# UNIT 10: MATERIALS REQUIREMENT PLANNING

## UNIT STRUCTURE


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## 10.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- explain the basic concept of Materials Requirement Planning (MRP)
- explain the various methods for Lot Sizing in MRP

- describe the concept of Capacity Requirement Planning
- obtain an overview of Manufacturing Resource Planning (MRP- II)

## 10.2 INTRODUCTION

In this unit, we are going to discuss the concept of Materials Requirement Planning (MRP), Capacity Requirement Planning, and Manufacturing Resource Planning (MRP- II). Proper implementation of these three concepts can play an important role in the production of any goods or in the delivery of any service. In fact, these concepts can lead to effective production process or service delivery process.

## 10.3 PRODUCT STRUCTURE/ BILL OF MATERIALS (BOM)

Product structure or Bill of Materials (BOM) refers to the listing of all components (sub assemblies and materials) that go into an assembled item. As a matter of fact, it is one of the basic input of Materials Requirement Planning (MRP). It normally indicates the part numbers and quantity required per assembly. In other words, it provides information regarding all the materials, parts, sub-assemblies that go into the end product. The following figure indicates the Product structure or Bill of Materials (BOM) of the final assembled item A.

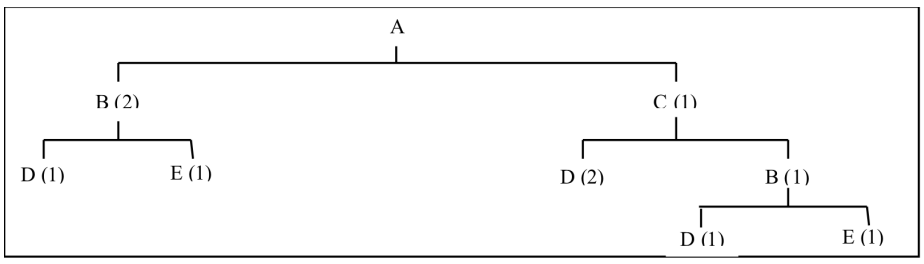



Fig 10.1: Product structure or Bill of Materials (BOM) of the final assembled item A

## 10.4 CONCEPT OF MATERIALS REQUIREMENT PLANNING (MRP)

Materials Requirement Planning (MRP) refers to the technique of determining the quantity and timing for the acquisition of dependent items needed to satisfy master schedule requirements. The primary objectives of MRP are:

(i) To improve customer service by meeting delivery schedules and shortening lead times

(ii) To reduce inventory costs by reducing inventory levels

(iii) To improve operating efficiency of the plant by better use of productive resources

### 10.4.1 Need for MRP

MRP is required for the following reasons:

(i) It forces the planner to determine the total material required during the year, to examine its required specifications and fixing of acceptable limits of the materials.

(ii) It helps in the development of procedures and systems and also helps in improving the existing procedures and systems.

(iii) It focuses on the control parameters and helps in fixing and revising them to suit the changing situation

(iv) It helps in the classification of spare parts and consumables.

(v) It helps in fixing norms for shelf life and in avoiding the spoilage of materials.

(vi) It helps in arranging items of correct specifications at the right time and in the right quantity.

## 10.4.2 MRP Process

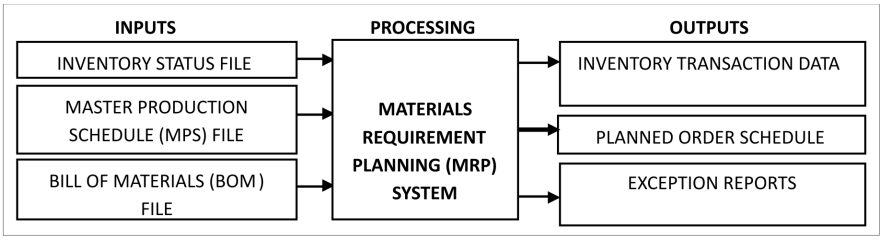



**Fig 10.2: Materials Planning Flowchart (*Source: Aswathappa and Bhat, 2001*)**

**MRP System Intputs:** The basic inputs of MRP are as follows:

(i) **Product structure or Bill of Materials (BOM):** As mentioned in earlier section 10.3.4 it is the listing of all components (sub assemblies and materials) that go into an assembled item. It frequently includes the part numbers and quantity required per assembly.

(ii) **Master Production Schedule (MPS):** It is the schedule of the quantity and timing of all end products to be produced over a planning horizon. The planning horizon should be long enough to cover the cumulative lead times of all components that must be purchased or manufactured to meet end product requirements.

(iii) **Inventory Status File:** It gives complete and up-to-date information on the on-hand quantities, gross requirements, scheduled receipts and planned order releases for the item.

The main factors that influence the requirement of materials in MRP are:

(i) Production Plans

(ii) Installed capacity of the plant

(iii) Market demand

(iv) Nature of the market

(v) Political scenario

(vi) Organizational resources

(vii) Reliable delivery schedule from the vendors

(viii) Reliability of records and store keeping

**MRP System Outputs:** The basic outputs of MRP are as follows:

(i) **Primary Outputs:** These include the following:

(a) **Planned Order Schedule:** It is the plan of the quantity of each material to be ordered ion each time period.

(b) Changes in the planned orders

(ii) **Secondary Outputs:** These include the following:

(a) **Exception reports:** It lists items requiring management attention and control.

(b) **Performance Reports:** It indicates how well the system is operating.

(c) **Planning reports:** These include inventory forecasts, purchase commitment reports etc.

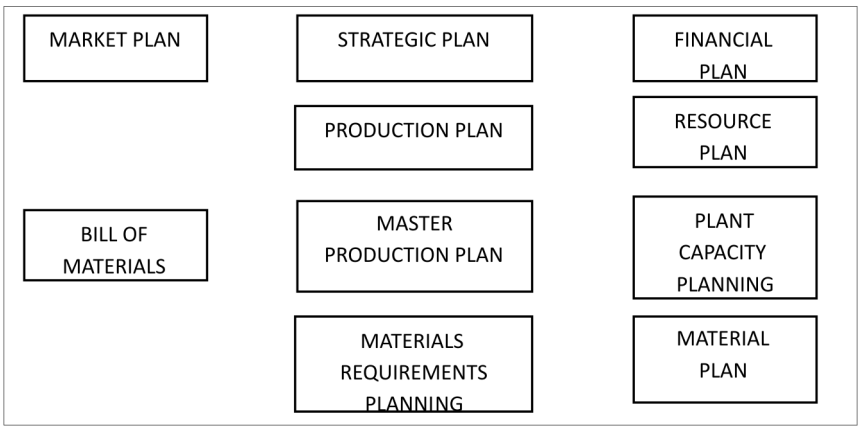



**Fig 10.3: Materials Planning Flowchart (*Source: Saxena, 2008*)**

### 10.4.3 Important Terminologies in MRP

The terminologies used in MRP calculations are as follows (Adam and Ebert, 2008):

(i) **Projected requirements:** These are given by the master production schedule relating to the particulars about the demands of the final assembly for the periods in the planning horizon.

(ii) **Allocated Quantity:** It is the quantity of any item committed for use and is not available to meet future requirements.

(iii) **Gross Requirements:** It is the overall quantity of an item needed at the end of a period to meet planned output levels.

(iv) **Scheduled receipts:** It is the quantity of an item that will be received at the beginning of a time period from suppliers as a result of orders that have been already placed (open orders).

(v) **Available Quantity:** It is the quantity of an item expected to be available at the end of a time period for meeting requirements in the succeeding periods.

(vi) **Net requirements:** It is the net quantity of an item that must be acquired to meet the scheduled output for the period. It is the quantity of an item that must be produced to meet the scheduled output for the period.

$$\textit{Net requirements for the period} = \begin{bmatrix}\text{Gross requirements for the period}\end{bmatrix} - \begin{bmatrix}\text{Scheduled receipts for the period}\end{bmatrix} - \begin{bmatrix}\text{Quantity available from the previous period}\end{bmatrix}$$

$$\textit{Net requirements for the period} = \begin{bmatrix}\text{Gross requirements for the period}\end{bmatrix} - \begin{bmatrix}\text{Materials available at the period}\end{bmatrix}$$

(vii) **Planned Order Receipts:** It is the quantity of an item that is planned to be ordered so that it will be received at the beginning of the period to meet net requirements for the period.

(viii) **Planned Order Release:** It is the quantity of an item that is planned to be ordered and the planned time period for releasing this order that will result in the order being received when needed.

$$\left[\begin{matrix}\text{Planned order release}\\ \text{(Time schedule)}\end{matrix}\right] = \left[\begin{matrix}\text{Planned order receipt}\\ \text{(Time schedule)}\end{matrix}\right] - \text{Lead Time}$$

(ix) **Economic Order Quantity:** It refers to the optimum quantity of items that can be ordered by any company or firm.

(x) **Stock on hand (SOH):** It is the level of inventory at the end of each period (Saxena, 2008). For each period, the Stock on hand is given by the following formula:

$$SOH_t = SOH_t\text{-}1 + R_t - PR_t$$

Where, SOHt is the stock on hand at the end of period 1

SOHt-1 is the stock on hand at the end of period t - 1

Rt is the receipt (scheduled receipt) at the beginning of period 1 through an order which has been placed at some early period

PRt is the projected requirement of the period t

(xi) Action Bucket: It is particular period of time in the planning horizon.

(xii) Low-level coding: It is the coding of each material at the lowest level in any product structure that appears.

(xiii) Lot-sizing decisions: They are decisions regarding the quantity of items in each lot.

(xiv) Load Schedules: It is a device for comparing the actual labour-hours and machine-hours required to produce the Master Production Schedule (MPS) against the available labour-hours and machine-hours per week.

(xv) Pegging: It is the process of tracing through the MRP records and all levels in the product structure to identify how changes in the records of one component will effect the records of the other components.

### 10.4.4 Benefits of MRP

The benefits of Materials Requirements Planning (MRP) are:

(i) Reduction in work-in-process

(ii) Priority benefits

(iii) Effective capacity utilization

(iv) Improved customer service

(v) Reduction in lead time

(vi) Reduction in past due orders

(vii) Reduction in the finished goods inventory, raw material, components and parts and safety stock

(viii) Increased productivity

(ix) Increased inventory turnover

(x) Improved production control

(xi) Quicker responses to changes in demand

### 10.4.5 Limitations of MRP

The limitations of Materials Requirements Planning (MRP) are:

(i) Incorrectness in the suppliers lead time and in manufactur-

ing led time leads to incorrect MRP calculations

(ii) Highly computational intensive approach of MRP causes overdependence on MRP outputs.

(iii) Unreliable inventory data leads to failure of the MRP system

(iv) Bill of materials and inventory status should be computerized

(v) The product structure must be assembly oriented

(vi) A valid must schedule must exist

(vii) The success of MRP depends on maintenance of accurate records, accurate reporting and awareness of reports.

### 10.4.6 Implementation of MRP

Proper implementation of MRP requires the following:

(i) Management Commitment

(ii) User Involvement

(iii) Education and Training

(iv) Selection of packages

(v) Data accuracy

(vi) Realistic Master Production Schedule (MPS)

### 10.4.7 Problems in using MRP

While using MRP, the following problems may be encountered:

(i) Problems while preparation of the Master Production Schedule (MPS)

(ii) Maintenance of accurate Bill of Materials (BOM) files

(iii) Incorrect inventory status

(iv) Unrealistic lead times

**Problems while designing MRP System:**

(i) Inadequacies of the chosen software

(ii) Deficient systems design

(iii) Improper and untimely information flow among the various related departments

**Problems in managing MRP:**

(i) Need for formal systems and the role of systems

(ii) Need for proper organisation of functions

(iii) Importance of proper appreciation of planning and control systems

(iv) Timeliness of generating information required in managing the plant

(v) Effective communication systems

(vi) Proper motivation of people concerned with the implementation of the system

(vii) Right leadership

### 10.4.8 Production systems suitable for MRP implementation

The following production systems are suitable for MRP implementation:

(i) An effective computer system

(ii) Computerized BOM files and inventory status files

(iii) A production system that manufactures discrete products made up of raw materials, parts, sub-assemblies and major assemblies which are processed through several production steps or operations

(iv) Production processes or operations requiring long processing times

(v) Short and unreliable lead time for procurement of raw materials and components from vendors

(vi) The time fence for the frozen MPS should be sufficient enough to procure materials without undue expediting effort

(vii) Support and commitment of the top management

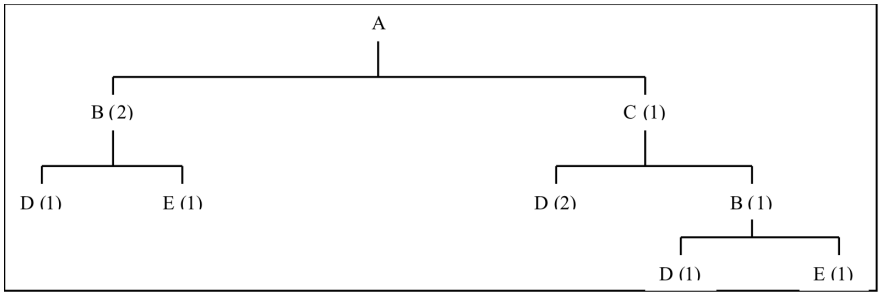
## 10.4.9 MRP Calculation Procedure

The following example attempts to provide an explanation regarding the MRP calculation procedure:

***Step-I: Making the Bill of Materials (BOM)/ Product Structure File:***

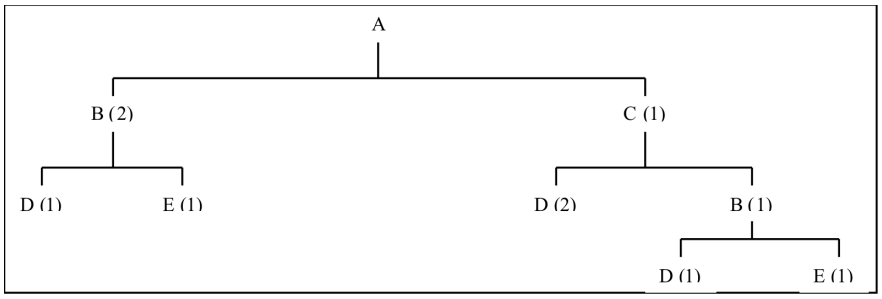
It provides information regarding all the materials, parts, sub-assemblies that go into the end product.

Example: Given the following product tree, explode, offset and determine the gross and net requirements. All LT are one week. The MPS calls for production of 100 As in week 4 and 50 in week 5. There are 300 Bs scheduled to be received in week1 and 200 Ds in week 3. There are also 20 As available in stock. Determine the purchase order requirement. (GU, MBA 2006)




**Solution:** Given from the above data,

***Bill of Materials (BOM) Structure is as follows***




All Lead Time (LT) = 1 week

Master Production Schedule (MPS) calls for production of 100 As in week 4 and 50 in week 5. There are 300 Bs scheduled to be received in week1 and 200 Ds in week 3. There are also 20 As available in stock.

Using Lot for Lot Method to find Planned order Requirements (POR)

Let,

GR- Gross Requirements

SR- Scheduled Receipts

AQ- Available quantity/ SOH- Stock on Hand

NR- Net Requirements

PORC- Planned order Receipts

PORL- Planned order Release

The POR- Planned Order Release for the different components can be found as follows:

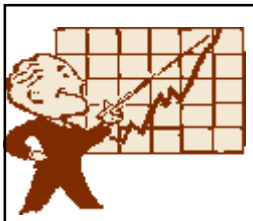
| Component A LT= 1 week | | | | | | |
|---|---|---|---|---|---|---|
| **Time** | **0** | **1** | **2** | **3** | **4** | **5** |
| **GR** | | | | | 100 | 50 |
| **SR** | | | | | | |
| **AQ** | 20 | 20 | 20 | 20 | | |
| **NR** | | | | | 80 | 50 |
| **PORC** | | | | | 80 | 50 |
| **PORL** | | | | 80 | 50 | |

| Component C LT= 1 week | | | | | |
|---|---|---|---|---|---|
| **Time** | **1** | **2** | **3** | **4** | **5** |
| **GR** | | | 80 | 50 | |
| **SR** | | | | | |
| **AQ** | | | | | |
| **NR** | | | 80 | 50 | |
| **PORC** | | | 80 | 50 | |
| **PORL** | | 80 | 50 | | |

| Component B LT= 1 week | | | | | |
|---|---|---|---|---|---|
| **Time** | **1** | **2** | **3** | **4** | **5** |
| **GR** | | 80 | 210 (160+50) *(2 × 80 + 50)* | 100 *(2 × 50)* | |
| **SR** | 300 | | | | |
| **AQ** | | 220 | 10 | - | |
| **NR** | | | | 90 | |
| **PORC** | | | | 90 | |
| **PORL** | | | 90 | | |

| Component D LT= 1 week | | | | | |
|---|---|---|---|---|---|
| **Time** | **1** | **2** | **3** | **4** | **5** |
| **GR** | | 160 *(2 × 80)* | 280 (100+180) *(2 × 50 + 2 × 90)* | | |
| **SR** | | | 200 | | |
| **AQ** | | | | | |
| **NR** | | 160 | 80 | | |
| **PORC** | | 160 | 80 | | |
| **PORL** | 160 | 80 | | | |

| Component E LT= 1 week | | | | | |
|---|---|---|---|---|---|
| **Time** | **1** | **2** | **3** | **4** | **5** |
| **GR** | | | 180 *(90+90)* | | |
| **SR** | | | | | |
| **AQ** | | | | | |
| **NR** | | | 180 | | |
| **PORC** | | | 180 | | |
| **PORL** | | 180 | | | |



## CHECK YOUR PROGRESS

Q 1: Which of the following is an input in the MRP process?

(a) Inventory Status File (b) Infant Mortality

(c) Production Planning (d) None of these

Q 2: Which of the following is needed for implementation of MRP?

(a) Inventory turnover (b) Gross Requirements

(c) Realistic Master Production Schedule (MPS)

(d) None of these

Q 3: Which of the following is a problem while designing MRP System?

(a) Quality Control Chart (b) CAM

(c) Batch Production (d) Deficient systems design

## 10.5 LOT SIZING IN MATERIALS REQUIREMENT PLANNING (MRP)

The various methods for lot sizing in MRP are as follows:

(i) Lot-for-lot ordering: It is a policy in which order quantity equals net requirements for the period provided there is no carry over to the future.

(ii) EOQ Method: Here economic order quantity based on the following formula is computed:

$$\text{Economic Order Quantity, } Q = \sqrt{\frac{(2 \times A \times C_p)}{C_c}}$$

(iii) Minimum cost per period method (MCP Method): Here initially the cumulative cost for each periods combination is computed. Thereafter the cost per period is computed by dividing the cumulative cost by the number of periods in the periods combination and shown in the last column of the same table. This cost per period goes on decreasing up to certain periods combination and then it starts increasing. This periods combination just prior to the increase in the average cost is selected as the desirable periods combination at this point, and planned order release is made for the cumulative projected requirements of all the periods in the periods combination. Then starting from the period where there is an increase in the cost per period, the whole process is repeated till al the period's projected requirements are met.

(iv) Period Order Quantity method (POQ Method): Here economic order quantity based on the basis of the following EOQ formula:

$$\text{Economic Order Quantity, } Q = \sqrt{\frac{(2 \times A \times C_p)}{C_c}}$$

$$\text{Optimal number of periods, } P = \frac{N}{D/EOQ}$$

In this method whenever a planned order release is made, its order quantity is equal to the sum of non-zero projected requirements of three periods in sequence starting from the first period in that periods combination.

(v) Part period Balancing Approach (PPB Approach): In the conventional EOQ calculations, the optimal EOQ results when the set-up cost is equal to the carrying cost. The PPB Approach attempts to exploit this property of equalizing the set-up cost and carrying cost to establish what is known as Economic Part Period (EPP).

$$\text{Economic Part Period} = \frac{\text{Set-up Cost}}{\text{Carrying Cost per unit per period}}$$

(vi) Least Unit Cost Method (LUC Method): Here the cumulative cost of the sum of the set-up cost and carrying cost is computed for each periods combination. Then it is divided by the cumulative projected requirements of that periods combination to obtain the cost per unit (unit cost). This type of calculation is done from the beginning period. The cost per unit (unit cost) goes on decreasing up to a periods combination and then it starts increasing. The periods just prior to the increase in the cost per unit (unit cost) is selected as the desirable periods combination at this stage, and a planned order release is made for the cumulative projected requirements of all periods in this periods combination. Then starting from the period where there is an increase in the cost per unit (unit cost), the whole process is repeated till all the periods' projected requirements are met.

## 10.6 CAPACITY REQUIREMENTS PLANNING

Capacity requirements planning (CRP) is the process of reconciling the Master Production Schedule (MPS) to the available capacities of the production departments over the planning horizon. It is a technique for determining the nature and quantity of labour/ personnel and equipment

capacities needed to met production objectives mentioned in the master production schedule (MPS) and Materials Requirement Planning (MRP-I). CRP is also defined as the process by which a company figures out how much it needs to produce, and determines if it is capable of meeting those production goals. Small businesses must conduct capacity requirements planning regularly to keep up with changes in supply and demand.

**CRP Inputs:** Following are the major inputs of the CRP process:

- Planned orders and release orders from the MRP system
- Loading information from the work centre status file
- Routing information from the shop routing file
- Changes which modify capacity and provide alternative routings or planned orders.

**CRP Outputs:** Following are the major outputs of the CRP process:

- Rescheduling information which require capacity modification o revision of the Master Production Schedule (MPS)
- Verification of planned orders for the MRP system
- Load reports

Keeping in view the above discussion, the following diagram provides the underlying logic of Capacity Requirements Planning (CRP).

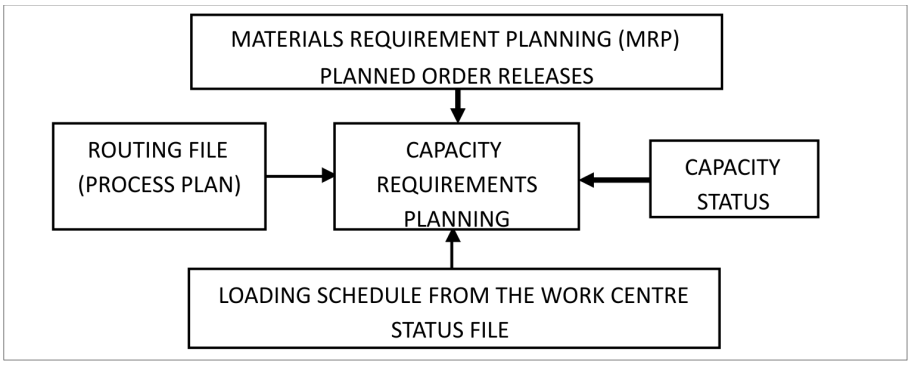



**Fig 10.4: The Underlying Logic of Capacity Requirements Planning (*Source: Mahadevan, 2015*)**

## 10.7 MANUFACTURING RESOURCE PLANNING (MRP- II)

Manufacturing Resource Planning- II (MRP- II) is a management process that involves extension of the closed loop MRP to incorporate financial, accounting, personnel, engineering and marketing information along with the production planning and control activities of the basic MRP system. MRP II provides information regarding inventory investment levels, plant expansion needs and workforce requirements that is essential in integrating financial, engineering, marketing and manufacturing efforts to achieve the company's overall business plans.

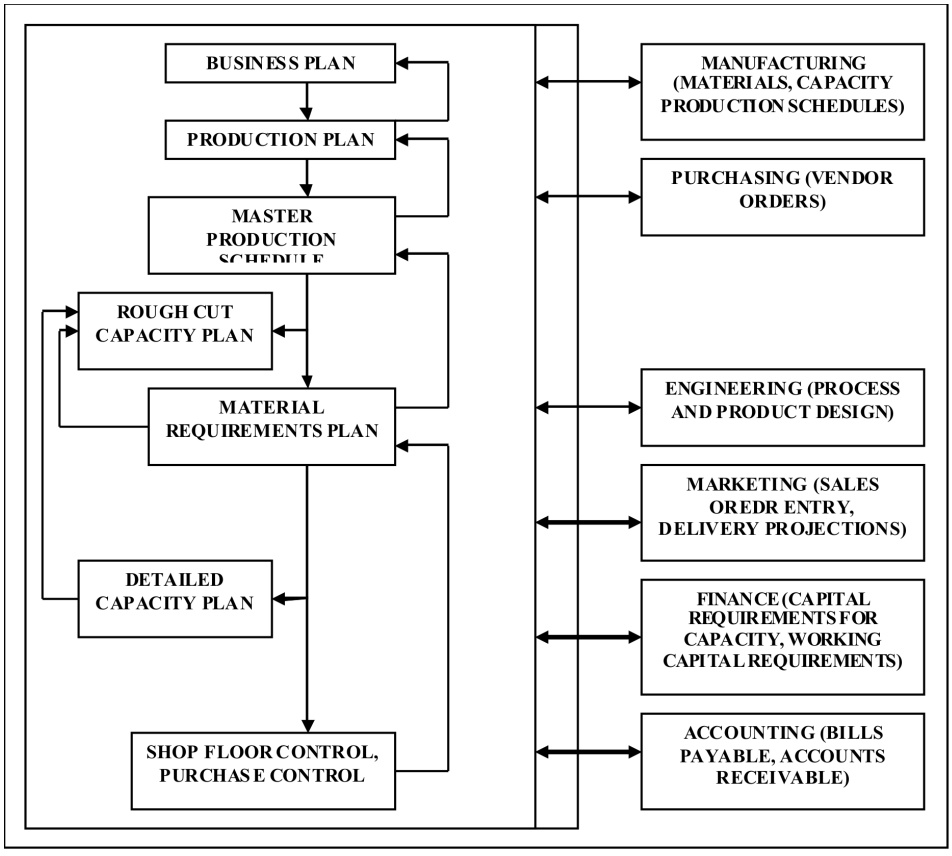



Fig 10.5: MRP II- An integrated system of planning and control (Source: Aswathappa and Bhat, 2001)



## CHECK YOUR PROGRESS

Q 4: Which of the following is a major input of the Capacity Requirement Planning process?

(a) Routing information from the shop routing file

(b) Net Requirement

(c) Production Control

(d) None of these

Q 5: Which of the following process that involves extension of the closed loop MRP to incorporate financial, accounting, personnel, engineering and marketing information along with the production planning and control activities of the basic MRP system?

(a) Inventory Control

(b) Manufacturing Resource Planning

(c) Computer Numerical Control

(d) Enterprise Resource Planning

Q 6: Load reports are output of which of the following processes?

(a) Materials Requirement Planning

(b) Pegging

(c) Master Production Schedule

(d) Capacity Requirement Planning



## 10.8 LET US SUM UP

Materials Requirement Planning (MRP) refers to the technique of determining the quantity and timing for the acquisition of dependent items needed to satisfy master schedule requirements. The primary objectives of MRP are:

- Product structure or Bill of Materials (BOM) refers to the listing of

all components (sub assemblies and materials) that go into an assembled item.

- Materials Requirement Planning (MRP) refers to the technique of determining the quantity and timing for the acquisition of dependent items needed to satisfy master schedule requirements.

- Capacity requirements planning (CRP) is a technique for determining the nature and quantity of labour/ personnel and equipment capacities needed to met production objectives mentioned in the master production schedule (MPS) and Materials Requirement Planning (MRP-I).

- Manufacturing Resource Planning- II (MRP- II) is a management process that involves extension of the closed loop MRP to incorporate financial, accounting, personnel, engineering and marketing information along with the production planning and control activities of the basic MRP system.



## 10.9 FURTHER READINGS


- Production and Operations Management by K. Aswathappa K.S. Bhat, Himalaya Publishing House, pp.294-322.

- Production and Operations Management by K. Bedi, Oxford University Press.

- Production and Operations Management by S.N. Chary, Tata-McGraw Hill Publishing Company Limited, pp.23.1-23.16.

- Production and Operations Management by R. Panneerselvam, Prentice Hall of India Private Limited, pp.264-279.

- Production and Operations Management by J.P. Saxena, Tata-McGraw Hill Publishing Company Limited, pp.359-378.



## 10.10 ANSWERS TO CHECK YOUR PROGRESS

**Ans. to Q. No.**1: (a) Inventory Status

**Ans. to Q. No.** 2: (c) Realistic Master Production Schedule (MPS)

**Ans. to Q. No.** 3: (d) Deficient systems design

**Ans. to Q. No.**4: (a) Routing information from the shop routing file

**Ans. to Q. No.** 5: (b) Manufacturing Resource Planning

**Ans. to Q. No.**6: (d) Capacity Requirement Planning

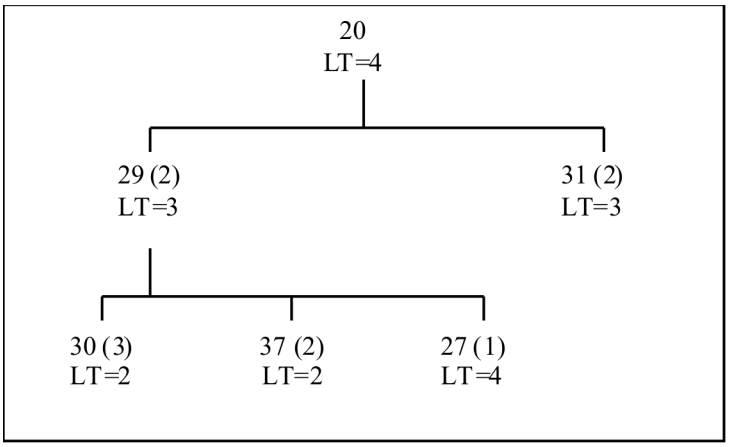


## 10.11 MODEL QUESTIONS

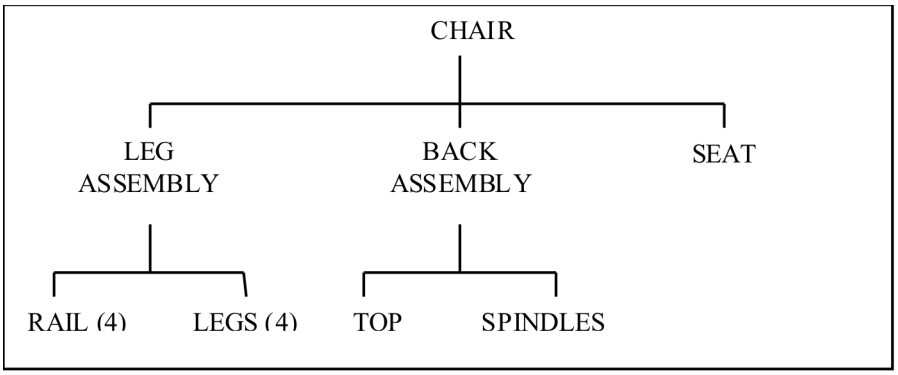
Q. 1) What is MRP? What is the context of overall planning and scheduling systems for operations? Explain the role of MRP.

Q. 2) Each unit of X requires two units of sub-component Z. The lead time for X is one week, The standard order quantity is 40 units and the current availability is 35 units. Gross requirements for the next six weeks are 25, 30, 20, 15, 15 and 20 units respectively. For unit Z, lead time is two weeks, standard order quantity is 80 units and the current availability is 90 units. A scheduled receipt for 80 Z's is due in week 1. Develop complete MRP records for X and Z. (GU, MBA 2009).

Q. 3) Ambrex Ltd. has received an order for 70 units of product 20 to be delivered in 12 weeks. The BOM of the product 20 is given below. Ambrex has on hand 300 units each of component 31 and 37; there is no stock on hand or on order for other components. Determine the sizes and timing of the planned order releases necessary to meet delivery commitment for product 20. (GU, MBA 2008).




Q. 4) BOM for a chair is given below:




The inventory parts and LT are as follows:

| | On hand inventory | LT |
|---|---|---|
| Chair | 100 | 1 |
| Leg Assembly | 50 | 2 |
| Back Assembly | 25 | 1 |
| Seat | 40 | 3 |
| Rails | 100 | 1 |
| Top | 30 | 2 |
| Legs | 150 | 1 |
| Spindles | 80 | 2 |

The company has received orders to deliver 400 chairs in week 5 sand 300 chairs in week 6. Develop complete MRP records for all parts.

Q. 5) What are the inputs and outputs required by the MRP processing logic?

Q. 6) What is ERP? Explain its benefits.

** *** **