Operation split. Move 100 minutes to another machine, overtime, or subcontract.
5	70	4,550	2,250	2,300	Lot split. Move 1600 minutes to week 6. Overlap operations to get product out door. Operations split. Move 700 minutes to another machine, overtime, or subcontract.
6	10	650	2,250	(1,600)	
7	40	2,600	2,250	300	Lot split. Move 300 minutes to week 8. Overlap operations to get product out the door.
8	30	1,950	2,250	(300)	
9	40	2,600	2,250	350	Lot split. Move 350 minutes to week 10. Overlap operations to get product out the door.
10	0	0	2,250	(2,250)	1950 available minutes. Look at next week for early production.

There are other possible solutions.

14.25 (a)



(b)



(c)

Stepper	1	2	3	4	5	6	7	8
Gross requirement								50
On hand 20								20
Net								30
P.O. receipt								30
P.O. release						30		

A	1	2	3	4	5	6	7	8
Gross requirement						30		
On hand 10						10		
Net						20		
P.O. receipt						20		
P.O. release					20			

B	1	2	3	4	5	6	7	8
Gross requirement						90		
On hand 30						30		
Net						60		
P.O. receipt						60		
P.O. release				60				

F	1	2	3	4	5	6	7	8
Gross requirement				180	40			
On hand 20				20	0			
Net				160	40			
P.O. receipt				160	40			
P.O. release		160	40					

14.26

Lot Size	Lead Time (# of periods)	On Hand	Safety Stock	Allo-cated	Low-Level Code	Item ID		Period (day)							
								1	2	3	4	5	6	7	8
Lot for Lot	1	—	—	—	0	Table	Gross requirement					640	640	128	128
							Scheduled receipt								
							Projected on hand								
							Net requirement					640	640	128	128
							Planned order receipt					640	640	128	128
							Planned order release				640	640	128	128	
Lot for Lot	1	—	—	—	1	Top	Gross requirement				640	640	128	128	
							Scheduled receipt								
							Projected on hand								
							Net requirement				640	640	128	128	
							Planned order receipt				640	640	128	128	
							Planned order release			640	640	128	128		
Lot for Lot gallons	1	—	—	—	1	Stain (gal.)	Gross requirement				80	80	16	16	
							Scheduled receipt								
							Projected on hand								
							Net requirement				80	80	16	16	
							Planned order receipt				80	80	16	16	
							Planned order release			80	80	16	16		
Lot for Lot gallons	1	— 100	—	—	1	Glue (gal.)	Gross requirement				40	40	8	8	
							Scheduled receipt								
							Projected on hand 100	100	100	100	100	60	20	12	4
							Net requirement								
							Planned order receipt								
							Planned order release								
Lot for Lot	1	—	—	—	1	Base	Gross requirement				640	640	128	128	
							Scheduled receipt								
							Projected on hand								
							Net requirement				640	640	128	128	
							Planned order receipt				640	640	128	128	
							Planned order release			640	640	128	128		
Lot for Lot	1	—	—	—	2	Short Brace	Gross requirement			1,280	1,280	256	256		
							Scheduled receipt								
							Projected on hand								
							Net requirement			1,280	1,280	256	256		
							Planned order receipt			1,280	1,280	256	256		
							Planned order release		1,280	1,280	256	256			

Continued

Lot for Lot	1	—	—	—	2	Long Brace	Gross requirement			1,280	1,280	256	256		
							Scheduled receipt								
							Projected on hand								
							Net requirement			1,280	1,280	256	256		
							Planned order receipt			1,280	1,280	256	256		
							Planned order release		1,280	1,280	256	256			

Lot for Lot	1	—	—	—	2	Leg	Gross requirement			2,560	2,560	512	512		
							Scheduled receipt								
							Projected on hand								
							Net requirement			2,560	2,560	512	512		
							Planned order receipt			2,560	2,560	512	512		
							Planned order release		2,560	2,560	512	512			

Lot for Lot	1	—	—	—	3	Brass Caps	Gross requirement		2,560	2,560	512	512			
							Scheduled receipt								
							Projected on hand			440	880	368	856	856	856
							Net requirement		2,560	2,120		144			
							Planned order receipt		3,000	3,000		1,000			
	1000 Min Lot Size						Planned order release	3,000	3,000		1,000				

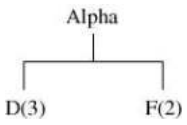
14.27

Coffee Table Master Schedule	Hrs Required	Lead Time	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
							640	640	128	128
Table Assembly	2	1				1,280	1,280	256	256	
Top Preparation	2	1			1,280	1,280	256	256		
Assemble Base	1	1			640	640	128	128		
Long Brace (2)	0.25	1		320	320	64	64			
Short Brace (2)	0.25	1		320	320	64	64			
Leg (4)	0.25	1		640	640	128	128			
Total Hours			0	1,280	3,200	3,456	1,920	640	256	
Employees need @ 8 hrs. each			0	160	400	432	240	80	32	

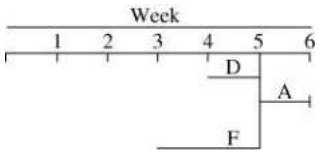
ADDITONAL HOMEWORK PROBLEMS

Here are solutions to additional homework problems 14.28–14.32 that appear on our Web site, www.myomlab.com.

14.28 (a)



(b)



(c)

Week 1	2	3	4	5	6	
Required Date					10	
Order Release				10		A
Required Date				30		
Order Release			30			D
Required Date				20		
Order Release		20				F

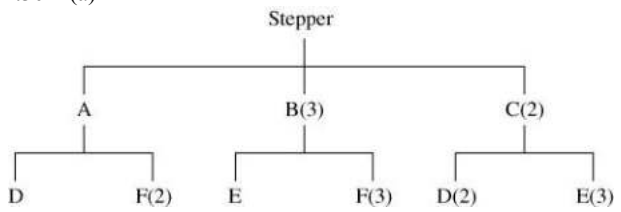
14.29

Level: 0		Parent: —					Quantity:				
Item: A		Lead Time: 1 week					Lot Size: L4L				
Week No.		1	2	3	4	5	6	7	8	9	10
Gross requirement							10				
Scheduled receipt											
On hand	2	2	2	2	2	2	2				
Net requirement							8				
Planned order receipt							8				
Planned order release						8					

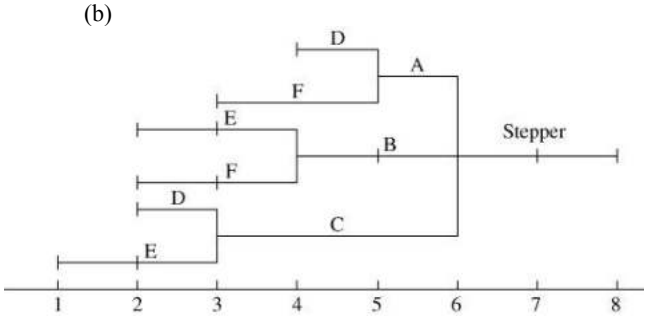
Level: 1		Parent: A					Quantity: 3				
Item: D		Lead Time: 1 week					Lot Size: L4L				
Week No.		1	2	3	4	5	6	7	8	9	10
Gross requirement						24					
Scheduled receipt											
On hand	4	4	4	4	4	4					
Net requirement						20					
Planned order receipt						20					
Planned order release					20						

Level: 1		Parent: A					Quantity: 2				
Item: F		Lead Time: 2 weeks					Lot Size: L4L				
Week No.		1	2	3	4	5	6	7	8	9	10
Gross requirement						16					
Scheduled receipt											
On hand	0	0	0	0	0						
Net requirement						16					
Planned order receipt						16					
Planned order release				16							

14.30 (a)



(b)



14.30 (c)

Stepper		1	2	3	4	5	6	7	8
Gross requirement									50
On hand	20								20
Net									30
P.O. receipt									30
P.O. release							30		

A		1	2	3	4	5	6	7	8
Gross requirement							30		
On hand	10						10		
Net							20		
P.O. receipt							20		
P.O. release						20			

B		1	2	3	4	5	6	7	8
Gross requirement							90		
On hand	30						30		
Net							60		
P.O. receipt							60		
P.O. release					60				

F		1	2	3	4	5	6	7	8
Gross requirement					180	40			
On hand	20				20	0			
Net					160	40			
P.O. receipt					160	40			
P.O. release			160	40					

14.31 (a) Economic Order Quantity

		Week									
	Now	1	2	3	4	5	6	7	8	9	10
Gr req		35	30	45	0	10	40	30	0	30	55
Beg inv	0	0	70	40	–5	100	90	50	20	125	95
End inv	0*	70	40	–5*	100	90	50	20*	125	95	40
Ord rcpt		105			105				105		
Ord rel	105			105				105			

Note: If the five units *not* produced in period 3 (because of five-unit shortage) *are* produced in week 4, then actual inventory drops by five units (from 680 to 675). This analysis includes holding cost for the 40 units held from period 10 for period 11.

Orders are placed in the weeks with ending inventory below the reorder point (i.e. 27.5) as noted with asterisks.

Economic Order Quantity:

$$Q = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2 \times 275 \times 50}{0.25 \times 10}} = 104.9 \text{ or } 105 \text{ units}$$

where D = period demand, S = setup or order cost, H = holding cost.

Reorder point:

Reorder point = demand during lead time

$$= \frac{275}{10} \text{units/period} \times 1 \text{ period}$$

$$= 27.5 \text{ or } 28 \text{ units}$$

Theoretical total cost:

$$C_T = \text{Order cost} + \text{holding cost} = \frac{DS}{Q} + \frac{QH}{2}$$

$$= \frac{275 \times 50}{105} + \frac{105 \times 0.25 \times 10}{2}$$

$$= 130.95 + 131.25 = \$262.20$$

Note: Order and carrying costs are not equal due to rounding the *EOQ* to a whole number.

Actual cost:

$$C_T = \text{Order cost} + \text{holding cost}$$

$$= 3 \text{ orders} \times \$50/\text{order} + 630 \text{ units} \times \$0.25/\text{unit/period}$$

$$= 150 + 157.50 = \$307.50$$

(b) Lot for Lot:

		Week									
	This week	1	2	3	4	5	6	7	8	9	10
Gr req		35	30	45	0	10	40	30	0	30	55
Beg inv	0	0	0	0	0	0	0	0	0	0	0
End inv	0	0	0	0	0	0	0	0	0	0	0
Ord rcpt		35	30	45		10	40	30		30	55
Ord rel	35	30	45		10	40	30		30	55	

Calculating total cost:

$$C_T = \text{Order cost} + \text{holding cost}$$

$$= 8 \text{ orders} \times \$50/\text{order} + 0 \text{ (no holding cost)}$$

$$= \$400.00$$

(c) Part-period balancing

		Week									
	Now	1	2	3	4	5	6	7	8	9	10
Gr req		35	30	45	0	10	40	30	0	30	55
Beg inv	0	0	85	55	10	10	0	60	30	30	0
End inv	0	85	55	10	10	0	60	30	30	0	0
Ord rcpt		120					100				55
Ord rel	120					100				55	

Calculating *EPP*:

$$EPP = \frac{\text{Order cost}}{\text{Holding cost}} = \frac{50}{0.25} = 200$$

Periods Combined	Cumulative Net Req.	Part Periods	Costs Order	Hold
1	35	0 = 0	50	+ 0.00
1, 2	65	30 × 1 = 30		21.25
1, 2, 3	110	30 × 1 + 45 × 2 = 120		13.75
1, 2, 3, 4	110	30 × 1 + 45 × 2 + 0 × 3 = 120		2.50
1, 2, 3, 4, 5*	120	30 × 1 + 45 × 2 + 10 × 4 = 160		2.50
1, 2, 3, 4, 5, 6	160	30 × 1 + 45 × 2 + 10 × 4 + 40 × 5 = 360		

* The part periods for an order encompassing periods 1, 2, 3, 4, and 5, most nearly approximates the *EPP* of 200.

Note: (1) We have assumed that: (a) a product ordered during a calendar week is available at the beginning of the following week; (b) shipments during a week take place at the beginning of the week; (c) no carrying cost occurs during the week the order is received.

(2) The POM for Windows program is unable to handle the non-zero lead-time—thus will produce a different answer. Excel OM does not perform Part-Period balancing.

Periods Combined	Cumulative Net Req.	Part Periods	Costs Order	Hold
6	40	$40 \times 0 =$	50 +	15.00
6, 7	70	$40 \times 0 + 30 \times 1 = 30$		7.50
6, 7, 8	70	$40 \times 0 + 30 \times 1 = 30$		7.50
6, 7, 8, 9*	100	$40 \times 0 + 30 \times 1 + 30 \times 3 = 120$		
6, 7, 8, 9, 10	155	$40 \times 0 + 30 \times 1 + 30 \times 3 + 55 \times 4 = 340$		

* The part periods for an order encompassing periods 6, 7, 8, and 9, most nearly approximates the *EPP* of 200. The last period with a demand of 55 units will also require an order of 55 units.

Calculating total cost:

C_T = Order cost + holding cost

= 3 orders × \$50/order + 280 units × \$0.25/unit/period

= 150.00 + 70.00 = \$220.00

14.32

Item A

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Total req.								10				10			5	
On hand	3	3	3	3	3	3	3	3				—			—	
Net req.								7				10			5	
Ord rec.								7				10			5	
Ord rel.							7				10			5		

Item B

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Total req.						10	7				10			5		3
On hand	2	2	2	2	2	2	2	—			—			—		—
Net req.						8	7				10			5		3
Ord rec.						8	7				10			5		3
Ord rel.					8	7				10			5		3	

Item C

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Total req.					10	7			10	10		5	5		3	
On hand	10	10	10	10	10	—			—	—		—	—		—	
Net req.						7			10	10		5	5		3	
Ord rec.						7			10	10		5	5		3	
Ord rel.				7			10	10		5	5		3			

Item D

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Total req.					8	7				10			5		3	
On hand	5	5	5	5	5	—				—			—		—	
Net req.					3	7				10			5		3	
Ord rec.					3	7				10			5		3	
Ord rel.				3	7				10			5		3		

Item E																
Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Total req.				3	9				20			10		3		
On hand	5	5	5	5	2				—			—		—		
Net req.					7				20			10		3		
Ord rec.					7				20			10		3		
Ord rel.				7				20			10		3			

Item F																
Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Total req.						10	7				10			5		
On hand	5	5	5	5	5	5	—				—			—		
Net req.						5	7				10			5		
Ord rec.						5	7				10			5		
Ord rel.					5	7				10			5			

Item G																
Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Total req.					5	7				10			5			
On hand	1	1	1	1	1	—				—			—			
Net req.					4	7				10			5			
Ord rec.					4	7				10			5			
Ord rel.	4	7				10			5							

Item H																
Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Total req.					5	7				10			5			
On hand	10	10	10	10	10	5				—			—			
Net req.						2				10			5			
Ord rec.						2				10			5			
Ord rel.					2				10			5				

CASE STUDY

HILL'S AUTOMOTIVE, INC.

In this case, each department argues that it is doing its job well—"the problem is with them." The result is confusion and poor results for the company as a whole. Many of the problems relate to the classic MRP issues of (a) lack of master schedule; (b) lack of capacity planning; and (c) few, if any, accurate lead times, all resulting in poor scheduling and chaos in the assembly area. There seems also to be a question as to whether the various departments are working toward common goals and whether appropriate measures of performance are in place. The specific issues in a plan would include (a) introduction of corporate wide goals and performance measures for each function; (b) development of labor standards for the assembly, and packaging operations; (c) development of quality standards for all production and purchased items, to which suppliers would adhere; (d) improvements in inventory management practices; (e) development of a capacity planning procedure (i.e., determination as to how many units can be produced during what time periods); (f) implementation of a master production schedule (which might encompass a relatively short horizon due to the typical short production cycle); and, ultimately, proper use of an

MRP system. When this is completed, everyone will be judged by corporate-based performance measures, using common information, in working toward common goals.

2. A properly used MRP system will provide the structure needed at Hill's Automotive; unneeded and excess inventory and poor bills of material will be evident, as will production schedules beyond the firm's capabilities. Lead times, order release dates, shortages, etc. will also be specified. Accuracy and discipline will be required.

The instructor may then want to discuss the problems one would encounter in implementing some of the changes discussed above. As a beginning, one might consider that the individual departments appear to be operating in a relatively informal manner and as separate entities. The student might be asked to consider how the persons employed within this organization will react to the changes suggested above, which, uniformly, result in increased demands on employees and increased integration among departments.

VIDEO CASE STUDY

MRP AT WHEELED COACH

A 7-minute video, filmed specifically for this text, is available from Prentice Hall and is designed to supplement the written case.

1. Accurate inventory is an important issue at Wheeled Coach because of the dynamic changes that occur in ambulances. Items that are purchased but not used promptly often end up as excess

inventory and must be disposed of at distress prices. Moreover, MRP does not work without accurate inventory. As in any dependent manufacturing process, shortage of a part may mean that the entire end unit, in this case an expensive ambulance, cannot be assembled, completed, or delivered. Accurate inventory has cost implications for both the units in which the inventory is to be installed (the ambulance) and as an asset.

2. Excess inventory exists because of minimum order requirements, BOM errors, customer-change orders, purchasing and receiving errors, etc. A plan for Wheeled Coach to deal with excess inventory is first to see what can be returned to the vendor for near full credit; second, see what can be substituted on subsequent units for the items called out on the bills of material; and third, work at some sort of sale or scrap or supply to other auto dealers or truckers who may have need for the items.

3. Wheeled Coach will find it difficult to dispose of excess inventory. It is hard to substitute excess components in units (and their related bills of material) as units are being assembled. It takes innovation on the part of the engineering shop and inventory personnel to make this work and keep the bills of material, through engineering changes notices, accurate. For those items that are changed but are not critical, management instituted an *effectivity date*. That is a date that the change would be effective to the date in the production schedule that allowed all of the components in stock to be used. Some material can be returned to the supplier, but most suppliers are not interested in taking old merchandise back, so that is a difficult option. Finally, selling the items themselves proved a reasonable last resort. However, even this is expensive. It requires cataloging, publicity, letter writing, phone calls, and follow-up. It is a real marketing challenge, and Wheeled Coach does this by having occasional sales of excess inventory on Saturdays. All of these options are being used, and all do reduce inventory ultimately.

ADDITIONAL CASE STUDY*

IKON'S ATTEMPT AT ERP

1. IKON needs comprehensive marketing information on potential customers, existing customers, and their copier installations, and then a service history on each machine sold and its owner or leaseholder. Additionally, it needs the usual accounting information on payables, receivables, assets, and liabilities as well as good inventory information on copiers, parts, and supplies.

2. The *advantages* of ERP software are that it is usually sold as an integrated system that ties HR, accounting, manufacturing, and suppliers together. Consequently, in theory, it provides for a high degree of timely, accurate information. Most of these systems deliver much less than the theory suggests.

The *disadvantage* of any standard software product is that it may not (or will not) fit a given (in this case IKON's) business. IKON's problem was complicated because many ERP systems are an outgrowth of manufacturing systems. This manufacturing base often means they are weak in the marketing, customer tracking, service, and repair features critical to IKON's competitive advantage. A wide variety of special programs have been written for customer sales and service tracking, but for SAP, like other vendors in the field, that was not an initial priority.

3. The bet was that the pilot installation would work at reasonable cost and, not incidentally, do the job. This did not turn out to be the case. (It cost over $14 million to get the system running, $8 million paid to IBM for consulting and the remainder of the $25 million paid in consulting fees since the system was turned on.)

4. The project was canceled because of the expense, combined with functionality gaps and the amount of internal business procedures IKON would have to change.

* This case study appears on our Companion Web site, www.pearsonhighered.com/heizer.