LESSON 21: MATERIAL REQUIREMENTS PLANNING

Outline

- Hierarchy of Production Decisions
- MRP and its importance
- Input and Output of an MRP system
- MRP Calculation
- Lot Sizing
- Lot Sizing with Capacity Constraint

Hierarchy of Production Decisions

- The next slide presents a schematic view of the aggregate production planning function and its place in the hierarchy of the production planning decisions.

- Forecasting: First, a firm must forecast demand for aggregate sales over the planning horizon.

- Aggregate planning: The forecasts provide inputs for determining aggregate production and workforce levels over the planning horizon.

- Master production schedule (MPS): Recall, that the aggregate production plan does not consider any "real" product but a "fictitious" aggregate product. The MPS translates the aggregate plan output in terms of specific production goals by product and time period. For example,

Hierarchy of Production Decisions

Forecast of Demand

↓

Aggregate Planning

↓

Master Production Schedule

↓

Inventory Control

↓

Operations Scheduling

↓

Vehicle Routing
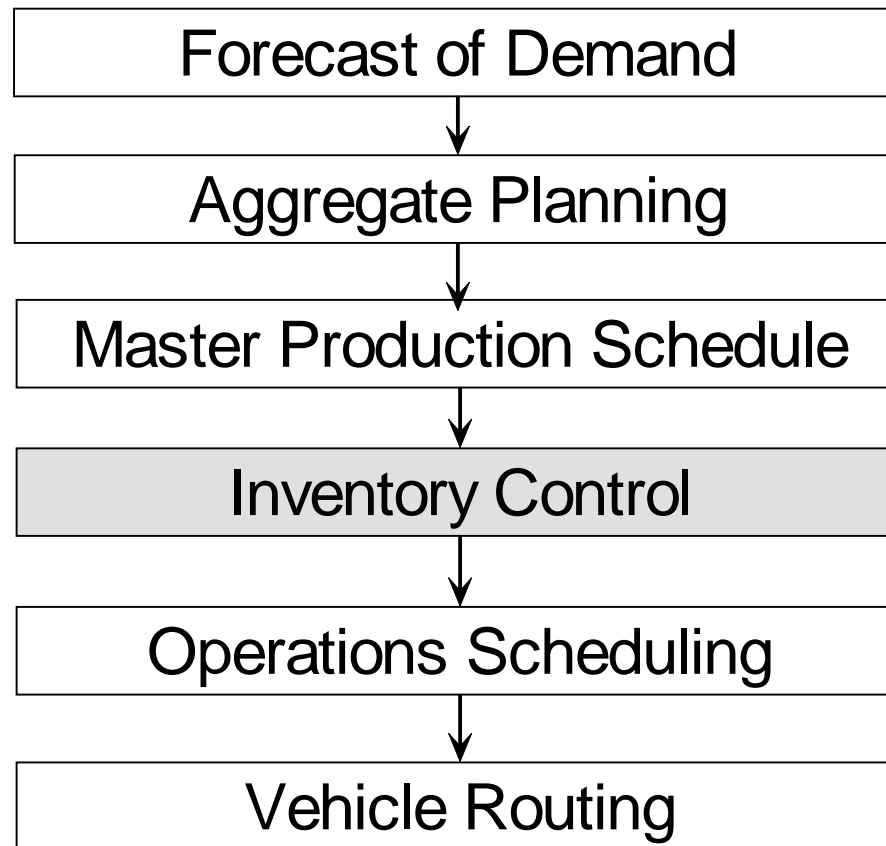
Hierarchy of Production Decisions

suppose that a firm produces three types of chairs: ladder-back chair, kitchen chair and desk chair. The aggregate production considers a fictitious aggregate unit of chair and find that the firm should produce 550 units of chairs in April. The MPS then translates this output in terms of three product types and four work-weeks in April. The MPS suggests that the firm produce 200 units of desk chairs in Week 1, 150 units of ladder-back chair in Week 2, and 200 units of kitchen chairs in Week 3.

- Material Requirements Planning (MRP): A product is manufactured from some components or subassemblies. For example a chair may require two back legs, two front legs, 4 leg supports, etc. While forecasting, aggregate plan

Hierarchy of Production Decisions
Master Production Schedule

|	April				May			
	1	2	3	4	5	6	7	8
Ladder-back chair		150				150		
Kitchen chair			200		120			120
Desk chair	200				200		200	
Aggregate production plan for chair family	550				790			

Hierarchy of Production Decisions

and MPS consider the volume of finished products, MRP plans for the components, and subassemblies. A firm may obtain the components by in-house production or purchasing. MRP prepares a plan of in-house production or purchasing requirements of components and subassemblies.

- Scheduling: Scheduling allocates resource over times in order to produce the products. The resources include workers, machines and tools.

- Vehicle Routing: After the products are produced, the firm may deliver the products to some other manufacturers, or warehouses. The vehicle routing allocates vehicles and prepares a route for each vehicle.

Hierarchy of Production Decisions
Materials Requirement Planning

Back slats

Seat cushion

Leg supports

Seat-frame boards

Back legs

Front legs
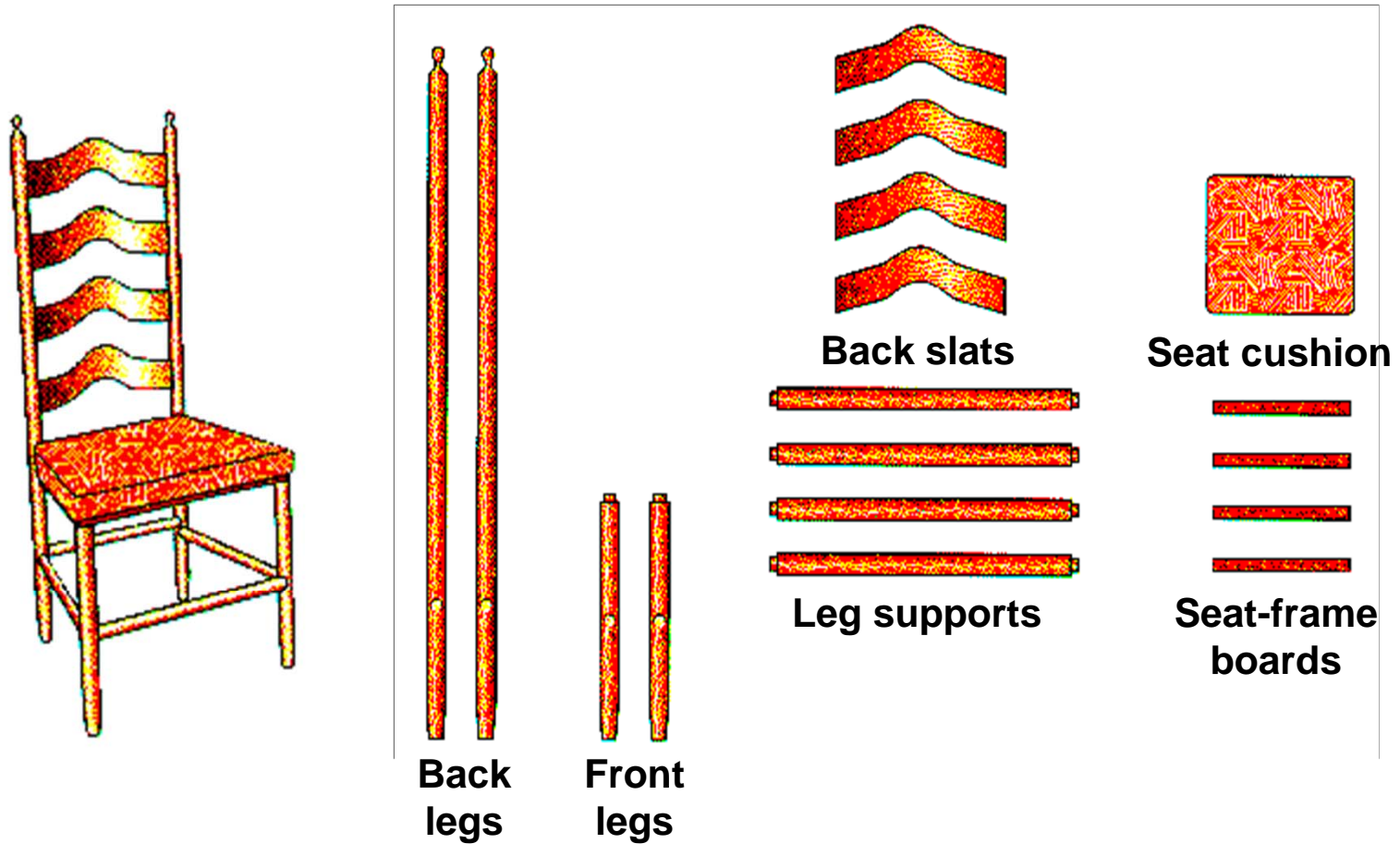
Material Requirements Planning

- The demands for the finished goods are obtained from forecasting. These demands are called independent demand.

- The demands for the components or subassemblies depend on those for the finished goods. These demands are called dependent demand.

- Material Requirements Planning (MRP) is used for dependent demand and for both assembly and manufacturing

- If the finished product is composed of many components, MRP can be used to optimize the inventory costs.
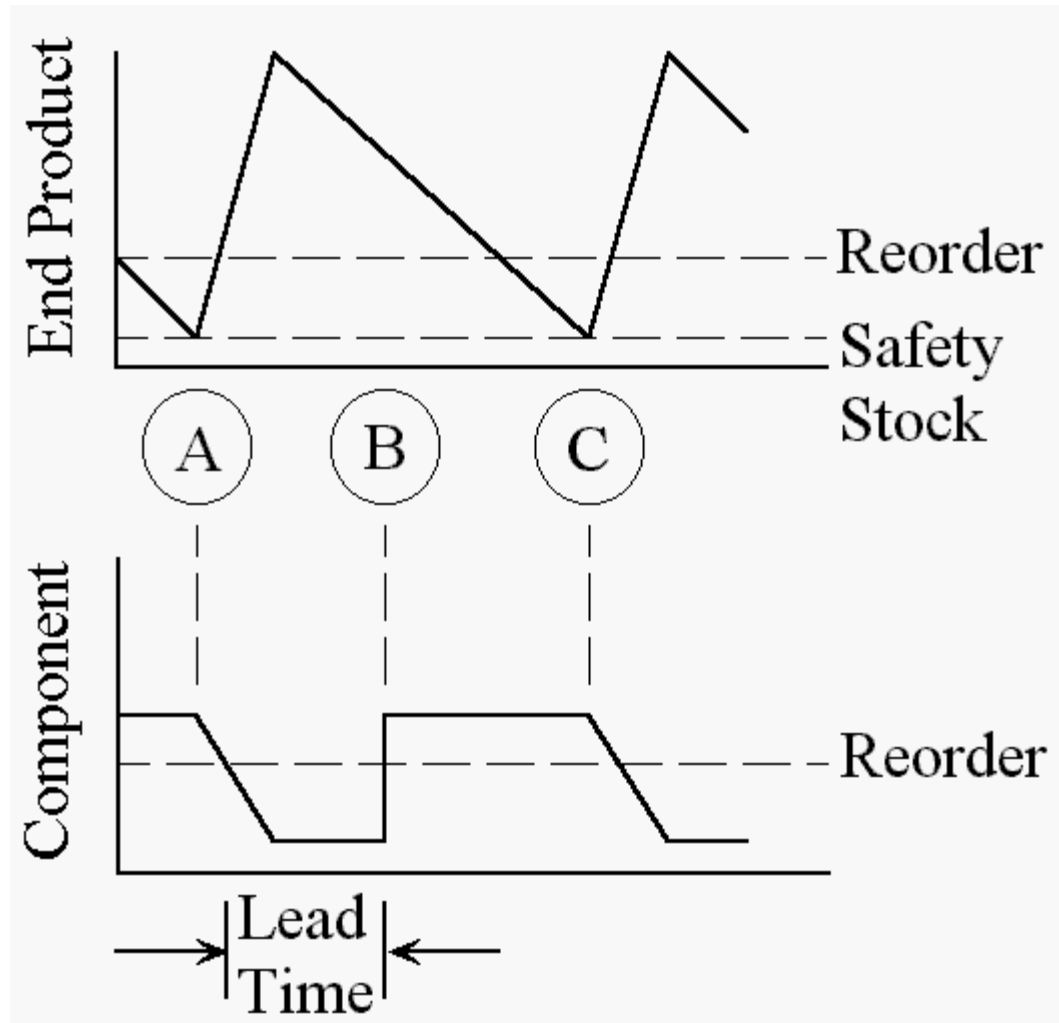
Importance of an MRP System

- Next two slides explain the importance of an MRP system. The first one shows inventory levels when an MRP system is not used. The next one shows the same when an MRP system is used.

- The chart at the top shows inventory levels of the finished goods and the chart on the bottom shows the same of the components.

- If the production is stopped (like it is at the beginning of the chart), the finished goods inventory level decreases because of sales. However, the component inventory level remains unchanged. When the production resumes, the finished goods inventory level increases, but the component inventory level decreases.

Importance of an MRP System

Inventory without an MRP System

Importance of an MRP System

Inventory with an MRP System
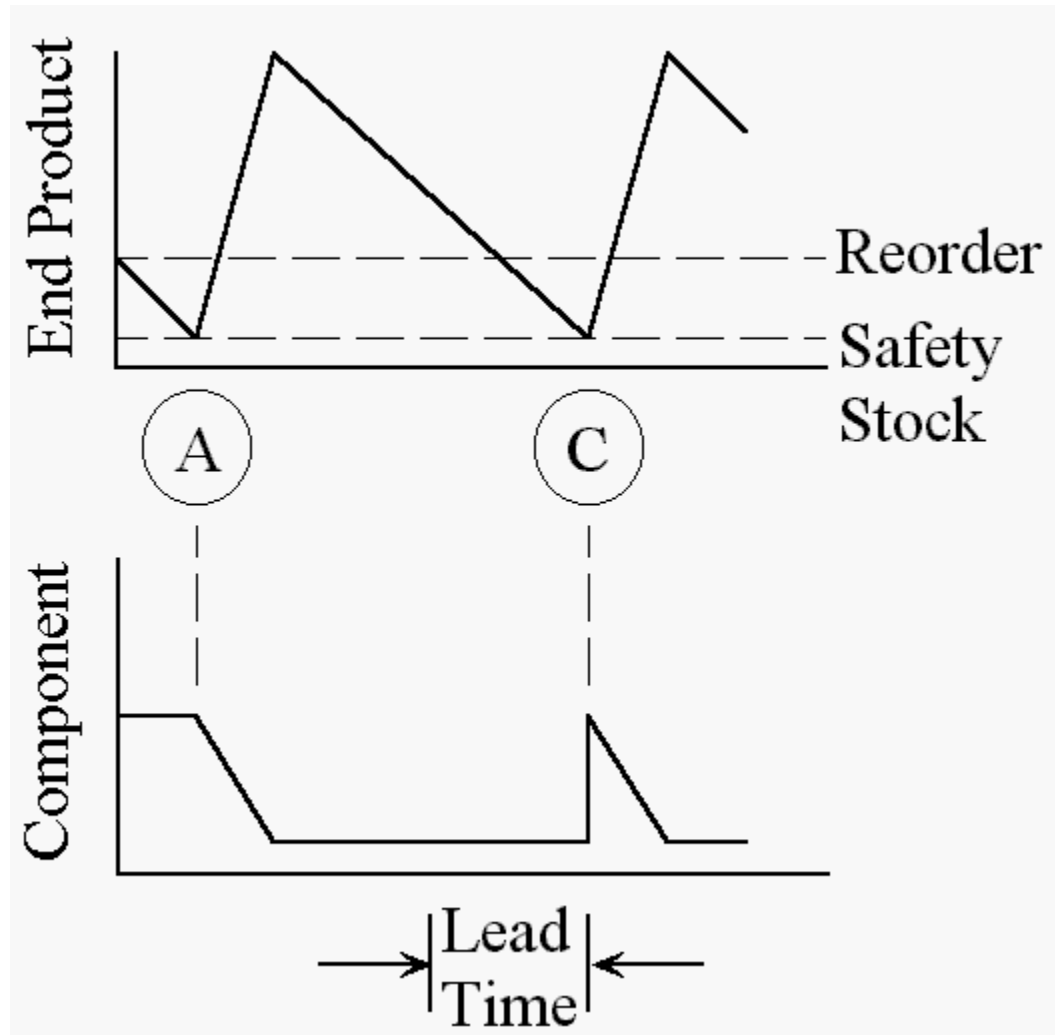
Importance of an MRP System

- Without an MRP system:
  - Component is ordered at time A, when the inventory level of the component hits reorder point, R
  - So, the component is received at time B.
  - However, the component is actually needed at time C, not B. So, the inventory holding cost incurred between time B and C is a wastage.
- With an MRP system:
  - We shall see in this lesson that given the production schedule of the finished goods and some other information (see the next slide), it is possible to predict the exact time, C when the component will be required. Order is placed carefully so that it is received at time C.

MRP Input and Output

- MRP Inputs:
  - Master Production Schedule (MPS): The MPS of the finished product provides information on the net requirement of the finished product over time.
  - Bill of Materials: For each component, the bill of materials provides information on the number of units required, source of the component (purchase/ manufacture), etc. There are two forms of the bill of materials:
    - Product Structure Tree: The finished product is shown at the top, at level 0. The components assembled to produce the finished product is shown at level 1 or below. The sub-components used to produce the components at level 1 is

MRP Input and Output

Orders → Master Production Schedule ← Forecasts

Master Production Schedule → MRP computer program

Bill of Materials file → MRP computer program ← Inventory file

MRP computer program → Reports

To Production ← Reports → To Purchasing

14
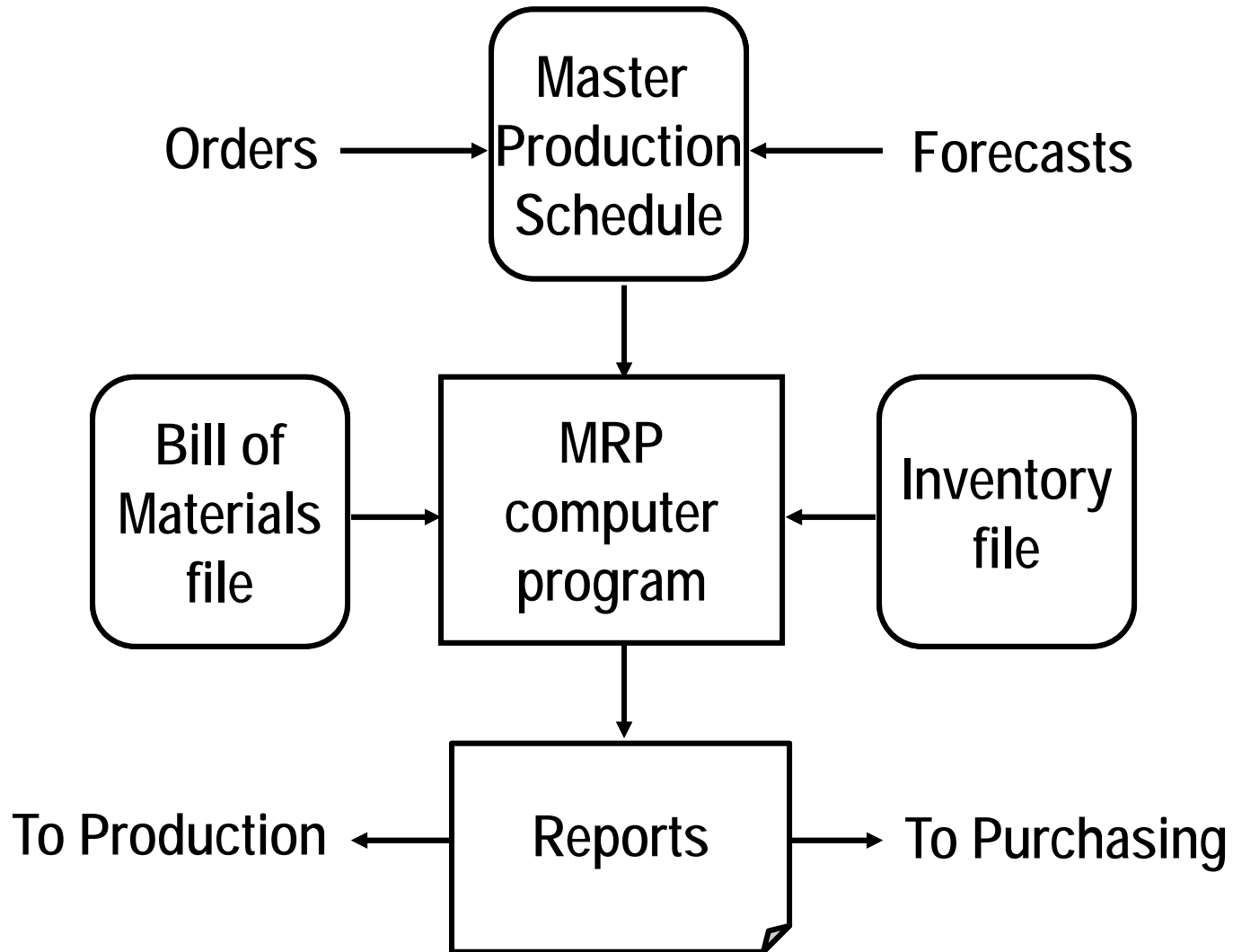
MRP Input and Output

shown at level 2 or below, and so on.

The number in the parentheses shows the requirement of the item. For example, "G(4)" implies that 4 units of G is required to produce 1 unit of B.

The levels are important. The net requirements of the components are computed from the low levels to high. First, the net requirements of the components at level 1 is computed, then level 2, and so on.

MRP Input and Output

- Bill of Materials: For each item, the name, number, source, and lead time of every component required is shown on the bill of materials in a tabular form.

  – Inventory file: For each item, the number of units on hand is obtained from the inventory file.

- MRP Output:

  – Every required item is either produced or purchased. So, the report is sent to production or purchasing.

Bill of Materials: Product Structure Tree

A — Ladder-back chair — Level 0

B(1) Back Subassembly — **C(2)** Front Legs — **D(4)** Leg Supports — **E(1)** Seat Subassembly — Level 1

F(2) Back Legs — **G(4)** Back Slats — **H(1)** Seat Frame — **I(1)** Seat Cushion — Level 2

J(4) Seat Frame Boards — Level 3
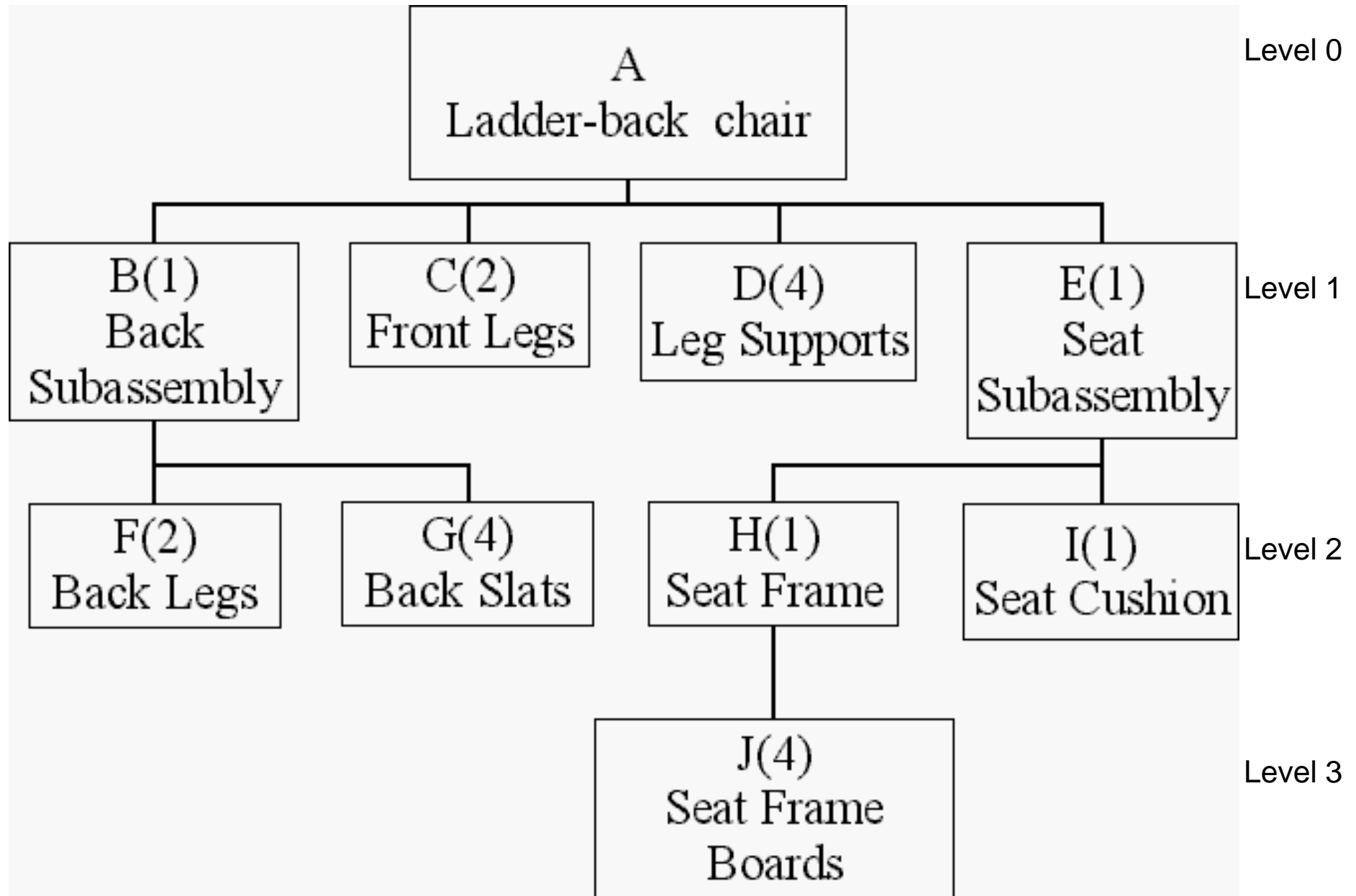
Bill of Materials

BILL OF MATERIALS			
Product Description: Ladder-back chair Item: A			
Component		Quantity Required	Source
Item	Description		
B	Ladder-back	1	Manufacturing
C	Front legs	2	Purchase
D	Leg supports	4	Purchase
E	Seat	1	Manufacturing

Bill of Materials

BILL OF MATERIALS				
Product Description: Seat *Item*: E				
Component			Quantity Required	Source
Item	Description			
H	Seat frame		1	Manufacturing
I	Seat cushion		1	Purchase

On Hand Inventory and Lead time

Component	Units in Inventory	Lead time (weeks)
Seat Subassembly	25	2
Seat frame	50	3
Seat frame boards	75	1

A
Ladder-back chair

E(1)
Seat Subassembly

H(1)
Seat Frame

J(4)
Seat Frame Boards
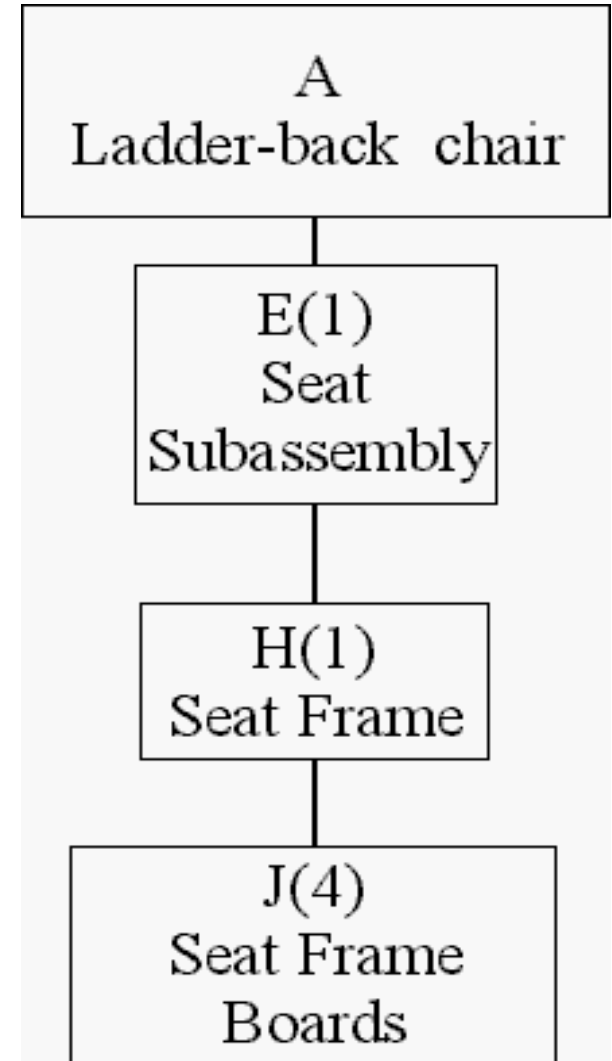
MRP Calculation

- Now, the MRP calculation will be demonstrated with an example.

- Suppose that 150 units of ladder-back chair is required.

- The previous slide shows a product structure tree with seat subassembly, seat frames, and seat frame boards. For each of the above components, the previous slide also shows the number of units on hand.

- The net requirement is computed from top to bottom. Since 150 units of ladder-back chair is required, and since 1 unit of seat subassembly is required for each unit of ladder-back chair, the gross requirement of seat-subassembly is $150 \times 1 = 150$ units. Since there are 25 units of seat-subassembly in the inventory, the net requirement of the seat-subassembly is 150-25 = 125

MRP Calculation

units. Since 1 unit of seat frames is required for each unit of seat subassembly, the gross requirement of the seat frames is 125×1 = 125 units. (*Note that although it follows from the product structure tree that 1 unit of seat frames is required for each unit of ladder-back chair, the gross requirement of seat frames is not 150 units because each of the 25 units of seat-subassembly also contains 1 unit of seat frames*.) Since there are 50 units of seat frames in the inventory, the net requirement of the seat frames is 125-50 = 75 units. The detail computation is shown in the next two slides.

- A similar logic is used to compute the time of order placement.

MRP Calculation

	Units
Quantity of ladder-back chairs to be produced	150
Gross requirement, seat subassembly	
Less seat subassembly in inventory	25
Net requirement, seat subassembly	
Gross requirement, seat frames	
Less seat frames in inventory	50
Net requirement, seat frames	
Gross requirement, seat frame boards	
Less seat frame boards in inventory	75
Net requirement, seat frame boards	

Assume that 150 units of ladder-back chairs are to be produced at the end of week 15

MRP Calculation: Time of Order Placement

	Week
Complete order for seat subassembly	14
Minus lead time for seat subassembly	2
Place an order for seat subassembly	
Complete order for seat frames	
Minus lead time for seat frames	3
Place an order for seat frames	
Complete order for seat frame boards	
Minus lead time for seat frame boards	1
Place an order for seat frame boards	

Assume that 150 units of ladder-back chairs are to be produced at the end of week 15 and that there is a one-week lead time for ladder-back chair assembly

MRP Calculation: Some Definitions

- Scheduled Receipts:
  – Items ordered prior to the current planning period and/or
  – Items returned from the customer
- Lot-for-lot (L4L)
  – Order quantity equals the net requirement
  – Sometimes, lot-for-lot policy cannot be used. There may be restrictions on minimum order quantity or order quantity may be required to multiples of 50, 100 etc.

MRP Calculation

Example 1: 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) 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.

MRP Calculation

Level 0

Level 1

Level 2
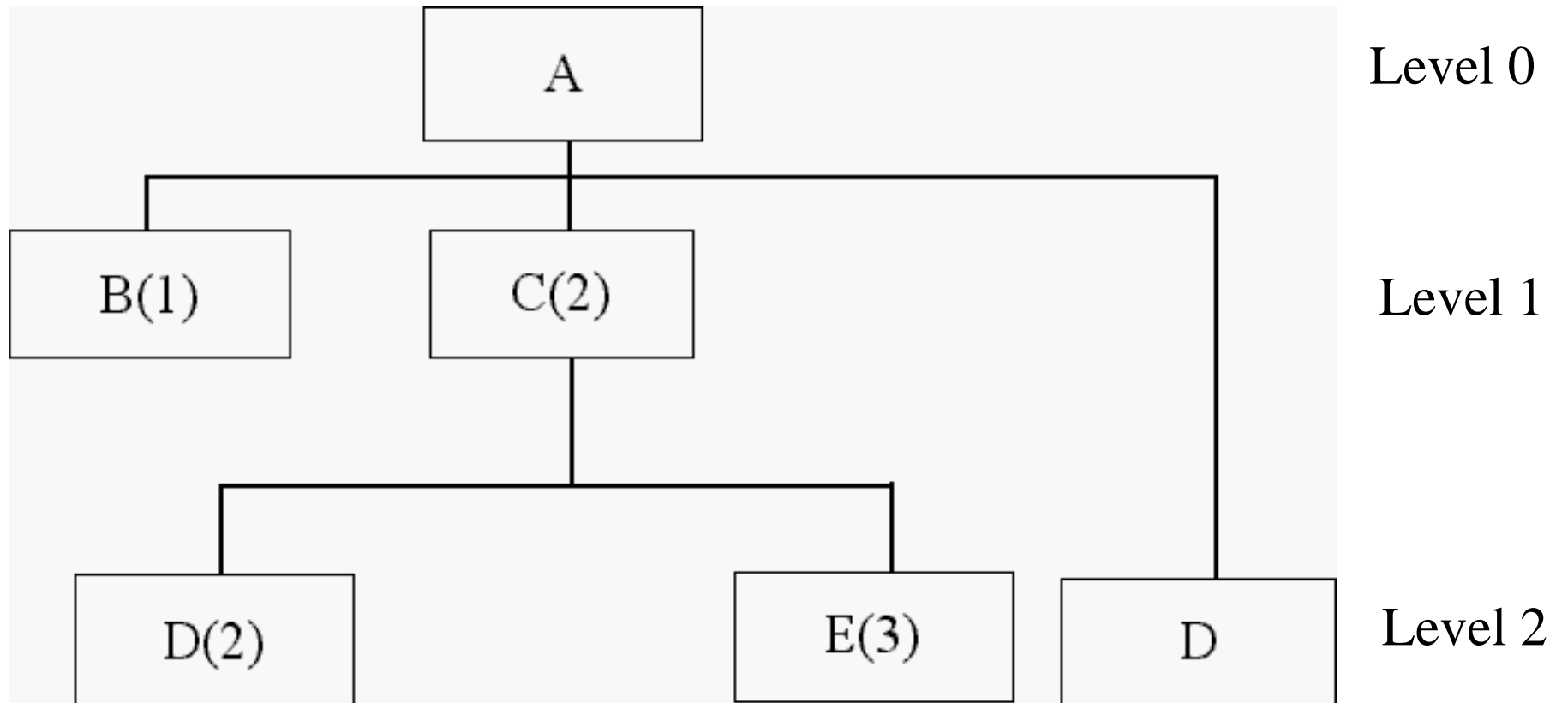
MRP Calculation

Period	1	2	3	4	5	6	7	8	9	10
Item Gross Requirements										
A Scheduled receipts										
LT= On hand from prior period										
Net requirements										
Q= Time-phased Net Requirements										
Planned order releases										
Planned order delivery										

MRP Calculation

Period	1	2	3	4	5	6	7	8	9	10
Item Gross Requirements		30			30			40		
A Scheduled receipts										
LT= On hand from prior period	20									
1 WK Net requirements										
Q= Time-phased Net Requirements										
L4L Planned order releases										
Planned order delivery										

All the information above are given.

MRP Calculation

Period		1	2	3	4	5	6	7	8	9	10
Item	Gross Requirements		30			30			40		
A	Scheduled receipts										
LT=	On hand from prior period	20	20								
1 WK	Net requirements	--									
Q=	Time-phased Net Requirements										
L4L	Planned order releases										
	Planned order delivery										

20 units are just transferred from Period 1 to 2.

MRP Calculation

Period	1	2	3	4	5	6	7	8	9	10
Item Gross Requirements		30			30			40		
A Scheduled receipts										
LT= On hand from prior period	20	20								
1 WK Net requirements	--	10								
Q= Time-phased Net Requirements	10									
L4L Planned order releases	10									
Planned order delivery		10								

The net requirement of 30-20=10 units must be ordered in week 1.

MRP Calculation

Period		1	2	3	4	5	6	7	8	9	10
Item	Gross Requirements		30			30			40		
A	Scheduled receipts										
LT=	On hand from prior period	20	20	0	0	0					
1 WK	Net requirements	--	10								
Q=	Time-phased Net Requirements	10									
L4L	Planned order releases	10									
	Planned order delivery		10								

32

On hand in week 3 is (20+10)-30=0 unit.

MRP Calculation

Period		1	2	3	4	5	6	7	8	9	10
Item	Gross Requirements		30			30			40		
A	Scheduled receipts										
LT=	On hand from prior period	20	20	0	0	0					
1 WK	Net requirements	--	10			30					
Q=	Time-phased Net Requirements	10			30						
L4L	Planned order releases	10			30						
	Planned order delivery		10			30					

The net requirement of 30-0=30 units must be ordered in week 4.

MRP Calculation

Period	1	2	3	4	5	6	7	8	9	10
Item Gross Requirements		30			30			40		
A Scheduled receipts										
LT= On hand from prior period	20	20	0	0	0	0	0	0		
1 WK Net requirements	--	10			30			40		
Q= Time-phased Net Requirements	10			30			40			
L4L Planned order releases	10			30			40			
Planned order delivery		10			30			40		

The net requirement of 40-0=30 units must be ordered in week 7.

MRP Calculation

Period	1	2	3	4	5	6	7	8	9	10
Item Gross Requirements		30			30			40		
A Scheduled receipts										
LT= On hand from prior period	20	20	0	0	0	0	0	0	0	0
1 WK Net requirements	--	10			30			40		
Q= Time-phased Net Requirements	10			30			40			
L4L Planned order releases	10			30			40			
Planned order delivery		10			30			40		

The net requirement of 40-0=30 units must be ordered in week 7.

MRP Calculation

Exercise

Period	1	2	3	4	5	6	7	8	9	10
Item — Gross Requirements										
B — Scheduled receipts										
LT= — On hand from prior period										
— Net requirements										
Q= — Time-phased Net Requirements										
— Planned order releases										
— Planned order delivery										

36

MRP Calculation

Exercise

Period	1	2	3	4	5	6	7	8	9	10
Item Gross Requirements										
C Scheduled receipts										
LT= On hand from prior period										
Net requirements										
Q= Time-phased Net Requirements										
Planned order releases										
Planned order delivery										

MRP Calculation

Exercise

Period	1	2	3	4	5	6	7	8	9	10
Item Gross Requirements										
D Scheduled receipts										
LT= On hand from prior period										
Net requirements										
Q= Time-phased Net Requirements										
Planned order releases										
Planned order delivery										

38

MRP Calculation

Exercise

Period	1	2	3	4	5	6	7	8	9	10
Item Gross Requirements										
E Scheduled receipts										
LT= On hand from prior period										
Net requirements										
Q= Time-phased Net Requirements										
Planned order releases										
Planned order delivery										

READING AND EXERCISES

Lesson 21

Reading:

  Section 7.1 pp. 355-364 (4th Ed.), pp. 346-358 (5th Ed.)

Exercise:

  4 and 9 pp. 364-366 (4th Ed.), pp. 356-358 (5th Ed.)