B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - V

OPERATIONS MANAGEMENT

Course Code	**18ME56**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To get acquainted with the basic aspects of Production Management.
- The expose the students to various aspects of planning, organising and controlling operations Management.
- To understand different operational issues in manufacturing and services organisations.
- To understand different problem-solving methodologies and Production Management techniques.

Module-1

Introduction, Functions within business organizations, the operation management function, Classification of production systems, Productivity, factors affecting productivity.

Decision Making: The decision process, characteristics of operations decisions, use of models, decision making environments, graphical linear programming, analysis and trade-offs.

Module-2

Forecasting: Steps in forecasting process, approaches to forecasting, forecasts based on judgment and opinion, analysis of time series data, accuracy and control of forecasts, choosing a forecasting technique, elements of a good forecast.

Module-3

Capacity & Location Planning: Importance of capacity decisions, defining and measuring capacity, determinants of effective capacity, determining capacity requirement, developing capacity alternatives, evaluating alternatives, Need for location decisions, nature of locations decisions, general procedure for making locations decisions, evaluating locations decisions, facilities layout – need for layout decisions, types of processing.

Module-4

Aggregate Planning & Master Scheduling: Aggregate planning – Nature and scope of aggregate planning, strategies of aggregate planning, techniques for aggregate planning – graphical and charting techniques, mathematical techniques. The master production schedule, Master scheduling process, Master scheduling methods.

Module-5

Material Requirement Planning (MRP): Dependent versus independent demand, an overview of MRP – MRP inputs and outputs, MRP processing, ERP capacity requirement planning, benefits and limitations of MRP.

Purchasing and Supply Chain Management (SCM): Introduction, Importance of purchasing and SCM, the procur process, Concept of tenders, Approaches to SCM, Vendor development.

Course Outcomes: At the end of the course, the student will be able to:

CO1: Explain the concept and scope of operations management in a business context
CO2: Recognize the role of Operations management among various business functions and its role in the organizations' strategic planning and gaining competitive advantage.
CO3: Analyze the appropriateness and applicability of a range of operations management systems/models in decision making.
CO4: Assess a range of strategies for improving the efficiency and effectiveness of organizational operations.
CO5: Evaluate a selection of frameworks used in the design and delivery of operations

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.

- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbooks:

1. "Operation Management, Author- Joseph G Monks McGrew Hill Publication, International Edition-1987.
2. "Production and Operation Management" ,Author-Pannerselvam R. PHI publications, 2nd edition
3. "An Introductory book on lean System, TPS Yasuhiro Modern.

Reference Books:

1. "Production and Operation Management" Chary S. N. TataMcGrew Hill 3rd edition.
2. "Production and Operations Management", Everett E. Adams, Ronald J. Ebert, Prentice Hall of India Publications, Fourth Edition.
3. Modern Production/Operations Management, Buffia, Wiely India Ltd 4th Edition.

Date: / /20
Page No:

OPERATIONS MANAGEMENT

06 Hours

UNIT 1: PRODUCTION AND OPERATIONS MANAGEMENT

→ Operations management is a systematic approach to address all the issues pertaining to the transformation process that converts some inputs into output that are useful, and could fetch revenue to the organisation.

→ An operations system can be defined as one in which several activities are performed to 'transform' a set of inputs into a useful output using a transformation process.

→ These inputs & outputs can be physical things like materials and/or informational and experiential things

→ To ensure that the desired outputs are obtained, an organisation takes measurements at various points and compares it with the previously obtained standard to determine whether corrective actions (Controlling of the System) is needed or not.

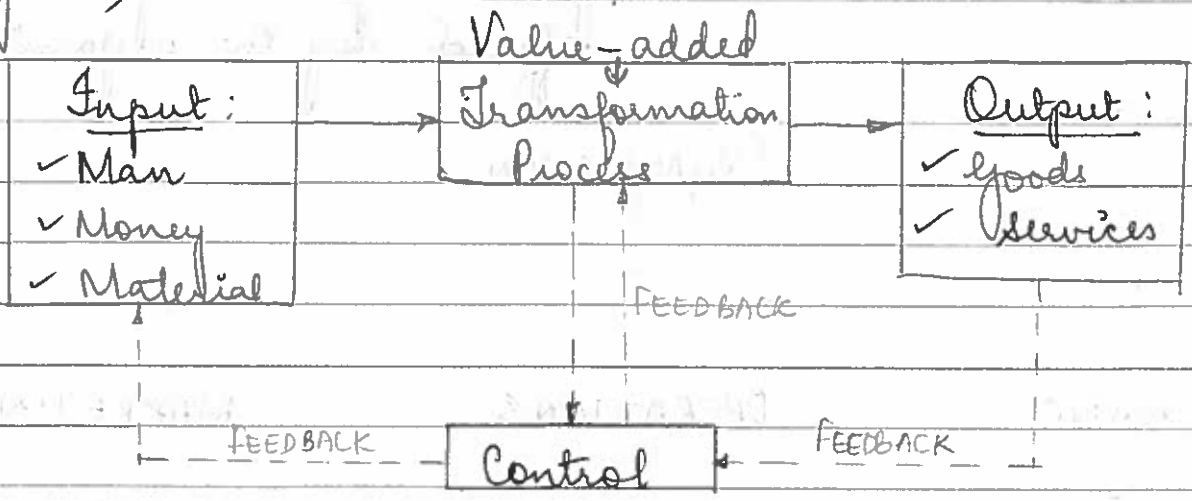


FIG: OPERATIONS SYSTEM

⊛ FUNCTIONS WITHIN A BUSINESS ORGANISATION

→ Business organisations have 3 major and basic functional areas — Finance
Marketing
Operations

→ Finance → Responsible for securing financial resources at favorable prices.
* These resources are then allocated throughout the organisation, budgeting, analysing investment proposals and providing funds for operation
* They are responsible for all the monetary affairs of the organisation.

→ Marketing → These are the primary functions or line & operations functions.

Marketing: Responsible for assessing consumer requirements, selling and promoting organisations goods or services.

Organisations: Responsible for producing the goods or providing services offered by the organisation.

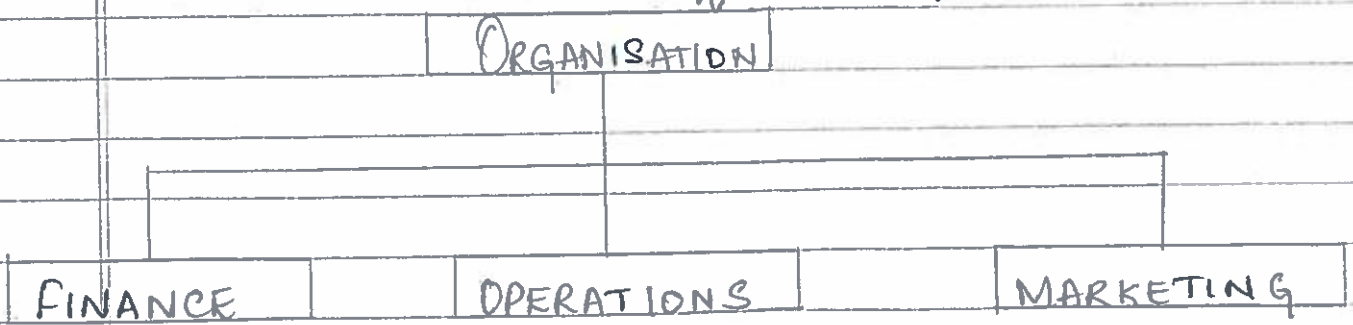


FIG: THE THREE BASIC FUNCTIONS OF A BUSINESS ORGANISATION

Date : / / 20
Page No:

OPERATIONS MANAGEMENT FUNCTION

→ Organisation management is the management of system or processes that create goods or services

→ The creation of goods or services involves the transforma of inputs into outputs.

→ Various inputs like labour, capital, equipment and information are used to create goods or services usin one or more transformation processes. (Eg: Storing, transporting, cutting etc...)

→ To ensure that the desired outputs are obtained, an organisation take measurements at various points in the transformation process (feedback) and then compa it with the previously established standards to detem whether corrective measures need to be taken (cont

→ The conversion system is depicted in the figure below:

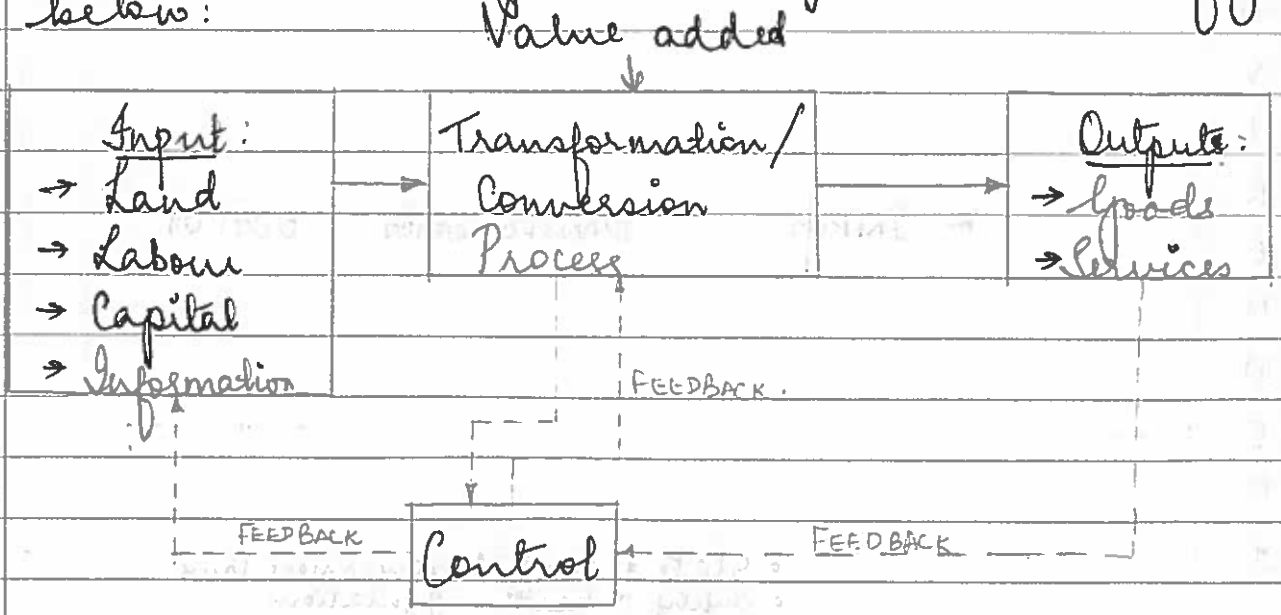


FIG: THE OPERATIONS MANAGEMENT FUNCTION

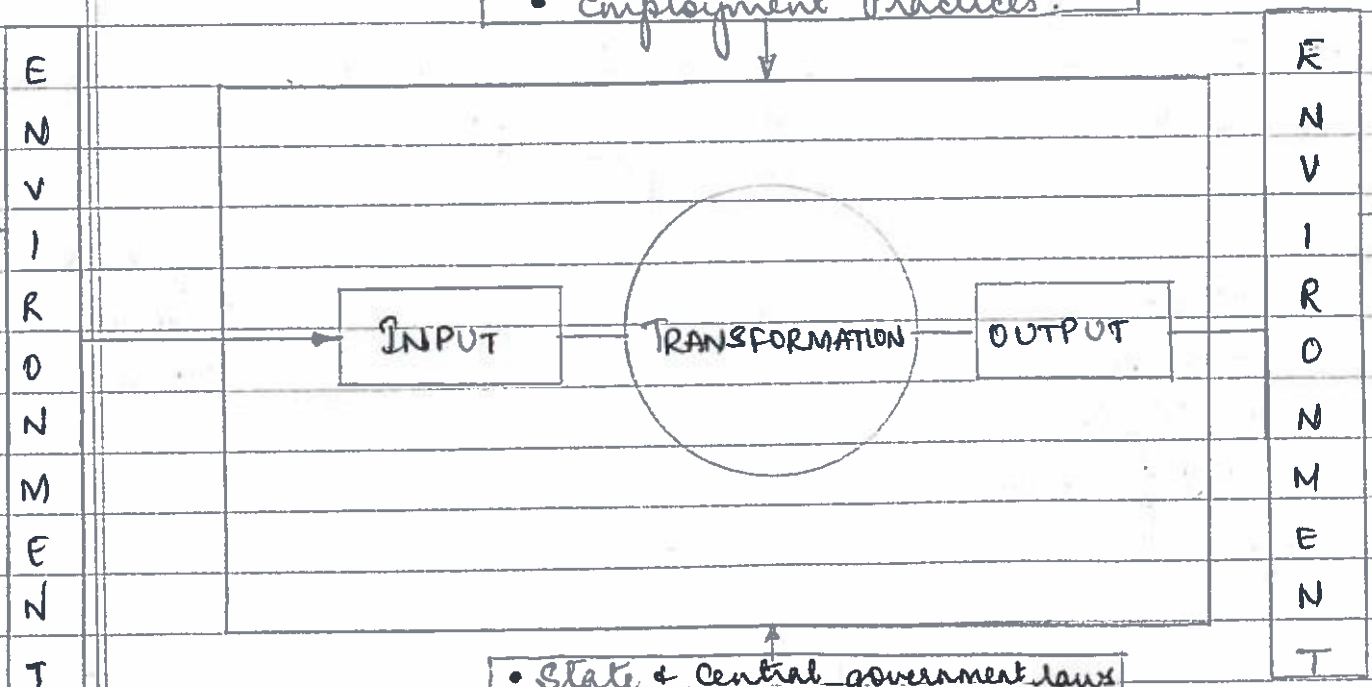
→ The essence of the operation function is to add value during the transformation process.

→ Value added is the term used to describe the difference between the cost of inputs & the value or price of outputs.

→ A general framework of planning, organising & controlling of decisions in a prodⁿ system is as shown below:

Interchanged (Contemporary Issues & Development)

- Consumer Protection laws
- Economic Conditions
- Environmental Regulations
- Present Technology
- Customer & Union demands
- Employment Practices.



- State & Central government laws
- Safety & health regulations
- Interest Rates
- Income taxes
- Financial Markets
- Available Resources.

Environmental Feed back

Date: / /20
Page No:

1. Planning:

→ • Establishes a course of action for the operations manager which serves as a guide to future decision making.

• Planning includes:
  * Planning for operations
  * " " capacity
  * " " Location of the facility
  * " " the layout

→ Tools used in planning are:
  * Forecasting
  * Aggregate Planning
  * Scheduling
  * Job shop scheduling
  * Project planning and scheduling.

2. Organisation

→ Establishes a structure of tasks & authority.

→ The operations managers determine the required activities to achieve goals and assign authority & responsibility for each worker or subordinate to carry them out.

→ Organising includes:
  * Staffing for operations
  * Organisation of activities
  * Job designing
  * Prod^n / operation standards & work measure

3. Controlling:

→ Establishes assurance of actual performance in accordance with the planned performance.

→ Controlling includes:
* Controlling operations
* Inventory control
* Cost control
* Maintenance.

4. Behaviour:

→ Establishes a platform for observation of the efforts to plan and organize and to control the operations

→ Behaviour includes:
* Studying the behaviours of the subordinates by their operations managers.
→ This is done because the behaviour of the employees affect
• planning
• Organising and
• Control of the management

5. Models:

→ These are used to solve problems or queries that may arise in the course of production and operation

→ Various models are available to the managers for problem solving:
a. Verbal models: Involve words + descriptions
b. Physical models: Built using a standard scale
c. Schematic models: Involve diagrams + charts
d. Mathematical models: Involving equations.

Date: / /20
Page No:

- Of all these models, the most useful is the mathematical mod as it perfectly describes the problem.
- It can be easily manipulated and computerized to test vari parameters.

⊛ CLASSIFICATION OF PRODUCTION SYSTEMS.

→ According to the quantities of prod", prod" systems are classified as follows: (into 4 types)

1. Job shop
2. Batch Prod"
3. Mass "
4. Continuous Prod".

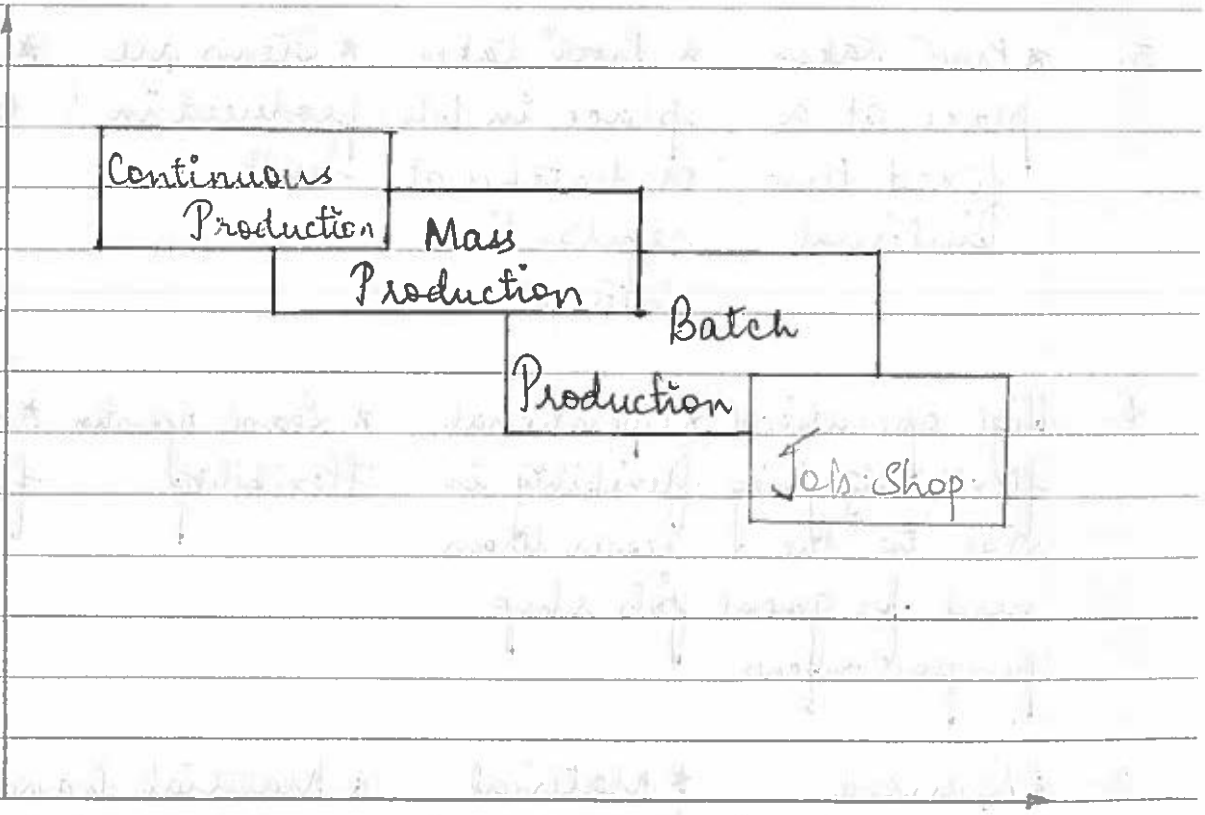


FIG: DIFFERENT TYPES OF PRODUCTION SYSTEMS

Sl. No.	JOB SHOP	BATCH PROD^{N}	MASS PROD^{N}	CONTINUOUS PROD^{N}
1.	Description : * It is the oldest method of prod^{n} * Used to produce items on a small scale.	* Used in medium sized enterprises	* Used in larger enterprises	* Used in enterprises where prod^{n} activity continues for 24hrs a day or 3 shifts a day.
2.	* Small no. of items produced only once	* Bigger prod^{n} scale as compared to job shop but smaller than mass-prod^{n}.	* Larger no. of identical items are produced.	* Divided into 2 parts • Mass prod^{n} • Flow prod^{n}.
3.	* Prod^{n} takes place at a fixed time interval	* Prod^{n} takes place in lots or batches at regular time intervals	* Items are produced in bulk.	* Items are produced continuously.
4.	High operational flexibility giving rise to the need for general purpose machines.	* Operational flexibility is lesser than job shop.	* Least operational flexibility	* Least operational flexibility.
5.	* Reduced automation is used	* Material handling System may be automated	* Material handling is fully automated.	

Date: / /20
Page No:

Sl. No	JOB SHOP	BATCH PROD^N	MASS PROD^N	CONTINUOUS PROD^N
6.	Low volume + large variety of prod^n	* Medium volume and variety of prod^n	* Large ~~variety~~ volume of product	
7.	* Advantages:			
	• Low risk of loss	• General purpose m/cnes are used	• Work In process is zero	
	• Factory failure is less	• Rate of prod^n is high	• High volume of prod^n	
	• Smaller work force is used.	• Medium risk of Loss	• Lower capital costs.	
8.	* Disadvantages :			
	• Increased labour cost due to need of multiple skill sets	• Increased raw material costs.	• Heavy losses when demand is less.	
	• Low equipment utilization	• Specially designed jigs & fixtures are required.	• System cannot be altered or changed.	
	• Material requirement is high in cost and purchased in low quantities		• Stoppage or breakdown of a single machine causes halt in the entire machine line.	
9.	* Examples:			
	• Boiler manuf. • Textile • Air craft	• Pharmaceuticals Industry	• Pressing Shops	• Automobile parts pipes etc...

[P]roduction Management : It is a process of planning, organising, directing & Controlling the activities of the prod^n function. [1. Right] Quality [2]. Right Quantity 3. Right Time 4. Right Manufacturing Cost.

[...] depend on the cost + technical characteristics. 2. Right Qty: Should be produced with respect to demand ~ slightly exact numbers. 3. Right time: Timeless delivery 4. Right mfg cost: established before mfg

* PRODUCTIVITY – Energized by competition

→ It may be defined as the tool used to measure the amount of products or services that an organisation provides with the resources used.

→ It is also defined as the effectiveness of resource utilization to produce goods or services.

→ It is given by:

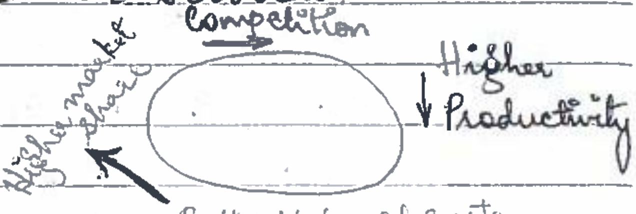


Fig: Dynamic concept of prod

$$\text{Productivity} = \frac{\text{Quantity of products / Services produced}}{\text{Amount of input resources used}}$$

$$= \frac{(\text{Value})_{\text{outputs}}}{(\text{Cost of})_{\text{inputs}}}$$

[Should always be greater than 1]

* FACTORS AFFECTING PRODUCTIVITY

→ Some of the factors affecting productivity are as follows:

1. Investment or capital / Labour Ratio.

* Capital / Labour ratio is the effective use of labour hours by making enough investment in the plant, machinery and other tools.

* Low savings rate will result in low investments thereby reducing the capital / Labour ratio in turn causing a dip in the productivity.

2. Resource availability / Scarcity.

Date: / /20
Page No:

* If the resources are available in sufficient quantit they will be procurable at cheaper rates thus increasing the productivity.

* If the raw materials / resources are scarce, this scarcity increases their prices thus decreasing productivity.

3. Education and skill level of people
* High technology production demands higher le of educational requirements.

* If the educational level and skill level of peopl is low, the organisation will have to spend more amount of time and money to either train th existing personnel or hire qualified workers from outside hence reducing productivity.

4. Innovations and new technologies.
* With the introduction of new technologies & innovative methods into the production system, productivity can be increased.

5. Goods versus services produced
* Productivity in the service sector is lesser wh compared to the manufacturing sector.

* Therefore, any shift from manufacturing t service will hamper the productivity thereby reducing it.

6. Regulatory and bargaining effects

* Increased regulatory measures (eg: safety etc). and bargaining agreements have an impact on productivity.

* A strict compliance as per the policies of the government with regard to safety and environmen issues, cause an increase in input costs and hence reduce the productivity

* Bargaining agreement is a written agreement between the organisation and the trade union which contains the terms and conditions of employment in the organisation.

* This limits the company's ability to hire more workers, leading to unemployment and also has a detrimental (negative) effect on the productivity as it may alter the output.

7. Ability to save versus Spend

* Money saved through some means may be spent/invested in another forum within the organisation thus increasing productiv as it increases the capital/Labour ratio.

8. Quality and global competitiveness.

* Improved quality of a good or service rendered by an organisation may result in global recognition of the company. This may lead to an increase in productivity as there will be fewer rejects & more team oriented activities.

MERIT
Date : / /20
Page No:

(*) METHODS TO IMPROVE PRODUCTIVITY

→ Productivity can be improved in several ways:

1. Increasing output for the same input. [I/p - c, O/p ↑]
   → Efficient handling of the existing facility
   → This can be achieved by:
      a. cutting down labour idle time
      b. Using cost effectively
      c. " resources like materials or energy effectively.

2. Decreasing input for the same output. [I/p ↓, O/p - c]
   → Finding cheaper / more economical substitute raw materials or equipment which are cheaper than the existing facility but do not alter the present quality of the output.

3. Increased output for decreased input. [I/p - ↓, O/p - ↑]
   → Utilization of modern technologies like CNC m/c robots etc... will decrease the amount of I/p and at the same time increase the output of the system.

4. Proportionate increase in output compared to input [I/p - ↑, O/p ↑]
   → In this case, there is an increase in both input and output.
   → The increase in output is proportional to the increase in input. hence striking an balance. Eg: Co. sells a new product along with the old indicating increased i/p which brings more revenue.

5. More proportionate decrease in input compared to output [I/p - ↓, O/p - ↓]

* When a company feels that one of its products is not doing well in the market or is obsolete, it withdraws the product from the market.

* This results in a loss due to the investments made on that product (output)

* This loss is compensated for by a decrease in raw material procurement, material cost, operational maintenance costs for that product.

* Decrease in input is more rapid when compared to decrease in output or revenue.

⊛ MEASUREMENT OF PRODUCTIVITY

→ Productivity can be measured in any of the following ways:

1. Partial Productivity
2. Multifactor Productivity
3. Total Productivity / Total measure.

	Partial Productivity	Multifactor Productivity.	Total Measure.
*	The ratio of the output to any one, single input is called Partial Productivity	The ratio of the output to a group of inputs is called multifactor productivity.	The ratio of the output to all the inputs is called Total measure or total productivity.
*	It is a measure of the effectiveness of a single resource	It is measure of the effectiveness of a group of resources but not all	It is a measure of the effectiveness of all the resources

Date: / / 20
Page No:

* Partial Measure = Output/Input or Output/Capital or Output/Material or Output/Energy

* Multifactor Measure = O/p / (Labour + capital) or O/p / (Labour + capital + mat)

* Total measure = Output of goods/services produced / All the resources used.

1. Two types of cars are (Deluxe & Ltd) were produced by a car manufacturer in 2005. Quantities sold, price/unit & Labour hours are as follows. What is the labour productivity for each car?

Deluxe Car
Ltd "

	Quantity	Rs/unit.
Deluxe Car	4,000 units sold	Rs. 3,20,000/c
Ltd "	6,000 " "	Rs. 4,00,000/c
Labour, Deluxe	20,000 hrs	Rs. 30/hr
" , Ltd	30,000 hrs	Rs. 40/hr

Soln: (Labour Productivity)$_{Deluxe}$ = Output/Labour = 1,28,00,00/6,00,0

= 2133.33 cars

(Labour Productivity)$_{Ltd}$ = Output/Labour = 6000 × 4,00,0/30,000 × 40

= 8 2000 cars

2. A US manufacturing company operating a subsidiary in a lesser developed country (LDC) shows the following results:

	US	LDC
Sales (units)	1,00,000	20,000
Labour (hours)	20,000	15,000
Raw material (currency)	$ 20,000	FC 20,000.
Capital equipment (hrs)	60,000	5000.

Find the Labour productivity of the companies.

Sol^n: (Productivity)$_{Labour}$ → US firm = $\frac{100000}{20000}$ = 5 units

→ LDC firm = $\frac{20000}{15000}$

= 1.33 units.

3. A firm generates revenue worth ₹80 crores in one year while total costs of prod^n is estimated to be ₹50 crores during this period. Determine its productivity.

Sol^n: $\text{Productivity} = \frac{O/P}{I/P} = \frac{₹80 \text{ crore}}{₹50 \text{ crore}} = 1.6.$

Jan/Feb 2015

4. Suppose a company produced 300 std book cases last week using 8 workers and 240 std book cases this week using 6 workers, in which week was productivity higher?

Date: / /20
Page No:

	Prod^n	Labour
Sol^n: Last week :	300	8
This " :	240	6

$$(\text{Productivity})_{\text{Last week}} = \frac{300}{8} = 37.5$$

$$(\text{Productivity})_{\text{This week}} = \frac{240}{6} = 40$$

∴ The productivity is higher this week.

Of recent times occurring presently

(*) CONTEMPORARY ISSUES AND DEVELOPMENT

→ Productivity is mostly influenced by the environment which the organization operates.

→ In earlier days, people were lesser concerned about the by-products of prod^n activities

→ They treated them as inevitable.

→ In more recent times, people have raised a voice of concern on the pollution of the environment by organizations.

→ The government also agreed to the drive against pollution of the environment. and as a result passed laws & regulations to safguard the same.

→ It is now the responsibility of every manager to study the environment in which his organisational functions and the impact of his organization on the society.

→ The figure below shows the environmental impacts on an organisation.

Interchanged

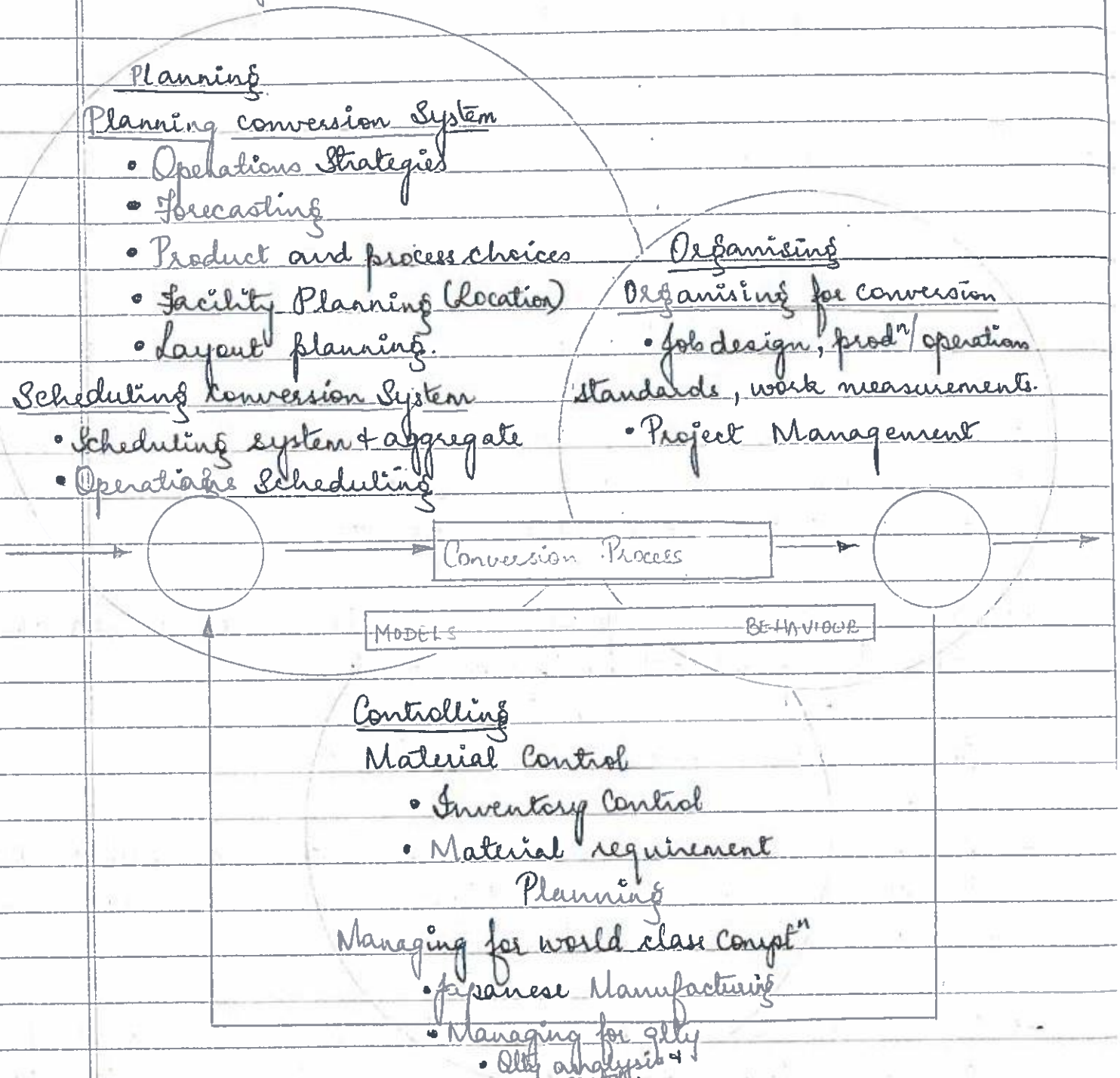


FIG: GENERAL MODEL FOR MANAGING OPERATIONS

Date: / /20
Page No:

→ Two factors affect the business plan of a firm:

1. Priorities from the external environment (external factors) → These are generally uncontrollable by the firm.
2. Firm's own capability (internal factors) to reach the goal.

→ Environmental factors are: (External)

1. Social factors
2. Political "
3. Economic "
4. Legal "
5. Technological factors.
6. ~~Supplier & Consumer Relationship~~

1. Social Factors:

* These include → Education
→ Employment Level
→ Culture of the society
→ Security
→ Communal attitudes
→ Poverty Level
→ Facilities available etc.

2. Political Factors:

→ Political stability of the country
→ Party policies towards globalization & liberali
→ Support towards joint ventures.

3. Economic Factors:

→ Economic stability of the contry

DI - An investment made by a co. or endowment in one country in business interests in another country in the form of establishing business operations or acquiring business assets such as ownership in a foreign co.

→ Country's policy towards Foreign Direct Investment (FDI)
→ Availability of raw materials, labour, technology etc.

4. Legal Factors :
→ Government grants
→ Subsidies
→ Tax structures
→ Environmental Regulations.
→ Rural Development. etc...

5. Technological factors.
→ Modes of transportation
→ Infrastructure facilities like water, power communicational skills, technical know-how
→ Ability to manufacture on their own.

→ Internal factors include:
1. Human Resource Skills.
2. Facilities available.
3. Financial Strength
4. Existing Product Base.
5. Technical Expertise
6. Supplier - Customer Relationship

1. HR skills :
→ Availability of cheap, skilled labour.
→ Provision of good working environment
→ " " Social infrastructure like housing and recreational facilities.
→ Incentives to boost Labourers morale.

Date : / / 20
Page No:

2. Facilities Available
→ Should be good enough to manufacture the product at a competitive cost with good qlty
→ Utilization of modern techniques and/or tools.

3. Financial Strength
→ Facilities should as much as possible be increased to global standards.

4. Existing Product Base.
→ There may either be a rise in demand for a particular product or an instability in the market due to intense competition from another firm manufacturing a similar product.

5. Technical Expertise :
→ A firm must have the required technical expertise in order to withstand the global competition.

6. Supplier - Customer Relationship
→ attending to customers problems.
→ Obtaining product feedback
→ Providing after sales services facility.

---

* A note on Scientific Management:

→ This era brought widespread changes to the management of factories.

→ This movement was spearheaded by the efficiency engineer & inventor Fredrick Winslow Taylor who is also called the father of Scientific Management.

→ F.W. Taylor believed in a "science of management". observation, measurement,

→ This included analysis and improvement of work methods and economic incentives.

→ Taylor's method emphasized on maximizing output.

→ His ways were not popular with workers, as they somethy thought that his method were to increase the output without a corresponding increase in compensation.

→ The cries and appeals of the workers were heard by the courts.

→ Taylor himself was called to testify in the year 1911.

→ The publicity of these hearings contributed to the growth of Scientific Management.

Date: / /20
Page No:

UNIT 2: DECISION MAKING

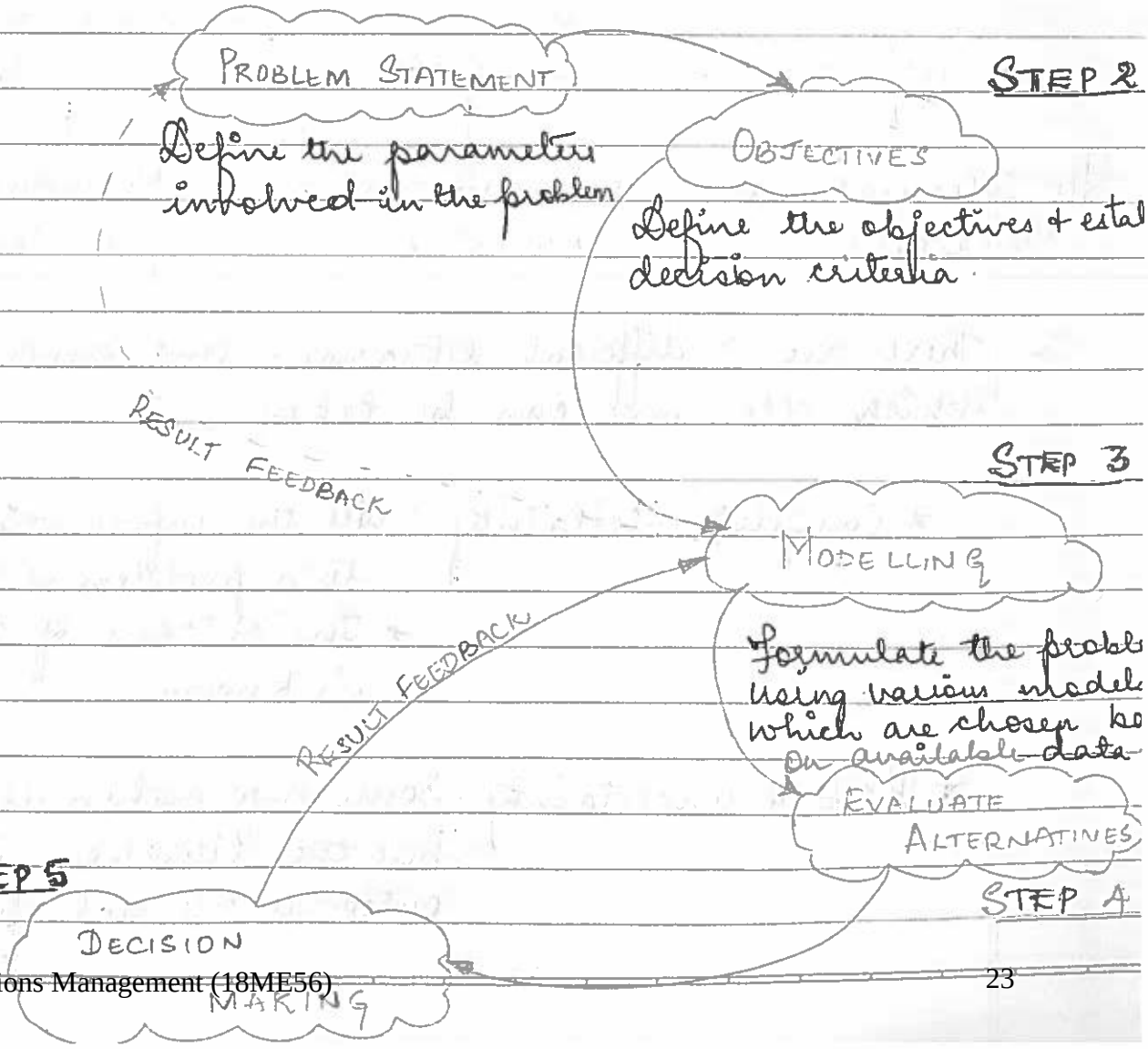
⊛ THE DECISION PROCESS

→ A decision is a choice that is made about something after thinking about it and considering all the factors related to it.

→ In an organisation, every aspect requires good decision making skills.

→ A schematic way of taking a decision can be outlined as follows:

STEP 1:

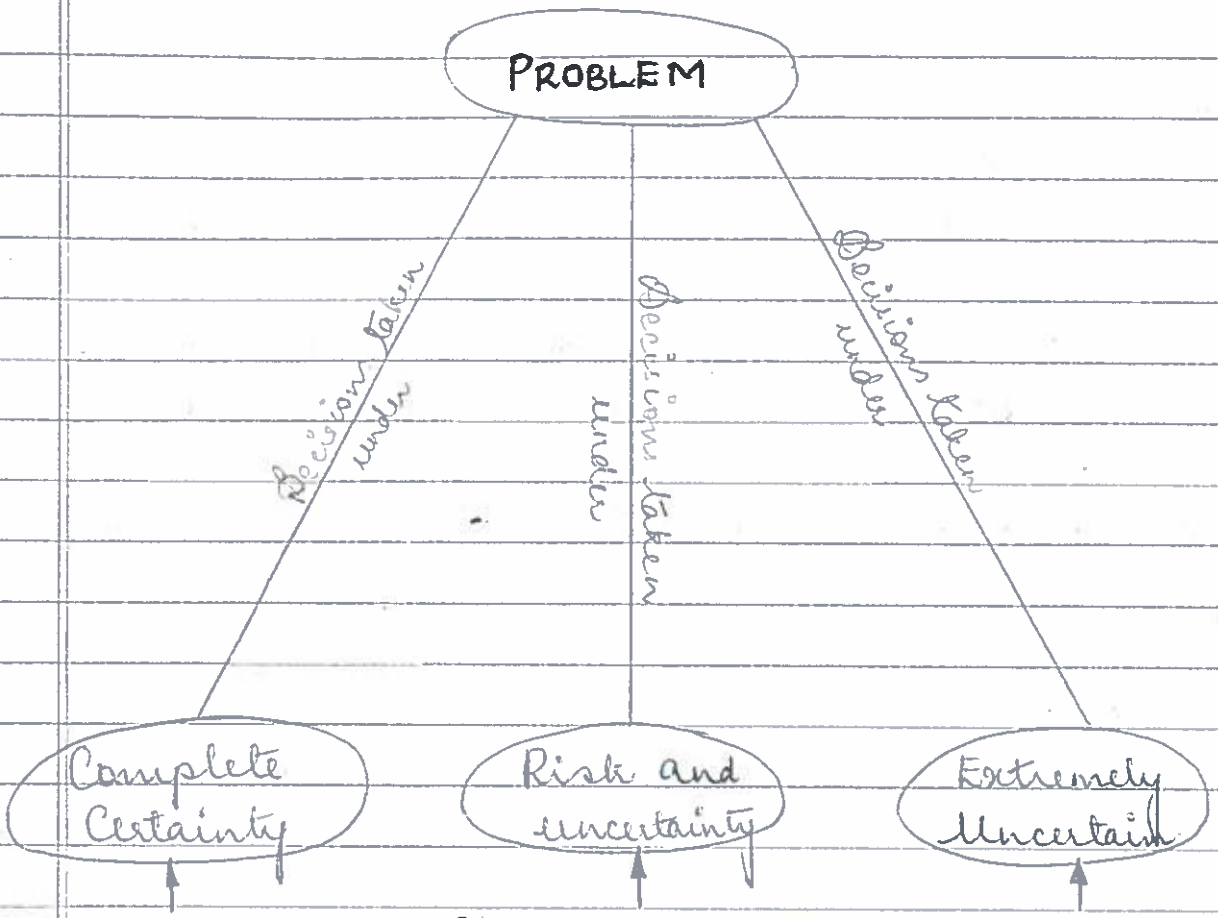


certainty : env. in which relevant parameters have known values

Risk : " " " certain future events have probable outcomes

Uncertainty : " " " it is impossible to assess the likelihood of various future outcomes

⊛ DECISION MAKING ENVIRONMENTS



→ There are 3 different situations and environments in which decisions can be taken:

* Complete certainty : All the information related to a problem is known.
  → The outcome of the decision is known.

* Risk & uncertainty : Some information is available but the situation is risky & outcomes are not fully known.

MERIT
Date: / /20
Page No:

★ Extremely Uncertain: No information is available & t outcome is not known.

→ Methods used to solve problems with complete certaint are:

- Algebraic models → Break even analysis
- Calculus
- Mathematical programming → Linear, non-linear integer, dynamic & g programming.

→ Methods used to solve problems with risk & uncertai are:

- Statistical Analysis
- Queuing Queueing Theory
- Simulation
- Heuristic Methods
- Network Analysis
- Utility Theory.

→ Methods to solve problems which are extremely uncertain are:

- Game theory
- Flip coin

⊛ CHARACTERICS OF BUSINESS DECISIONS

1. It should have been selected among various alternat
2. It should be rational.
3. " " " Consistent
4. " " " Cost-effective
5. " " " Systematic in nature
6. " " " Pragmatic (Opinionated & practical) in nature.
7. " " " give rise to self awareness.

USE OF MODELS

→ A model is an abstraction of reality, a simplified representation of something.

→ Eg: A toy car is a model of a real automobile with many of the visual features intact but it does not have a real engine and cannot transport people.

→ Other egs : Formulas, graphs & charts etc....

→ Models are sometimes classified into 3 types :

1. Physical Models: Look like the real life counterparts
   Eg: Miniature cars, airplanes, trucks, scale-model buildings.

2. Schematic Models: These are more abstract from their real life counterparts as compared to physica Models. → They have less resemblance to their physical counterparts
   Eg: graphs, charts, blueprints, pictures, drawings etc...

3. Mathematical Models: These are the most abstract
   → They have no resemblance to their real life counterparts.
   → Eg: Numbers, formulae & Symbols
   → These are the easiest to manipulate

→ Models are beneficial because:

1. They are easy to use, less expensive and deal directly with the situation.

Date: / /20
Page No:

2. The users organize and quantify information the need to be added.
3. They increase understanding of the problem.
4. " help managers to analyze the "what if" pro
5. Serve as a consistent tool for evaluation & provide a standard format for analyzing the problem.
6. They enable users to use the power of mathema to solve the problem.

→ The disadvantages of using models are:
1. Quantitative information may be emphasized more than Qualitative information.
2. They may be applied incorrectly & misinterpret
3. They do not guarantee good decisions.

→ The different types of models available are:
1. Economic Models
2. Statistical Models
3. Decision Tree Analysis
4. Graphical Linear Programming
5. Analysis & trade-offs
6. Decision theory & expec value criteria.

1. Economic Models.

→ This is a model that is used in completely certai situations.

→ The most commonly used economic model is the Break-even-analysis model.

→ BEA is an algebraic or graphic model relating cost

and revenues for different volumes of production.

→ It differentiates between profits and losses.

→ All costs are assumed to be known, and they may be Fixed or Variable.

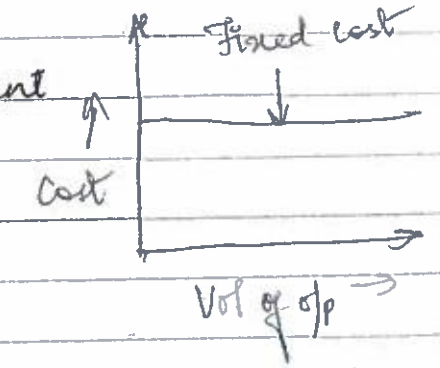
→ The assumptions made in BEA are as follows:
1. All costs & volumes are known
2. There is a linear relationship b/w cost & volume.
3. All output can be sold (Prod^n matches quantity)
4.

→ In this analysis the following terms are used:

1. FIXED COST (FC)

→ It is the cost which doesn't change with production volume or output.

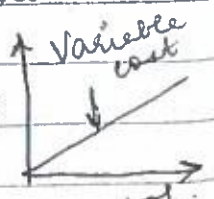
Eg: • Land & building cost
• Salaries to the management
• Insurance
• ~~Repairs~~ Depreciation
• Taxes



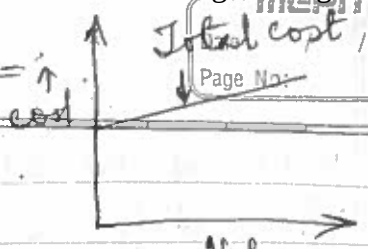
2. VARIABLE COST (VC)

→ This cost is that which is depends on the volume of output.

Eg: • raw material cost
• Labour
• Transport of finished product
• Packing costs etc...



3. TOTAL COST (TC)



→ It is the sum of FC and VC.

→ It is also called as the Manufacturing Cost.

4. PROFIT

→ It is the sales revenue received on selling the fi product subtracted from the Manufacturing Cost

Profit = Sales Revenue - Total Cost

$$\text{Profit} = TR - (FC + TVC)$$

5. BREAK-EVEN POINT

→ It is the volume of output at which the co and total revenue are equal.

$$Q_{BEP} = B.E.P = \frac{FC}{(\text{Selling Price} - \text{Variable Cost})}$$

→ When volume is < B.E.P ⇒ There is Loss
" " > " ⇒ " " Profit

→ Deviation from this point leads to greater prof greater loss).

$$Q_{BEP} = \frac{FC}{(\text{Total Sales revenue} - \text{Total Variable Cost})}$$

where

$$\text{Selling Price} = FC + VC \times Q$$

$$Q = \frac{FC}{P - VC}$$

6. MARGIN OF SAFETY:

→ The difference between the actual output of a plant to the break even output is called the Margin of Safety.

→ Higher margin of safety → More profit
Lower " " " → Less "

$$\% \text{ Margin of safety} = \frac{\text{Actual o/p} - \text{Break Even o/p}}{\text{Actual o/p}}$$

7. ANGLE OF INCIDENCE (θ)

→ It is the angle between the sales revenue line & the total cost line, represented by θ.

→ Higher value of θ → Higher Profit to the company.

→ This usually takes place when the BEP is at a lower level.

8. PROFIT VOLUME RATIO (P/V RATIO)

→ The ratio of the contribution to total sales revenue or turnover of the company.

→ The profitability of different products can be measured using this.

→ Higher the P-V ratio → Higher the profit.

$$\text{P/V ratio} = \frac{\text{Contribution}}{\text{Total sales revenue}} \times 100.$$

$$= \frac{\text{Total Sales revenue} - \text{TVC}}{\text{Total sales revenue}} \times 100$$

Date : / / 20
Page No:

9. CONTRIBUTION

→ The difference between the total revenue and the tot cost is called Contribution.

→ For maximum profit, the contribution should alway be higher than the fixed cost.

Contribution = Total Sales Revenue - Total variable Cost
= TSR - TVC.

(*) Advantages of Break-even analysis

1. The SP of a product can be fixed easily
2. The method is simple and easy to visualize
3. It focuses on profits
4. Decision making is possible
5. Algebraic & graphical methods of display can be obt

(*) Limitations of Break-even analysis

1. The assumptions made may not be practical.
2. Suitable when the decision to be made is on a sing factor.

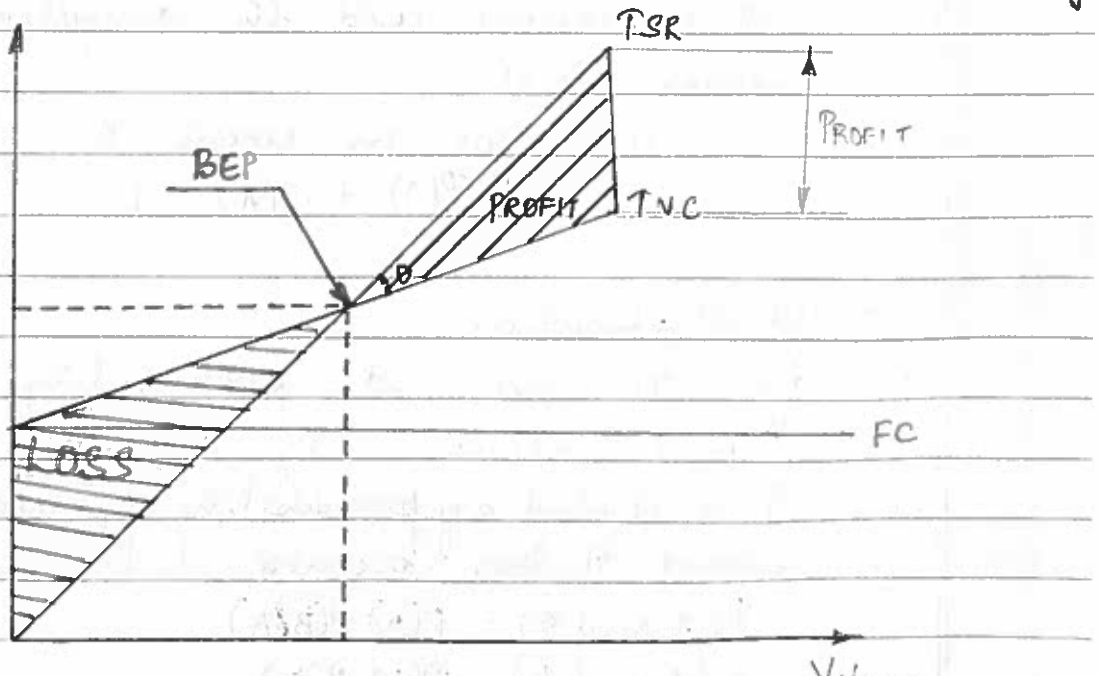


Fig. Terminologies used in BEA

2. Statistical Models

→ These models are based on probability theory.

→ They are used to measure uncertainty.

→ The different rules of probability that are used to solve uncertainty are:

- Probability Rules
- Discrete and continuous distribution.

- **Probability Rules**

→ Assuming A & B to be two events:

1. Complement:

* In this case, two events are assumed to be complementary to each other.
* Eg: If the outcome required is heads in a coin toss event, its complement is tails.
* According to this rule, the sum of the probabilities of an event and its complement must be equal to 1.

i.e for an event A,

$$P(A) + P(\bar{A}) = 1$$

2. Multiplication:

* In this rule, the probability that both events A and B occur is equal to the probability of event A occurance multiplied by probability of event B occurance, assuming event A has occured.

$$P(A \text{ and } B) = P(A)\,P(B/A)$$

$$P(A \text{ and } B) = P(A)\,P(B)$$

MERIT
Date: / /20
Page No:

3. Addition:

★ According to this rule, when 2 events A & B a mutually exclusive, the probability that event A or B occurs is given by the sum of the probabilities of each event.

$$P(A \text{ or } B) = P(A) + P(B)$$

Dependent

$$P(A \text{ or } B) = P(A) + P(B) - P($$

★ Eg: On a die, what is the probability of rolling a 2 or 5.

$$P(2) = \frac{1}{6} \qquad P(5) = \frac{1}{6}$$

$$P(2 \text{ or } 5) = P(2) + P(5) = \frac{1}{6} + \frac{1}{6} = \frac{1}{3}$$

4. Baye's Theorem:

★ This theorem describes the probability of an event, based on prior knowledge of condition that are related to the event.

★ If the events are A & B then, . . .

P(A|B) denotes the conditional probability o event A occuring, given that B oc

P(B|A) denotes the conditional probability & event B occuring, given that A o

P(A) is called the marginal or "prior" pro probability of A because it does not consider any information of B.

P(B) is called marginal probability of B

∴ Conditional Probability = P(A|B)

$$P(A|B) = \frac{P(A \text{ and } B)}{P(B)}$$

$$\boxed{P(A|B) = \frac{P(A|B)\,P(A)}{P(B)}}$$

• Discrete and continuous distribution.

→ Discrete data are countable in nature. Eg: defective items

→ These are expressed in proportions of 'π'.

→ Continuous data are measurable in nature. Eg: Time.

→ These are expressed in proportions of 'μ'.

→ To get discrete probabilities, sum of individual prob. is needed

→ " " continuous " , integration of area under a continuous probability function is needed.

3. Decision theory and expected value criteria

→ Data in this model are expressed in the form of a payoff matrix.

→ The criteria used are:

1. Maximax → Selection of alternative is on 1st payoff
2. Minimax → " " " " worst "
3. Laplace → " " " avg. payoff.

→ Choosing best among the least.

4. Decision tree analysis

→ A decision tree is a schematic representation of a problem along with its alternatives and their possible consequences.

→ The steps for constructing a decision tree is as follows:

MERIT
Date: / / 20
Page No:

1. TREE DIAGRAMMING.

→ In this, Sequence of decisions and events flow from LEFT to RIGHT.

→ The following steps are followed:
- Identify all the decisions and the order in which they occur.
- Identify alternative decision points for each decisi point.
- Identify the chance events occuring after each decision.
- Develop the tree diagram showing the sequence of decisions & events.

2. ~~EXPLANATION~~ ESTIMATION

→ In this step, the outcomes & probabilities of each event is estimated.

~~Risk Risk~~

→ Whenever a chance event occurs in a diagram, probabi estimates are needed.

→ The sum of the events probabilities is = 1 (always)

→ The following steps are followed:
- Estimate the probability for each possible outcome of each event.
- Estimate the financial outcome & consequence o each possible outcome of each event. (alternati

3. EVALUATION AND SELECTION.

→ Expected values of all possible actions are calculated.

→ This calculation is done starting from the right most node of the diagram and then working backward towards the left of the diagram.

→ Following steps are followed
- Calculate expected value for each decision alternative
- Select the alternative which gives the best expected value.

Example of decision tree analysis.

1 For the pay off table shown below, find the expected monetary value of each alternative in the table & identify the best alternative with a probability of 0.60 for a new bridge and 0.40 for no new bridge.

Alternative	Capacity for new Bridge	New Bridge	No new bridge
	A	1	14
	B	2	10
	C	4	6

where A = Small
B = Medium
C = Large

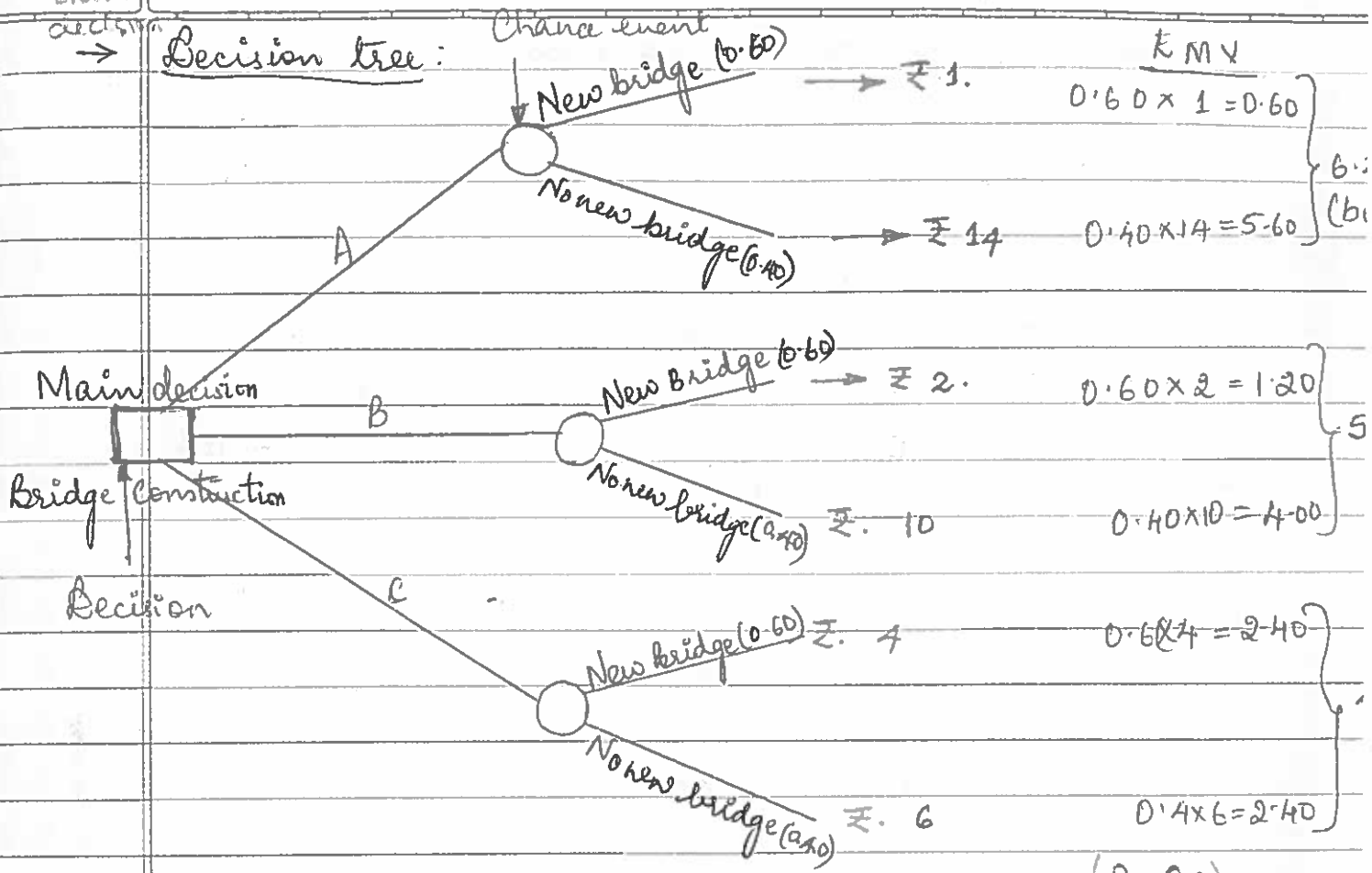
Construct a decision tree for the problem showing the EMV.

EMV is calculated by multiplying the probability with the pay off values.

∴ EMV for A : 0.60 (1) + (14)(0.40) = 6.20 → Best
" " B : 0.60 (2) + (10)(0.40) = 5.20
" " C : 0.60 (4) + 6 (0.40) = 4.80

Date: / /20
Page No:

→ Decision tree:



→ ~~Probability of~~ Other problems from text book (Pg 69)

→ Therefore, the best EMV occurs from capacity A & no new bridge constructed giving an EMV of ₹ 5

5. Graphical Linear Programming.

→ This method uses an LP to be solved in graphic form to give the required solution to the problem

→ This LP can be formulated in 2 ways.

1. Standard Form: Max. $Z = c_1x_1 + c_2x_2 + \cdots + c_nx_n$

s.t $a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n + s_1 = b_1$

$a_{21}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n + s_2 = b_2$

$\vdots$

$a_{m1}x_1 + a_{m2}x_2 + \cdots + a_{mn}x_n + s_n = b_m$

where, $x_1, x_2 \ldots S_1, \ldots S_n \geq 0$.

2. Matrix form

$$\text{Max. } Z = cx^T$$
$$\text{S.T } AX = b, \quad b \forall 0, \quad x \forall 0$$
$$\text{where } X = \{x_1, x_2 \ldots x_n, S_1 \ldots S_n\}$$
$$c = \{c_1, c_2 \ldots c_n, 0, 0 \ldots 0\}$$
$$b = \{b_1, b_2 \ldots b_n\}$$

$$A = \begin{bmatrix} a_{11} & a_{12} \cdots a_{1n} & 1 & 0 & 0 \\ a_{21} & a_{22} \cdots a_{2n} & 0 & 1 & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{m1} & a_{m2} \cdots a_{mn} & 0 & 0 & 1 \end{bmatrix}$$

where x includes all the variables and
c " " " constants (coefficients in the objective function).

Example

Old hens can be bought at ₹ 2 & young ones at ₹5. The old hens lay 3 eggs/week & young ones 5 eggs/wk. each egg worth 30 paise. A hen costs ₹1/wk to feed. I have only ₹80 to spend for hens, how many of each kind should I buy to give a profit of more than ₹6 per week assuming I can not house more than 20 hens?

Soln:

Total gain =

~~Let no of old hens x_1~~

Old hen gain = $3x_1$ / per week

New " " = $5x_2$ / wk

MERIT
Date : / /20
Page No:

Total gain = $(3x_1 + 5x_2) \times 0.30$ per week
& expense = $1(x_1 + x_2)$ per week.

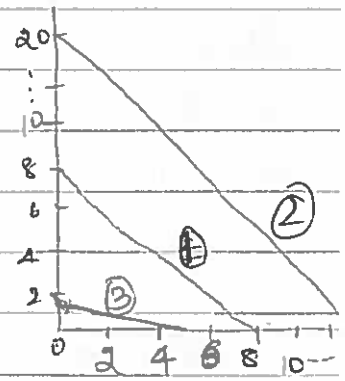
Profit $Z = 0.30(3x_1 + 5x_2) - (x_1 + x_2)$
$= 0.9x_1 + 1.5x_2 - x_1 - x_2$
$= -0.1x_1 + 0.5x_2$
$= 0.5x_2 - 0.1x_1$

Max. $Z = 0.1x_1 - 0.5x_2$
s.t $2x_1 + 5x_2 \leq 80$ $0.5x_2 - 0.1x_1 \leq 6$
$x_1 + x_2 \leq 20$
$x_1, x_2 \geq 0$

Solving graphically,

(1)
$2x_1 + 5x_2 = 80$
$2x_1 = 16$
$x_1 = 8$
$5x_2 = 40$
$x_2 = 8$

(2)
$x_1 + x_2 = 20$
$x_1 = 20$
$x_2 = 20$



~~Max. $Z = 0.5(20) - 0.1(20)$~~
$0.5x_2 - 0.1x_1 \leq 6$
$0.5x_2 - 0.1x_1 = 6$
$0.5x_2 = 0.1x_1$
$\frac{x_2}{x_1} = \frac{5}{1}$ $\therefore x_1 = 5, x_2 = 1$

Z line cuts at (0, 16)
$\therefore Z = 0.5 \times 16 - 0.1 \times 0 = 8$

$\therefore$ 16 young hens should be bought to get max profit.

) A balancing of factors all of which are not accomplished at the same time.

D) C- Analysis and Trade-offs. [Exercise]

→ A trade-off exists when an organisation cannot perform simultaneously on two dimensions.

→ In order to increase the performance on one dimension, it should decrease performance on another dimension.

→ A balance achieved between two desirable but incompatible features; a compromise — is called a Trade-off.

→ Eg: A trade-off between objectivity and relevance.
Choice of car, choice of house, food, investment.

PROBLEMS

1. A manufacturer of farm equipment is considering 3 locations A, B & C for a new plant. Cost studies show that fixed cost per year at the sites are ₹2,40,000, ₹2,70,000 & ₹2,52,000 respectively, whereas variable costs are ₹100/unit, ₹90/unit & ₹95/unit respectively. If the plant is designed to have an effective system capacity of 2500 units/yr & is expected to operate at 80% efficiency, which is the most economical location based on their actual output.

Sol": → Total annual cost for location A

$TC = FC + VC \times Q \times \eta$ ₹

$= 2,40,000 + 100 \times 2500 \times 0.8$

$= ₹4,40,000.$

→ Total annual cost for location B

$TC = FC + VC \times Q + \eta$

$= 2,70,000 + 90 \times 2500 \times 0.8 = ₹4,50,000.$

Date : / / 20
Page No:

→ Total annual cost for location C

$TC = FC + VC \times Q \times \eta$

$= 252000 + 95 \times 2500 \times 0.8$

$= ₹\ 1,42,000.$

→ Therefore the best location is Location A.

* * * * * * * * * * *

? Bayes' theorem $P(\alpha) = P(\beta)\, P(\alpha/\beta) + P(\bar{\beta})\, P(\alpha/\bar{\beta})$

$P(d) = \frac{40}{400} = 0.1$

$P(x) + P(y) = 1$

$P(y) = 1 - P(x)$

$P(y) = 0.5 \qquad P(x) = 0.5$

$P(d \text{ and } x) = P(d)\, P(x/d)$

$= (0.1)\ (0.4) = 0.04$

$P(d \text{ or } x) = P(d) + P(x) - P(d \text{ and } x)$

$= 0.1 + 0.5 - 0.04$

$= 0.56.$

2. Potential locations in A, B and C cities have the cost structures shown below for a product expected to sell for ₹ 130/-

Potential Locations	Fixed cost	Variable cost/yr
A	150000	75
B	200000	50
C	400000	25

(i) Find the best economic location for an expected volume of 6000 units/yr.
(ii) What is the expected profit if the selected option is used?
(iii) For what output range each location is best?

Sol?: → Best economic location

Total cost for location A ⇒ $TC = FC + VC \times Q = 150000 + 75 \times 6000$
$= ₹.\ 6,00,000$

Total cost for location B ⇒ TC = ₹. 5,00,000

Total cost for location C ⇒ TC = ₹. 5,50,000

∴ The best economic location is B.

(ii) Expected profit

Sales revenue = Selling price × Q
$= 130 \times 6000$
$= ₹.\ 7,80,000/-$

Profit = Sales revenue − Total cost for selected option (Location B)

Profit = 7,80,000 − 5,00,000 = ₹ 2,80,000.

(iii) Output for each location.

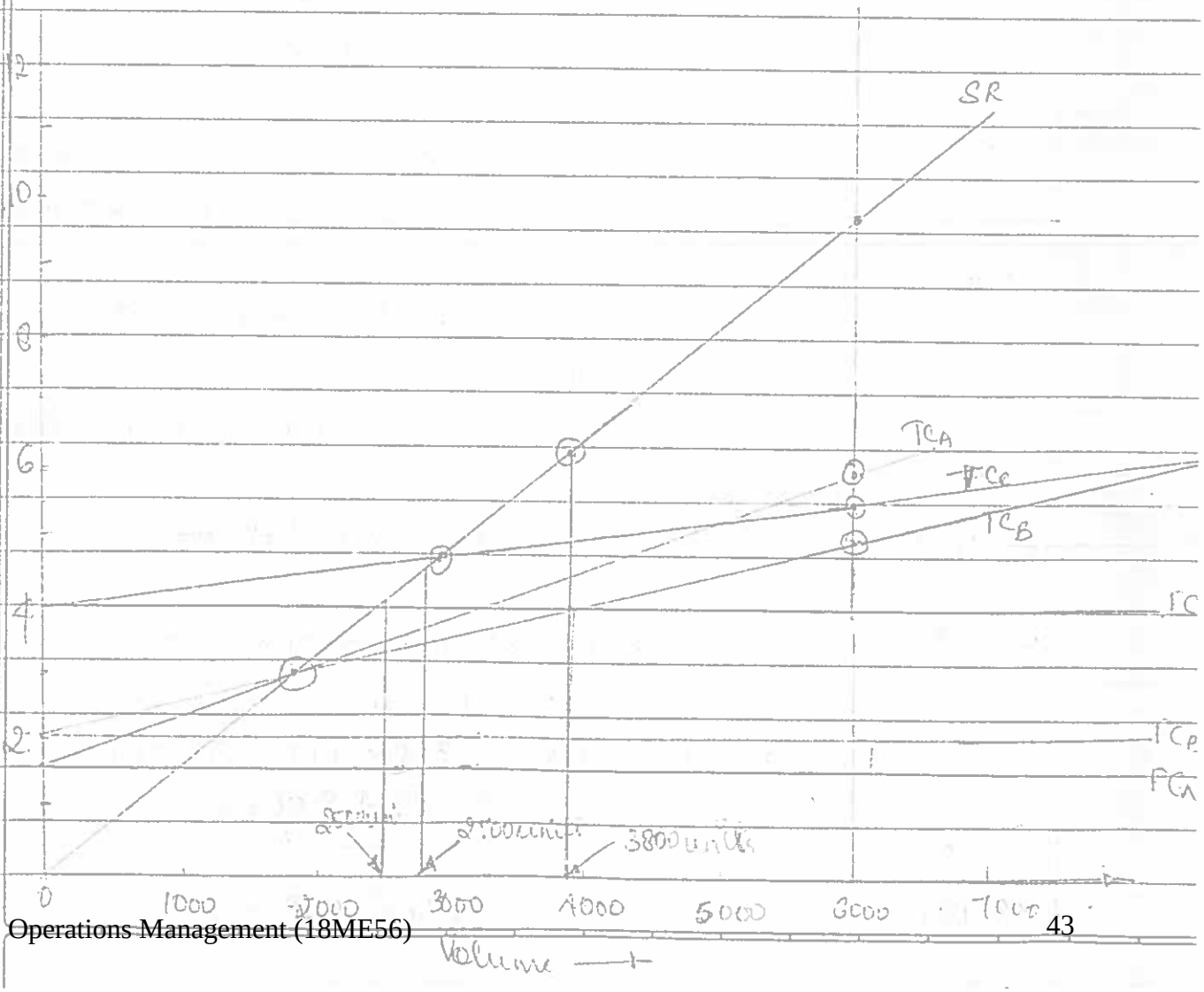
P = 8 P/unit.

Q_{BEP} for location A = $\frac{FC}{P - VC} = \frac{1500000}{130 - 75}$

$= \frac{30000}{11} = 2727.27 \cong 2727$ units

Q_{BEP} for location B = $\frac{200000}{130 - 50}$ = 2500 units.

Q_{BEP} for location C = $\frac{100000}{130 - 25} = 3809.52 \cong 3810$ unit



3. A computer company is evaluating 3 cities for a new plant to manufacture hardware components which will sell @ ₹. 170/- each. The economic portion of a plant location study shows the following cost and market data. *(For 6000 units)*

Cost data:

Cities	A	B	C
Fixed cost/yr in ₹1000.	300	200	150
Variable cost/unit	30	45	65

Market data:

Volume (x)	Probability - P(x)
4500	0.10
5500	0.30
6500	0.60

(i) On the basis of maximizing an economic expected value, graph the plant location curve (cost) using appropriate scale.

(ii) Which city should be selected on the basis of given volume estimate (from graph)?

(iii) What is the break-even volume for the city selected?

?: (i) Volume estimate, (from market data)

$$\Sigma x\,p(x) = 4500 \times 0.1 + 5500 \times 0.30 + 6500 \times 0.60$$
$$= 6000 \text{ units.}$$

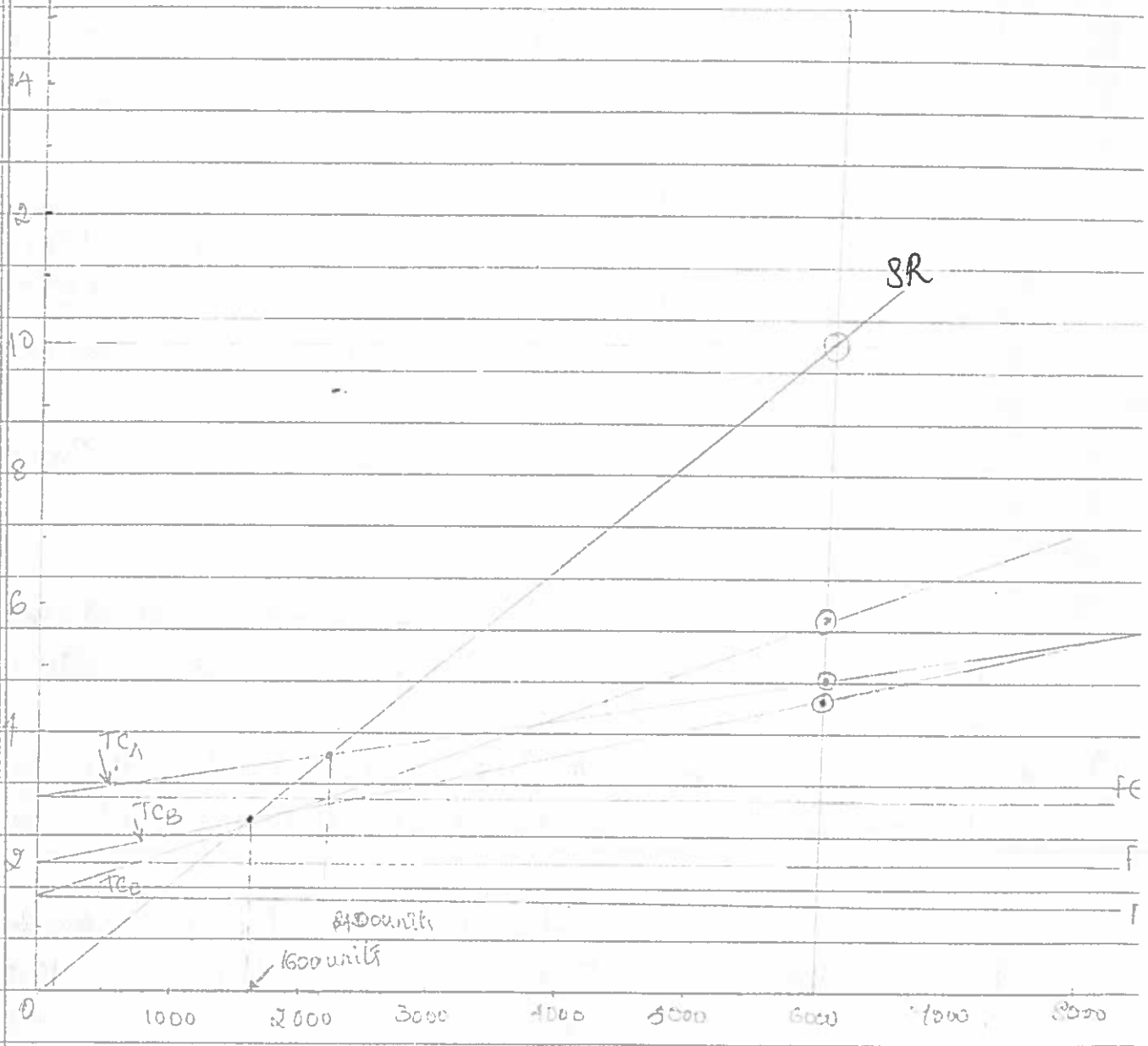
(ii)

$$(TC)_A = FC + VC \times Q = 300 \times 1000 + 30 \times 6000$$
$$= ₹\ 4,80000.$$

(iii)

$$(TC)_B = 200 \times 1000 + 45 \times 6000 = ₹.\ 4,70000$$

$(T_C)_C = 150 \times 1000 + 65 \times 6000 = ₹\ 5,40,000$



$\{SR = SP * Q = 170 \times 6000 = ₹\ 10,20,000\}$

(ii) → B is the best location.

(iii) → Break-even volume for city B.

$$Q_{BEP} = \frac{FC}{P - VC} = \frac{200 \times 1000}{170 - 45} = 1600 \text{ units}$$

From the graph = 1600 units [where T_C meets SR]

4. An equipment supplier has collected the following data on possible plant locations. The cost are given in ₹ per year.

	Locations A	Location B	Location C.
Rent & Utilities	10000	12,000	15,000
Labour	95,000	80,000	90,000
Taxes	2000	1500	1000
Materials	1,30,000	1,32,000	1,27,000
Community Services	Good	Poor	Average
Community Attitude	Indifferent	Indifferent	Favourable.

If you were responsible for making decision on the basis of the given information which site would you prefer and why?

Sol^n: → The rent, ~~Labour~~ & Taxes constitute the fixed cost. Material & labour constitute the variable cost.

	Location A	Location B	Location C.
Rent & Utilities	10,000	12,000	15,000
Taxes	2000	1500	1000
Fixed Costs	12,000	13,500	16,000
Labour	95,000	80,000	90,000
Materials	1,30,000	1,32,000	1,27,000
Variable costs	2,25,000	2,12,000	2,17,000
Total costs	2,37,000	2,25,500	2,33,000

→ TC for A = ₹ 2,37,000 → Highest cost
" " B = ₹ 2,25,500.
" " C = ₹ 2,33,000.

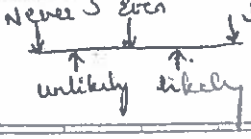
Date : / /20
Page No:

→ Location A → Highest Total Cost
Indifferent community attitude
∴ Rejected

Location B → Higher Lower TC than Location C
Indifferent Community attitude
∴ Rejected.

Location C → Higher TC than B
But average community service & favourable attitude
∴ C is selected.

PROBLEMS CONTINUED AT THE BACK



UNIT 4 : FORECASTING.

(*) INTRODUCTION

→ Managerial decision making is often a complex process due to the element of uncertainty that exists in the variables affecting the decision making process.

→ If an organisation is planning on the launch & introduction of a new product, there are various aspects to be considered before the launch of the product like demand in the market etc... which are not known with certainty.

→ If a hospital administration team is planning on the addition of a new wing in the hospital, they need to consider the kind of services that would be offered and the customer demand for those services.

→ Since these decisions involve cash flow, time for arrangements / changes in existing set up, making various resources available etc.. a good estimate of the future is required to be made.

→ The branch of OM that provides a manager with tools and set up techniques to carry out this process is 'Forecasting'.

→ A 'forecast' is a statement about the future value of a variable of interest.

Difference b/w forecasting & prediction → Prediction is indicating that something will happen with or without

Calculation/estimation of a future event using data from the past, prior data & information.

Date: / /20
Page No:

→ The estimation of the future demand for products/services and the resources needed for these output is called 'Forecasting'. Eg: Weather forecasting, game or political outcomes, Coin toss, roll of dice, lottery

(*) STEPS IN THE FORECASTING PROCESS

→ There are 7 basic steps involved in the forecasting processes:

1. Determine the purpose of the forecast (objective) Healthcare
→ This answers the questions: How will it be used?
When will it be needed?

→ It determines the level of detail required to carry out the forecast.

→ The design model, the amount of resources (personnel, computed time, money etc...) have to be justified and the level of accuracy required.

2. Select the items for which the forecast is to be carried out (what kind of healthcare)
→ This depends on whether the forecast is being carried out for a single product or for a group of products or production line.

3. Determine the time horizon → clinic, hospital, multi-specialty
→ • Short-term forecasting
• Medium- " "
• Long- " "

→ This is done in order to know if the forecast should be done monthly, quarterly or yearly.

4. Select a forecasting model or technique.
→ Quantitative * These use statistical models like moving averages, regression models or exponential smoothing.

→ Qualitative * These use judgemental / market research methods and surveys.

5. Obtain, clean and analyze the data received
→ Before forecasting, data should be obtained

→ This data should be cleaned to get rid of outliers (redundant) data and incorrect data before analysis

6. Prepare the forecast
→ This is done using the selected method. [from the previous method]

7. Monitor the forecast.
→ To check if the forecast is performing correctly or not.

→ If not carry out a review of the method in use, assumptions made, validity of the data etc... and modify the forecast as needed and prepare a revised forecast.

(*) APPROACHES TO FORECASTING
→ There are 2 General approaches to forecasting:

Qualitative and
Quantitative

Date: / /20
Page No:

Qualitative	Quantitative (How it looks)
→ Involves soft data or info which cannot be quantified	→ Involves hard data or info which can be quantified
→ Involves only subjective data and inputs which defy precise numerical description Demand, Expert opinions suggest that the market will behave a certain way.	→ Involves either projection historical data or developm of associated models that u casual variables to make forecast.
→ Eg: Human guesses, assumptions, expert opinions etc....	→ Eg: Hard data copies of historical events

→ Based on the above two basic general approaches, forecasting can be:

Judgemental Forecasts	Time Series Forecasts	Associative Mod
• Rely on subjective I/ps obtained from market surveys, consumer surveys, opinions from sales staff, experts, managers etc...	• They project pattern identified in recent times. This projection is a projection of the past model experience into the future. • Use of historical data with the assump-tion that the future will be like the past. • Used to identify specific patterns in the data.	• These use explanatory variables to pr future demand eg: demand f paint → • price/gall • advertising • drying time • ease of clea

Judgemental Forecasts

→ Based on judgement and opinion

* In some cases, forecasters rely only on judgement and opinion to make forecasts.

* This is mainly in cases where the management needs to prepare quick forecasts with less time to gather and analyse quantitative data.

* It also prevails during change in economical and political situations where available data may be obsolete and more recent and up-to-date information may not yet be available.

* Another situation is when there is either an introduction of a new product or a redesign of an existing product or packaging suppa the system may undergo a loss of history or data that would be useful in forecasting.

* In such instances, forecasts are based on the following:

(a) Executive Opinions
(b) Salesforce Opinions
(c) Consumer Surveys
(d) Other approaches

(a) Executive Opinions

→ In this type of forcasting, a group of managers which belongs to the upper level management (eg; marketing managers, operations managers, finance managers) meet and collectively develop a forecast.

Date: / / 20
Page No:

→ This is generally used in long-range planning an new product development.

→ Its advantage is that it brings together the conside - able knowledge & talents of various managers.

→ It also, however, has a risk that the view of one person may prevail.

→ Diffusing responsibility for the forecast over the gro may result in less pressure to produce a good fore

(b) Salesforce Opinions

→ Salesforce members comprise of marketing executives, Sales staff and customer service staff.

→ These members of the organisation are in direct conta with the customers.

→ This makes them aware of any plans the custome may be considering for the future.

→ There are several drawbacks to this procedure.

* Staffs may not be able to distinguish between what the customers would like to do and what the customers actually will do

→ These people are sometimes overly influenced by experien and may be biased.

→ If the sales are low, their opinions may become pessimi Good, opini

(c) Consumer Surveys

→ Input is taken from consumer because the demand is determined by them.

→ In some cases, each customer & potential customer can be contacted but this is not possible in the case of large companies.

→ In the latter case, 'Sample' consumer opinions are considered.

→ The major advantage of using consumer opinions is that information which may not be available elsewhere can be tapped.

→ A good amount of knowledge and skill is reqired to design the survey, administer it & interpret its results.

→ Also, collecting information is a tedious process.

(d) Other Approaches

→ Another approach is called the 'Delphi Approach'.

→ This is an iterative process intended to achieve a consensus forecast.

→ In this method the managers and staff complete a series of questionnaires, each developed from the previous one to achieve a consensus forecast.

→ This method provides an anonymised summary of the forecast given by experts

PART - B

UNIT - 7: MATERIAL REQUIREMENT PLANNING

⊛ INTRODUCTION

→ Material Requirement Planning (MRP) is a planning & scheduling technique that is used for batch prod^{n} of assembled items.

→ The raw materials, purchased parts and other components of assembled items are subject to what is called as 'Dependent Demand'.

→ The concept of MRP particularly deals with the managem of dependent demands & its other components

⊛ DEPENDENT VERSUS INDEPENDENT DEMAND

→ When the demand for an item arises from the plans to make certain products, as in raw materials, spare parts and assemblies - that constitute a finished product, that item is said to have 'Dependent Demand'

→ Eg: Parts & raw materials involved in the production of an automobile are in dependent demand because the total no. of these is a function of the number of automobiles that will be produced.

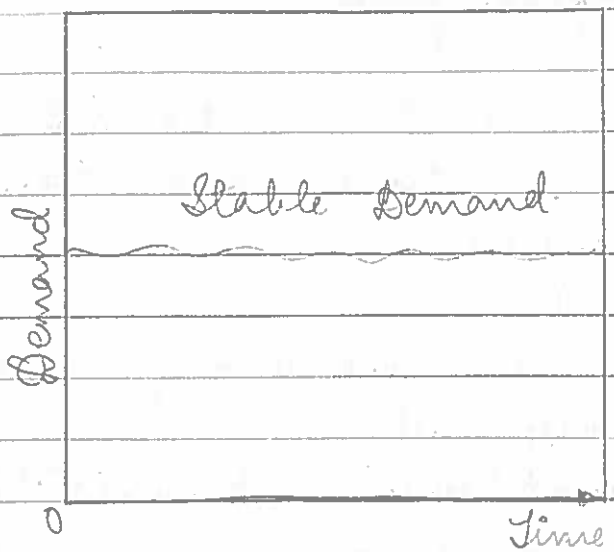
→ Independent demands are stable in nature while depende demands are Sporadic in nature (irregular).

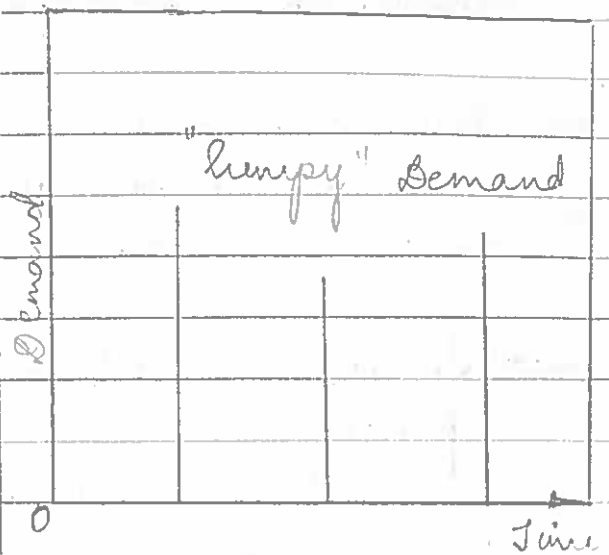
→ The demands that are independent in nature are those which are generally the final products.

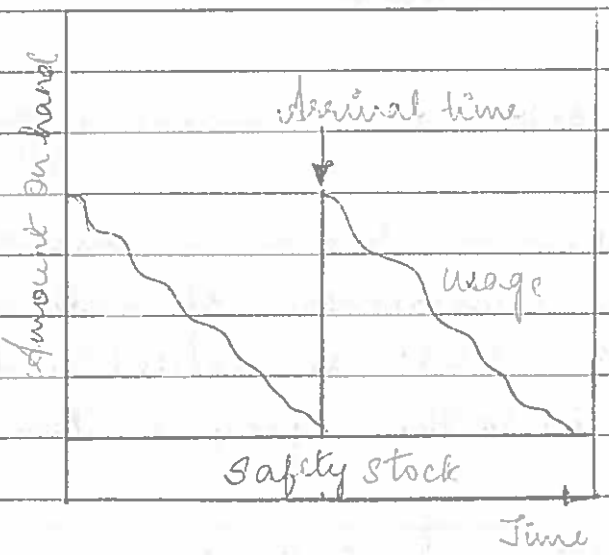
→ Independent demands do not depend on or are not functi of any other demand.

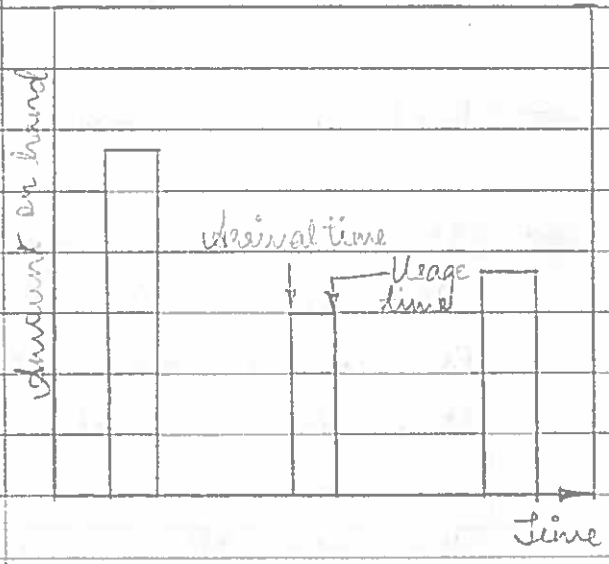
Date : / /20
Page No:

Independent Demand	Dependent Demand









Required on a continuous basis	Requirement is not continuous; stocked only when required.
Safety stock is required	No need for safety stock

An Overview Of MRP

MRP is a computer based information system that translates the finished product requirements of the master schedule into time-phased requirements for sub assemblies, raw

materials and component parts.

→ The requirement for end items determine the requirement for low-level items which are broken down into time periods.

→ In the past, ordering and scheduling of assembled products faced 2 difficulties:
1. The scheduling task which was tedious
2. The lack of differentiation between dependent & independent demand.

→ MRP starts with a schedule for finished goods.

→ It then works backwards converting this schedule into a schedule for requirements of subassemblies, components, & raw materials that are needed to produce the finished items in the specified time frame.

→ Therefore, MRP is designed to answer:
WHAT is needed?
HOW MUCH is needed?
WHEN is it needed?

→ The flow chart below gives an overview of MRP.

→ The primary input of MRP are a 'Bill of Materials'.

→ These give the composition of a finished product;

→ The next is the Master Schedule and the inventory records file.

Date : / /20
Page No:

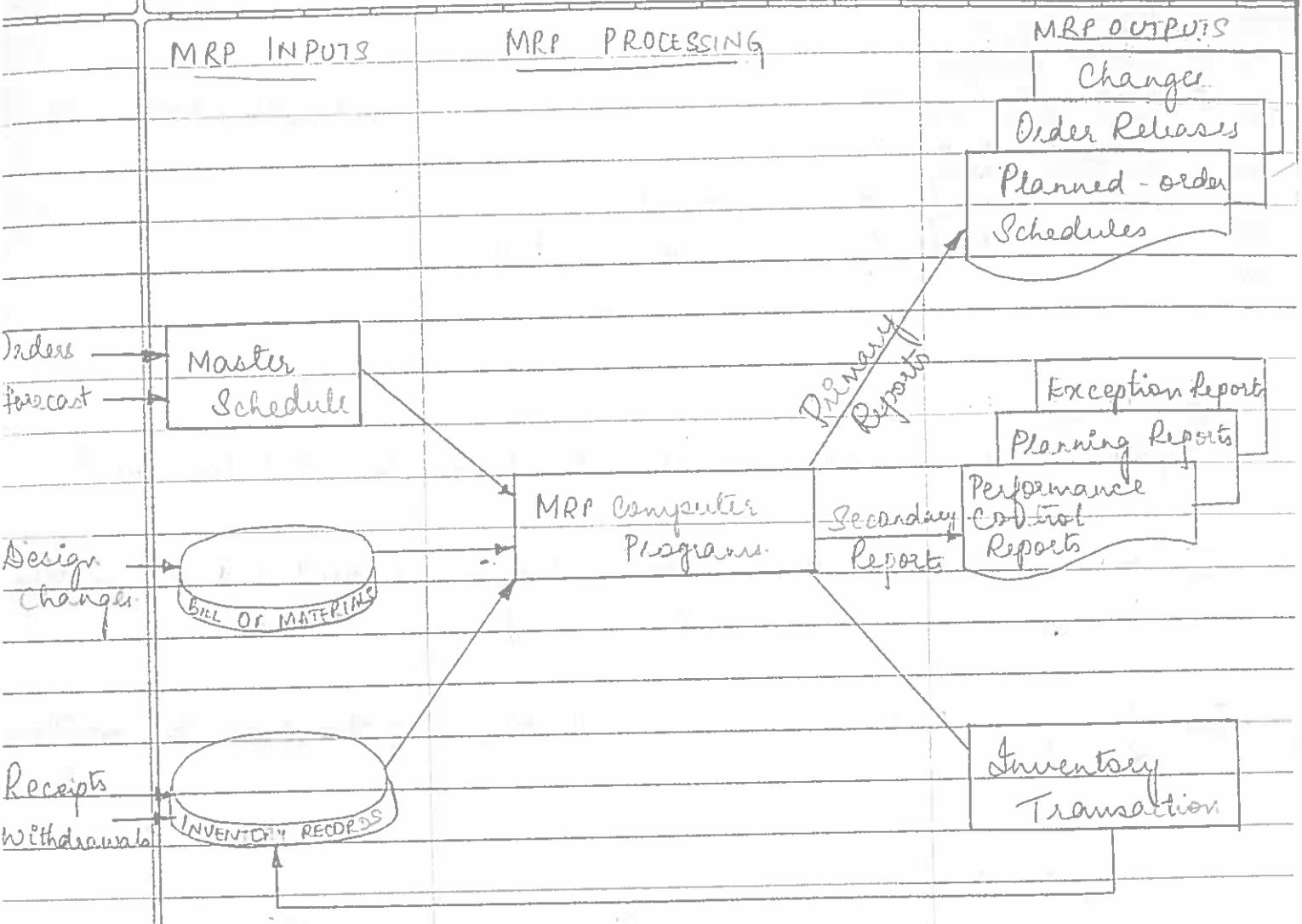


FIG: OVERVIEW OF MRP

INPUTS

Bill of Materials → Composition of the finished produ

Master Schedule → How much of the finished prod and when it is needed.

Inventory Records file → How much inventory is needed & how much is on hand & what amount should be procured.

* MRP INPUTS

→ An MRP system has 3 major inputs (3 major sources of information).

1. A Master Schedule
2. A Bill of Materials File
3. An inventory Records File.

⊛ THE MASTER SCHEDULE

→ It is also called the Master Production Schedule (MPS).

→ This states which end items are to be produced, when they are needed and in what quantities.

→ The figure below shows a portion of the MPS for an item X.

Week number

Item : X	1	2	3	4	5	6	7	8
Quantity				100				150

FIG: MASTER SCHEDULE FOR PRODUCT X

→ This schedule that 100 units of X will be needed at the start of week 4 and another 150 units will be needed at the start of week 8.

→ The Master Schedule separates the planning horizon into a series of time periods or 'Time Buckets', which are often expressed in weeks & later scaled to months & y

→ The MS should cover the stacked time or 'Cummulati Lead time' which is the sum of the lead times that the sequences of a process require from the ordering of parts and raw materials till the completion of the assem

Date: / /20
Page No:

(*) THE BILL OF MATERIALS

→ It is one of the 3 primary inputs to the MRP system.

→ It contains a listing of all the assemblies, subassemblies, parts, and raw materials that are needed to produce one unit of a finished product.

→ Therefore, each finished product has its own BOM.

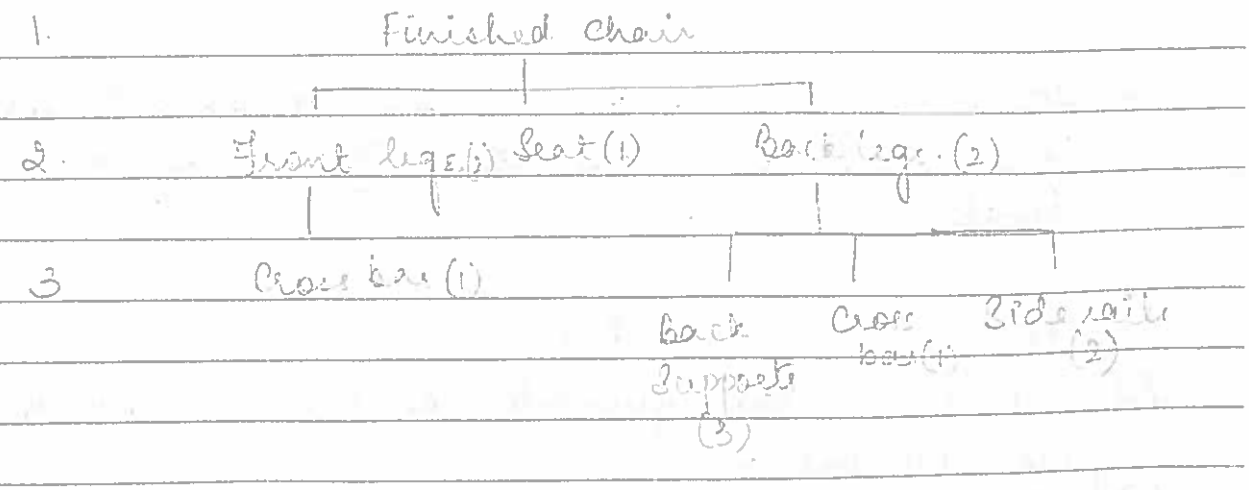
→ The listing in the BOM is hierarchical

→ It shows the quantity required of each item to complete the following assembly level.

→ This is in the form of a 'Product Structure Tree'.

→ This tree provides a visual depiction of the requirement in a BOM of the subassemblies & components needed to assemble a product.

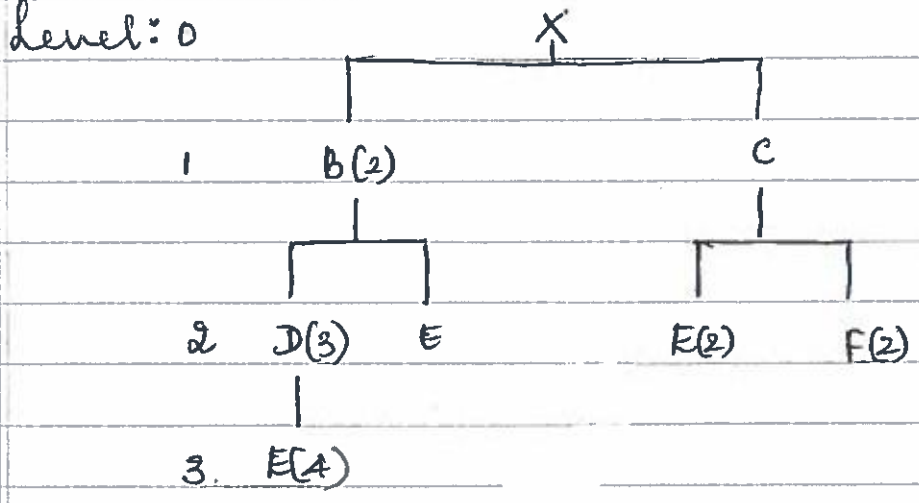
→ Eg: The Assembly Diagram of a chair shown below



Eg: from MPG

→ A product tree illustrates BOM.

→ Consider the following shown below. The end item is X



{→ According to this,

One	X	requires	2B	and	1C
1	B	"	3D	"	1E
1	D	"	4E		
1	C	"	2E	"	2F

→ These are listed in levels which begin with 0 for the end item.

→ Items at each level are the components for the upper levels and they are the 'Parents' of the next lower levels. }

Using the above tree,

(a) Determine the quantities of B, C, D, E & F needed to assemble one X

(b) Determine the quantities of these components required to assemble 10 X's. taking the following on hand inventory

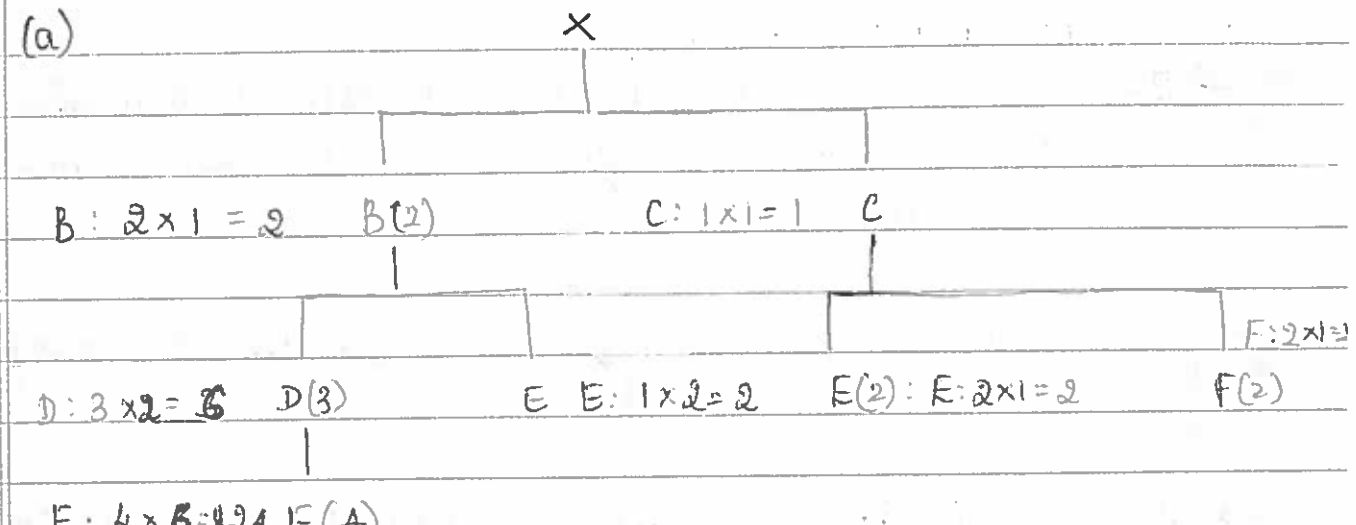
Date: / /20
Page No:

information:

Component	On Hand
B	4
C	10
D	8
E	60
F	4

Sol^n.

(a)



∴ One X needs

B = 2

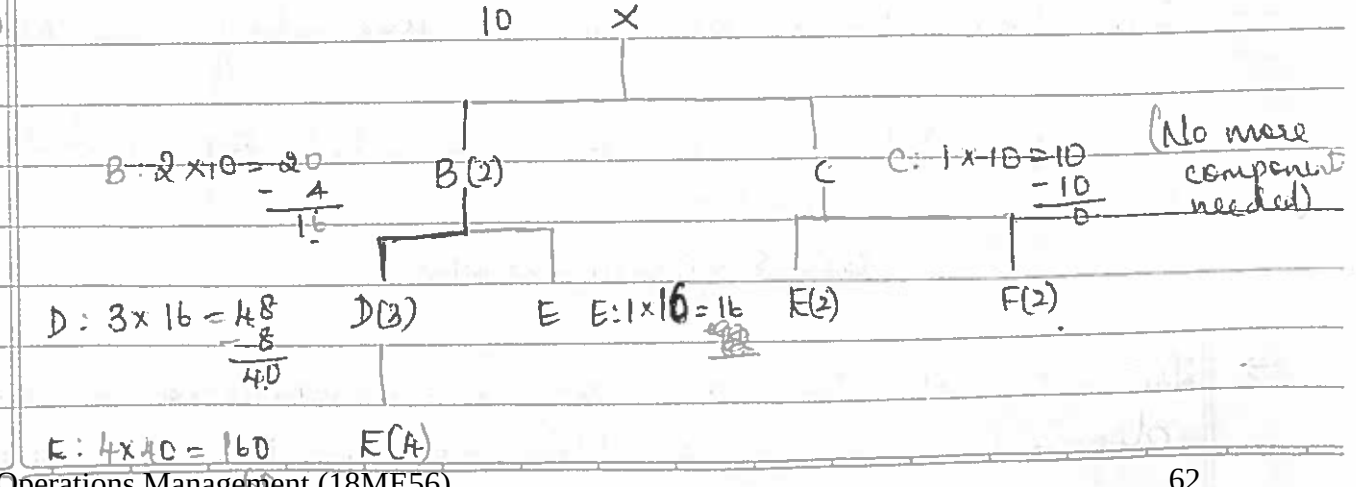
C = 1

D = 6

E = 24 + 2 + 2 = 28 [E occurs 3 times]

F = 2.

(b)



∴ 10 Xs need

B = 16

C = 0

D = 40

E = 100 + 16 = 116

F = 0.

⊛ THE INVENTORY RECORDS

→ The inventory records refer to stored information on the status of each item by time periods called 'TIME BUCKETS'.

→ This includes gross requirements, scheduled receipts & expected amount at hand.

→ It also includes supplier, lead time, and lot size, stock receipts, changes, withdrawals and cancelled orders.

* THE MRP PROCESSING

→ The MRP takes the end item requirements and explodes them into time phased requirements for assemblies, parts, and raw materials using BOM.

→ The chart below shows an assembly time chart

→ The quantities that are generated by exploding the BOM are called 'GROSS REQUIREMENTS'.

→ The materials that a firm must acquired to meet the demand generated by MPS are 'NET MATERIAL REQUIREMENT

Date : / / 20
Page No:

→ The determination of net requirements is called 'netting'.

→ Netting is done by subtracting the total inventory on hand from the gross requirements and adding safety stock if needed.

Net Requirements = Gross Requirements - Available Inventory

Available inventory = Projected inventory on hand - Safety stock - inventory allocated to other items.

Note: Unless otherwise stated, assume safety stock + allocated stock = 0

→ The following terms are important in MRP Processing

* Gross Requirements : The total expected demand for an item or raw material in a period without regard to amount on hand

* Scheduled Receipts : Open orders (orders that are placed) scheduled to arrive from vendors or elsewhere in the pipeline by the beginning of a period.

* Projected on hand : Expected amount of inventory that will be on hand at the beginning of each time period : Scheduled Receipts + available inventory from the previous period.

* Net Requirements: actual amount needed in each time period.

* Planned Order Receipts: The quantity expected to be received by beginning of the period in which it is shown.

* Planned Order Release: Planned amount to order in each time period; planned-order receipts offset by lead time.

MRP LOGIC

Item No: #1234	Week							
Item Name: Journal Bearing								
Record Time: 3 weeks	1	2	3	4	5	6	7	8
Date of Report: Week 0								
Gross Requirements				400				600
Scheduled Receipts								
Available on Hand	50	50	50	50				
Net Requirements				350				600
Planned order Receipts				350				600
Planned Order Releases	350				600			

The following points are noted from the reports:

1. Gross Requirements:
   → Report shows that 400 units of this item are needed in week 4 and another 600 are needed in week 8.

2. Scheduled Receipts:
   → No outstanding order were previously placed.

Date: / /20
Page No:

So there is no quantity of this item scheduled for receipt as of time.
→ ∴ Therefore there is no entry against scheduled Receipts.

3. Available on Hand:
→ There are 50 units of the item which are available in the inventory, remaining from the earlier period, and these will go towards meeting week 4 requirements.
→ 50 units are entered as it is for the first 3 weeks

4. Net Requirements:
→ This is the requirements after taking inventory into consideration.
→ It is always calculated as

Net Requirements = Gross Requirements - [Available on hand + Scheduled Receipt]

= 400 - [50 + 0] = 350

∴ Net Requirements for week 4 is 350 units
" " " " B " = 600 - [0+0]
= 600

5. Planned Order Receipts:
→ An item planned to be received in time for a particular work period.
→ ∴ According to the report, in order to meet the net requirements in the above case, we should plan on receiving 350 units in week 4

and 600 units in week 8.

6. Planned Order Release:
   → This item has a 3 week procurement lead time.
   → The first order must be placed in (released) in week 1 so they arrive in week 4.
   → The 2nd order in week 5 so they arrive in week 8.

Worked example

1. Compute the MRP for an item shown below. This item has an independent demand, and a safety stock of 40 is desired.

Order Quantity = 70 Lead time = 4 weeks Safety Stock = 40	Week											
	1	2	3	4	5	6	7	8	9	10	11	12
Projected Requirements	20	20	25	20	20	25	20	20	30	25	25	25
Receipts [Scheduled + Planned]		70		9	70			70			70	
Available on hand 65	45	95	70	50	100 ~~30~~	75	55	105 ~~35~~	75	50	95 ~~25~~	70
Planned order Release	70		70								70	

Sol: STEP 1 : Order Quantity = 70, which means whenever order is placed it should be = 70 units

2. Lead time = 4 weeks, which means that it takes 4 weeks for an order to realize.
   eg: Order planned to be placed in wk 1 will be realized in week 5.

3. Safety stock = 40, after the weekly demand is met,

Date: / /20
Page No:

there should be a surplus of at least 40 units.
→ There should be an entry of 40 against 'available on hand' row under each week till the end.

5. Receipts = 70 under week 2, which means, because of an earlier order placed, 70 units are being received in week 2.
→ This row accomodates both scheduled receipts + planned receipts.
→ The first 70 is scheduled all others are planned receipts

6. Available on hand is 65, means 65 units brought forward from the previous period.
→ It is calculated for each week as:

Available on hand = available on hand at the end of previous period + Scheduled Receipts +- Proj Req.

Eg: For week 1, AOH = 65 + 0 - 20 = 45
" 2, " = 45 + 70 - 20 = 95
3, " = 95 + 0 - 25 = 70
4 " = 70 + 0 - 20 = 50
5, " = 50 + 0 - 20 = 30 → Violates safety stock Requirements

∴ Order of 70 units should be received in week 5 so that AOH becomes
50 + 70 - 20 = 100.

4. When an order is planned to be released in wk 1, it is realized in week 5. As it is entered against scheduled receipts. beginning of week 1, 4 & 7

ging is the process of identifying the parent items that have generated a set of material requirements for an item

2. Given the forecast requirements for end item Y, complete the MRP report. Scheduled receipt of 60 units is due in week 2 + safety stock of 25 is to be maintained. Lead time = 2 weeks, Order Quantity = 60 units.

Order Q ty = 60
Lead time = 2 weeks
Safety Stock = 25

	Week									
	1	2	3	4	5	6	7	8	9	10
Projected Requirements	20	20	20	30	20	20	20	25	20	35
Scheduled / Planned Rec.		60		60		60		60		60
AOH 150	30	70	50	80	60	100 / 40	80	115 / 55	95	120
Planned order Release	60	~~60~~	60		60		60		60	

Solution: In the above table.

* MRP OUTPUT

→ The outputs of an MRP systems are called 'Reports'.

→ These are classified as
Primary Reports → Main Reports
Secondary Reports → Optional outputs.

→ Primary Reports: The prod^n and inventory planning and control constitute the primary reports. These include:

1. Planned Orders: A schedule indicating the time and amount of future orders.
2. Order Releases: Authorization for the execution of planned orders.
3. Changes: Revisions of due dates or order quantities or cancellation of orders.

Date: / /20
Page No:

→ Secondary Reports: Performance control, planning and exceptions belong to secondary reports.

1. Performance Control Reports: Evaluation of system operation, including deviations from plans and cost information
2. Planning Reports: Data useful for assessing future material requirements.
3. Exception Reports: Data on discrepancies encountered.

(*) MRP II - Manufacturing Requirement Planning.

→ It is an expansion of MRP for production resource planning, involving other areas of a firm in the planning process enabling Capacity Requirements Planning.

→ It is a closed loop system that includes information from the MPS, CRP and feedback reports.

→ When MRP was first introduced there was no way of assessing the plan before execution or assessing its success after execution.

→ Due to this a new plan had to be developed every week.

→ When MRP II systems began to include feedback loops, they were referred to as closed-loop MRP.

→ Closed loop MRP systems evaluate a proposed MRP relative to the available capacity. If the plan is not feasible, it must be revised. The evaluation is called Capacity Requirement Planning.

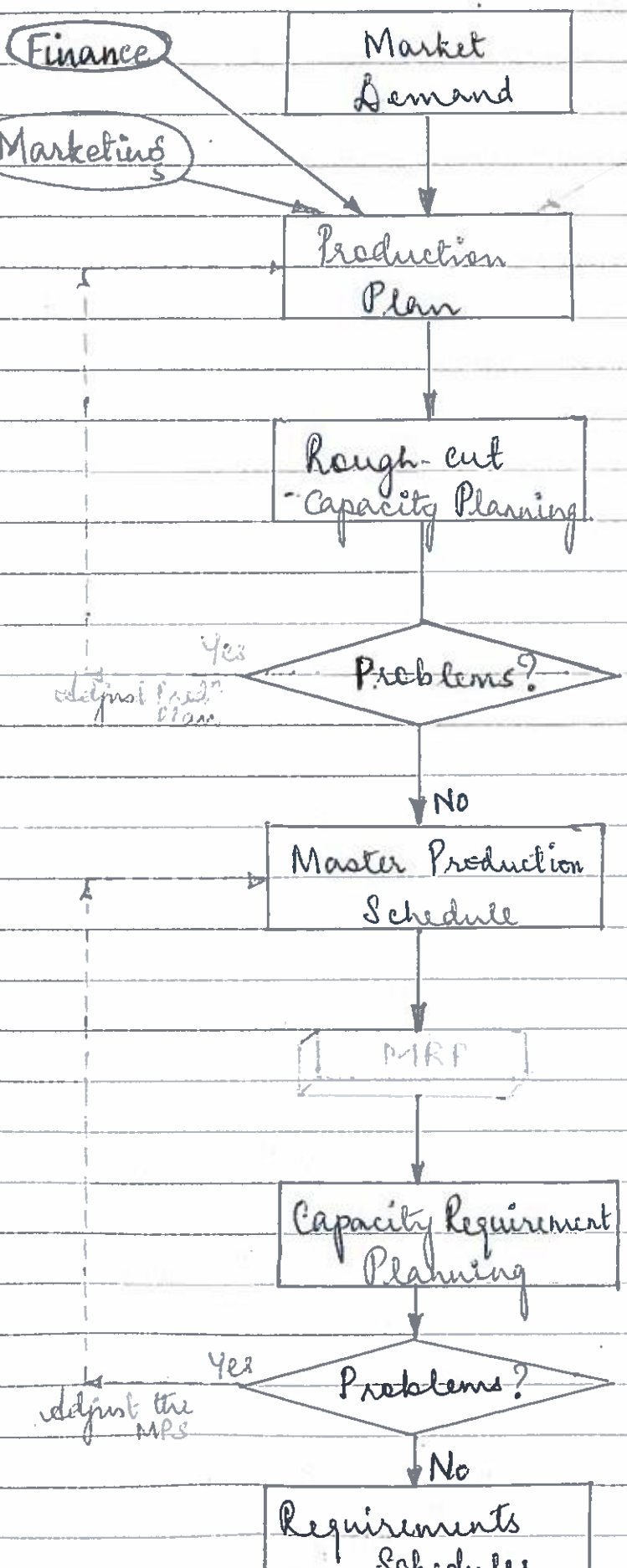


FIG: OVERVIEW OF MRP II

Date: / /20
Page No:

⊛ Capacity Requirement Planning (CRP)

→ One of the most important features of MRP II is its ability to aid managers in capacity planning.

→ CRP is the process of determining short range capacity Requirements.

→ The inputs are: * Planned order receipts → for MRP
* Current Shop load
* Routing Information
* Jobs Times

→ The outputs are: * Load reports for each work center
* Variance changes.

→ An MRP system cannot distinguish between the feasibility and infeasibility of an MPS.

→ If the current MPS fails or is not feasible, it may be revised.

→ At this point, it is 'frozen' for a term.

→ These revisions give rise to System nervousness which defined as the way a system reacts to change.

→ Its reaction may be greater or lesser than required

→ To minimize such problems, many firms establish a series of time intervals called 'Time Fences', during which changes can be made to orders. Eg: A fence of 4, 8 & 12 weeks. Beyond 12 weeks – Changes

are expected:

* Between 8 and 12 weeks:
  ↳ Substitution of one end item with another is permitted without altering the MPS.
* From 4 to 8 weeks:
  ↳ Plan is fixed and frozen.

→ This makes the nearest time fence the most restrictive and the farthest the least restrictive.

JUST-IN-TIME MANUFACTURING

→ Just-in-time (JIT) Manufacturing concept was developed in Japan in the late Seventies to help high volume prod" systems especially in automobile industry

→ It deals with having a control on the inventory as a means of improving productivity, reducing wastes + decreasing product costs.

→ In JIT mfg,

Products are assembled → just before they are sold
Subassemblies are made → " " they are assembled
Components are fabricated → " " " made into sub-assemblies
Raw materials are processed → just before they are fabricated into components.

→ This chain brings the inventory related costs to nearly Zero.

Date : / / 20
Page No:

(*) The Seven - Wastes

→ Shigeo Shigo, a japanese authority of IIT & an engineer o Toyota Motor company, identifies 7 wastes occuring commo in any industry.

1. Waste of Over Production

→ Over prod" can be eliminated by reducing m/c setu times, synchronizing material on hand, capacity & deliver schedules, solving layout problems etc...

2. Waste of Waiting

→ Waiting can be eliminated by avoiding bottlenecks, line - balancing, proper design of layout etc...

3. Waste of Transportation

→ Excessive transportation can be eliminated with proper material handling systems, better designs of layouts etc

4. Waste of processing

→ Not manufacturing unnecessary products.

5. Waste of Stocks

→ Reducing Stocks and inventory thus reducing all oth wastes.

6. Waste of Motion

→ First fix the most economic and consistent motion for an activity before mechanizing and automati

7. Waste of making defective products

→ Develop a good prod" process to prevent defective piece pr therefore eliminating or reducing time & effort for inspe

⊛ CAPACITY MANAGEMENT

→ Capacity is defined as "the rate of prod^n capability of a facility".

→ It is expressed in terms of volume of output per unit of time.

→ Capacity should be managed effectively because:

1. Sufficient capacity is reqd to meet the customer demand time.
2. Capacity affects cost effeciency of operations
3. " " prod^n + delivery schedules.
4. " " cost of maintaining the facility
5. " creation requires huge investment.

→ Capacity planning is the first step adopted by any organisation when it wants to produce more of an existing product or produce an entirely new product.

→ It is a strategic decision.

→ It cannot change from time to time.

→ It involves the proper review and evaluation of costs & revenues before any decision is taken.

→ Decisions are made keeping future growth, expansion plan market fluctuations, technological trends etc. in mind.

• STEPS IN CAPACITY MANAGEMENT

→ Capacity has various steps involved as shown below:

Date: / /20
Page No:

Step 1: Environment impact study

Step 2: Demand forecasting

Step 3: Assessing existing capacity

Step 4: Identifying alternative ways for modifying existing capacity

Step 5: Evaluating economical + technological feasibility of alternate capacity plans

Step 6: Select the best plan

Step 7: Implementation

Fig: Steps in capacity Planning Implementation

- MEASURING CAPACITY

→ Capacity is measured differently from one organisation to another.

→ For some organisations, it is measured in terms of output. Eg: Automobile industry → No. of vehicles

→ For some others, it cannot be measured as output in such cases, it is measured as input. Eg: Seats, beds rooms etc. are taken as capacity measures.

→ Therefore, capacity can be measured in terms of the i/ps & o/ps of the conversion process.

Organisation	Measure	Input / output
Automobile Mfr.	No. of vehicles	o/p
Diary Prod^{n}	Litrs / tons	o/p
Steel Industry	Tons of steel	o/p
Airline	No. of seats	i/p
Hospital	" " beds	"
Restaurant	" " tables	"

CAPACITY MEASUREMENT

→ Manufacturing industries have output as their capacity measure.

→ Service industries have input as their capacity measure

→ Capacity can rarely be measured precisely due to the variations that occur due to employee absenteeism, machine breakdown, m/c setup time etc...

→ It is referred to as the average of all previous actual capacities.

→ In the event that previous capacities are not available 'rated Capacity' is measured.

$$\text{Rated Capacity} = (\text{Number of m/cnes})(\text{m/c Hours})(\%\text{ of utilization})(\text{System efficiency})$$

WORKED EXAMPLES

1. Operates 6 days a week on a 2 shifts/day basi

Date: / /20
Page No:

June/July 2015 (8 hours/shift). It has 4 m/cnes with the same capacity. If the machines are utilized 75% of the time at a system effeciency of 90%, what is the rated o/p in std hrs/wk?

Solution; No. of m/cnes = 4
m/c hrs = 6 x 8 x 2 = 96 hrs
% utilization = 75% = 0.75
η = 90% = 0.90

Rated η capacity = no. of m/cnes x m/c hrs x % Utilization x η
= 4 x 96 x 0.75 x 90
= 259.2
≅ 259 Standard hours per week.

CAPACITY TIME HORIZONS

→ Capacities can be planned for 3 general time horizons –
Long Term
Short Term
Medium Term.

1. Long Term Capacity Planning
   → Company's policies, goals and objectives are the types of plans that are carried out in this Horizon.
   → This planning is carried out by the TOP LEVEL MANAGEMENT.

2. Medium Term Capacity Planning.
   → Aggregate plans, master schedules, prodⁿ schedules and the like come under this horizon.
   → This planning is carried out by the MID LEVEL

MANAGEMENT.

→ Involve the planning for inventory & subcontracting including back-orders etc..

3. Short Term Planning.

→ Production and activity control and execution are planned at this level

→ Carried out by MID LEVEL AND LOW LEVEL MANAGEMENT.

→ Flow of work is monitored, controlled, results are compared with standards and necessary corrections are made.

⊛ CRP ACTIVITIES

→ CRP is the technique used to determine the manpower, and equipment capacities needed to meet the prod^{n} objectives as put forth by the MPS & MRP.

INPUTS TO CRP PROCESS

1. Planned orders & Released orders from MRP System.
2. Loading information from the center status file.
3. Routing information from the shop routing file.
4. Changes which modify capacity & give alternatives.

INFORMATION FLOW OF THE CRP PROCESS.

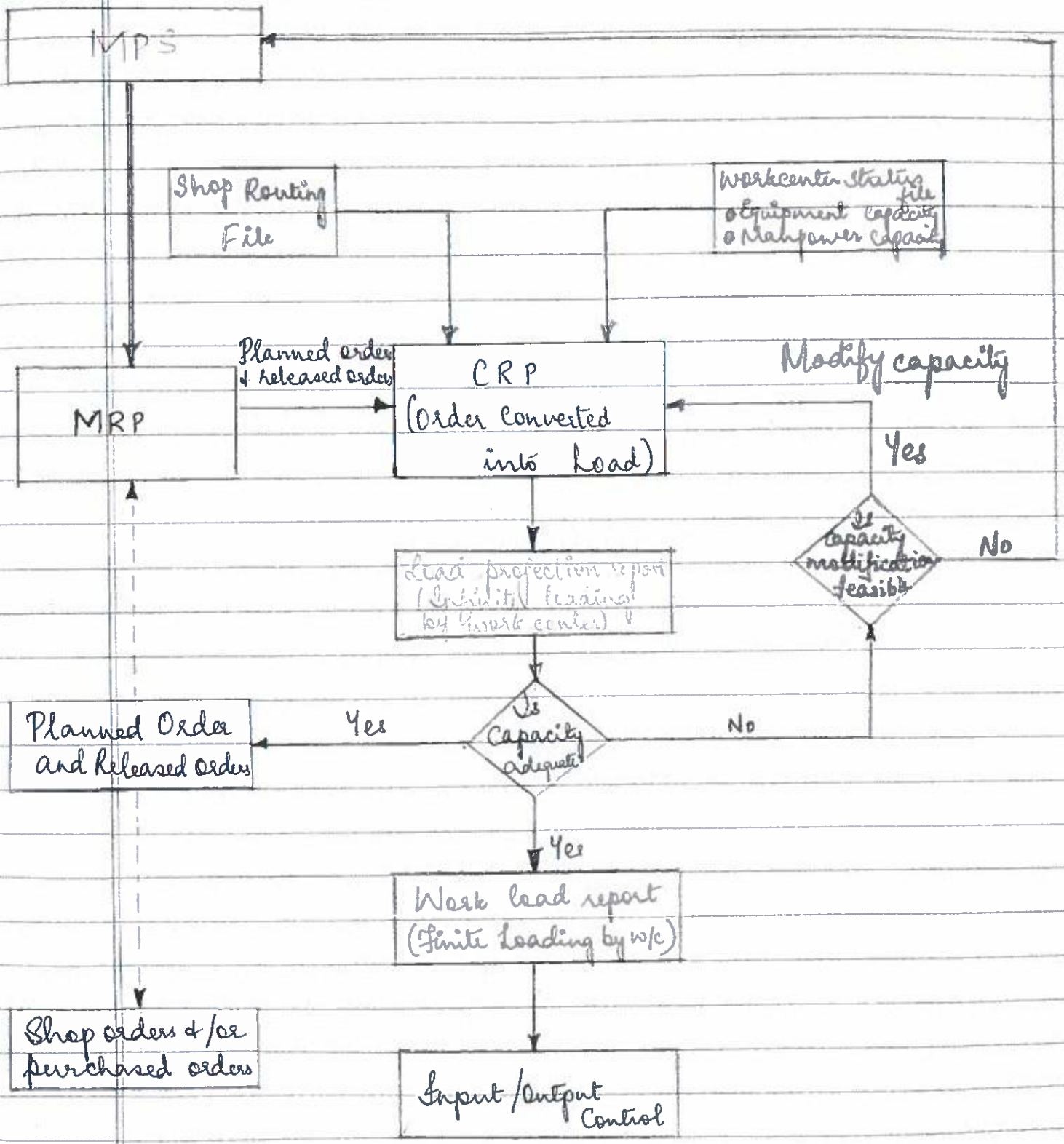


FIG Flow chart of CRP Process

OUTPUTS OF CRP

→ Planned orders are verified for the MRP System.

→ Work load reports are generated based on priorities.

→ These show the status of both planned and released orders and help in future planning

→ Capacity modification or MPS revision is called for, if needed by rescheduling messages.

FINITE AND INFINITE LOADING.

→ Consider a requirement of a 10mm bolt.

→ According to the MRP, it needs to be produced on a particular work center.

→ This work center contains several m/cnes.

→ According to the information given, the avg capacity of this work center is 250 std m/c hours/week.

→ Requirement for the component in each week period is shown below.

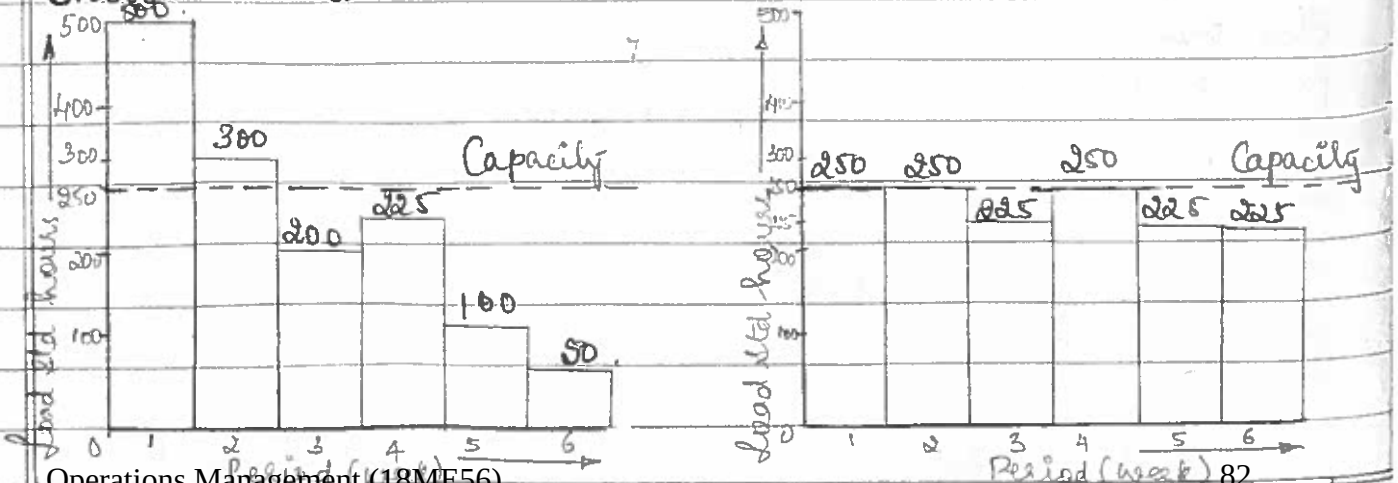


Fig (a): Infinite Loading

Fig (b): Finite Loading

→ From the above figure, it can be observed that the req at some time periods exceed the avg capacity of the work center and in some weeks it is less

→ The process of loading the workcenters with all loads witho considering the capacity is called 'INFINITE LOADING'.

→ It is the process of loading the work centers as if their capacities were infinite.

→ This helps in determining excess capacity required in certain periods

→ In cases for excess capacities, managers decide on overtim subcontracts, Sub routings, alternate routings etc.

(*) BENEFITS OF MRP

1. Generation of lower-level requirements.

→ It has the ability to give the requirements of lower level compon like nuts, bolts, pins, brackets etc.

→ These can be commonly used for various products.

→ Producing such components on a large scale helps reduce costs.

2. Time phasing of lower-level requirements.

→ They indicate requirements in time phased manner depe on current needs and needs of the immediate future.

3. Planned order release.

→ It calculates lead times required to manufacture & procure

components and allows exactly so much time before giving a planned order release.

4. Rescheduling capability.

→ They allow for rescheduling from time to time because of internal & external environments.

→ Marginal changes in conditions are accomodated by MRP logic while bigger changes in production plans require the intervention of management.

5. Utilizing firm planned orders

→ Certain end items may be required as a top priority irrespective of what ~~they~~ may happen to the rest of the items

→ In such cases system designers can instruct the computer running the MRP package to accept & hold firm to certain requirements.

→ Planners can gain this added control over planned orders by designating them as "firm planned orders".

→ In this case the computer will not automatically change the release date, the planned order receipt date, or the other order qty.

6. Pegging Capability

→ It refers to the ability to identify the parent item or items that generated the component requirements.

→ E.g. If a supplier fails to deliver a lot of certain

Date : / /20
Page No:

lower level components, the system would identify each end item that is relying upon that supply.

→ Then changes can be made to rectify the problem.

Priority Planning and Control.

— x —

UNIT- 5 AGGREGATE PLANNING AND MASTER SCHEDULING.

⊛ Nature and Scope of aggregate planning

→ After demand forecasting has been carried out by a company, it is possible to estimate the demand of its products in the market.

→ Once this demand is estimated, all the resources are gathered together to meet this demand.

→ Decisions on ways and means to utilize the available resources to produce output in order to meet the estimated demand is called 'Aggregate Planning'.

→ It is always carried out over an intermediate time horizon of 3 months to 1 year.

→ Aggregate planning is different from scheduling in the property that scheduling is for a few weeks whereas aggregate planning is for a longer period.

⊛ Objectives of Aggregate Planning

→ It balances demand against capacity by various methods.

→ It provides the overall levels of output, inventory & backlogs according to the forecast and business plans of the organisation

→ It uses the organisations capacity to its best as an underutilized capacity can be an expensive waste

Date : / /20
Page No:

Stable policy + hire & fire policy → Super market

Goal → It should be consistent with organisational goal and policies regarding its employees.

→ It should be flexible to market fluctuations

→ Aggregate planning influences the decisions of every department in the organisation. - Sales, Finance, Purchase etc...

→ It uses various strategies modify demand capacities.

⊛ STRATEGIES OF AP

→ There are 2 main strategies used in AP:

1. 3 Pure Planning Strategies (Internal to the organisation)
2. Other pure strategies (External to the org.)

1. 3 Pure Planning Strategies.

→ When Strategies aim at modifying the capacity to meet the demand only with the help of inter resources, they are called 'Pure Planning Strategies' There are 3 such strategies:

Strategy 1: Vary the size of the work force

→ Here, the organisation varies the number of employees in response to varying outputs.

→ Hiring & firing of workers is carried out in proportion to changes in demand.

→ Eg: Daily wage workers, some software companies etc...

(*) Advantages
1. Economical with respect to employee usage
2. Promotes hardwork among employees.

(*) Disadvantages
1. Hiring & lay off costs are incurred
2. Skilled labour may not be available when needed.
3. Morale of temporary workers is always low.
4. Community reaction to hiring and firing may not be healthy.

Strategy 2: Vary the number of working hours.
→ Organisation maintains constant work force but alters the working hours.

→ Idle time during less demand & Over Time during larger demand.

→ Eg: Seasonal industries like umbrella factories, crackers etc., hotels, tourism agencies etc...

(*) Advantages
1. Hiring & layoff cost is avoided.
2. Employee morale is not wounded.

(*) Disadvantages
→ Idle Time is a disadvantage.

→ OT wages are more expensive than Regular Time.

→ Job related accidents may occur during over time that result from inefficiency due to work load.

Date : / / 20
Page No:

→ Machine down time & labour down time results in reduced profits.

Strategy 3 : Vary the inventory levels.

→ This strategy shows a constant work force and a consta working period.

→ The inventory is piled up in this case.

→ The finished products are stacked as a buffer in the case of fluctuating demands.

→ Eg : Tangible goods industries.

(*) Advantages :

1. Stable employment to maintain constant workfo
2. No IT or OT due to constant prod^n level.

(*) Disadvantages .

1. Locked capital
2. Material Handling costs are increased due to larger inventories.
3. Perishable goods cannot be carried as inventory
4. Cannot be applied to the service industry.
5. Customers may go elsewhere to buy due to constant rate of prod^n going down in some case

2. OTHER PURE STRATEGIES (External)

1. Back Ordering :

→ This a method of modifying demand.

→ Backorders are outstanding, unfulfilled demands

of customers' orders.

→ Customers are asked to wait for a time period before they receive their orders.

→ If the customers are willing to wait, back ordering becomes a good strategy else it causes loss of business opportunities.

2. Sub-Contracting

→ It is widely used to modify the supply

→ Here, organisations off load some of the jobs to outside vendors thus hiring external capacity to meet the demand especially during peak periods

→ It generally reduces investment on capacity but increases product cost & dependencies on external agencies.

3. Product Promotion

→ This is a method of modifying demand.

→ Advertisements, off-season discounts, development of complimentary products are used here.

→ These bring down the profit margin but reduces the burden of costs by getting rid of inventory.

Date : / / 20
Page No:

TECHNIQUES FOR AGGREGATE PLANNING:

→ There are many techniques for aggregate planning. These broadly fall into 2 categories:

(a) GRAPHICAL AND CHARTING TECHNIQUES

(b) MATHEMATICAL TECHNIQUES.

→ In any of the cases, aggregate plans have to be formulated carefully using the following guidelines:

(1) Determine Corporate Policy.

→ Company policies regarding the usage of resources like capital, employees, inventory, plant & building etc.

→ Company outlook towards the society, stock holders, competitors etc.

(2) Select a good forecasting technique.

→ A technique that is appropriate for the product should be chosen and the forecast error measure should be calculated from time to time to check the validity of the technique.

(3) Plan using appropriate units of capacity

→ Aggregate plans should be made keeping in mind the capacity of the system allowing space for problem

→ The plans should not be in terms of monetary units but should be homogeneous in nature - units of productions, m/c hours, labour hours etc

(4) Maintain a stable work force.

→ High employee attrition reflects poor management skills & thereby increases costs associated with employ

→ Effort should be made to maintain a stable workforce

(5) Have good control over inventories.
→ For aggregate plans to work properly, proper inventory control should exist.
→ This can be done by adopting an MRP package if the operations are large enough.

(6) Flexibility to changes.
→ The plan should be flexible to the inevitable changes that occur in a business environment.

(7) Respond to demand in a controlled manner.
→ Before reacting to a change in demand, proper study of the demand pattern must be carried out.

(8) Evaluating and checking on a regular basis.
→ Controlling activity should be built into the AP system so that the actual levels of the activity can be measured, comparison can be made & planned levels, and corrections & variations can be carried out.

(a) GRAPHICAL AND CHARTING TECHNIQUES.

→ Here the plan strategies are based on cost considerations.

→ The various components are:

(i) Hiring & lay-off costs:

Costs of → Recruiting, Screening, Training } → New employees.

costs of → Lay-off benefits, Loss of good will } Laid-off employees

These costs are made in pure strategy No. 1

Date : / / 20
Page No:

(ii) Overtime and Undertime costs:

Costs incurred → Paying for overtime
+
Costs → ——— → Paying for undertime → here this means the worker is idle & still has to be paid for regular time + unproductive time.

These costs are prevalent if the co. opts for pure strategy No. 2.

(iii) Inventory carrying costs. – Capital investment, storage cost, Obsolescence cost, pilferage cost

(iv) Sub-contracting costs. – always costlier than in-house mfg.

(v) Back-Ordering costs – Discounts made to satisfy waiting

(vi) Part time labour costs. – Part time labourers are paid higher than regular workers.

WORKED PROBLEMS

1. A firm has developed the following forecast (units) for an item which has a demand influenced by seasonal factors.
   (a) Prepare a table showing daily demand requirements
   (b) Plot the demand as a histogram & as a cummulative requirement
   (c) Determine the ~~prod^n rate~~ Avg demand reqd to meet average demand & plot it as a dotted line on the graph.
   (d) By graphical method determine the minimum prod^n rate when back orders are not permitted
   (e) Interpret the 3 pure planning strategies w.r.t the problem.

Month	Demand	Prod^n Days
January	220	22
February	90	18
March	210	21
April	396	22
May	616	20
June	700	20
July	378	21
August	220	22
September	200	20
October	115	23
November	95	19
December	260	20

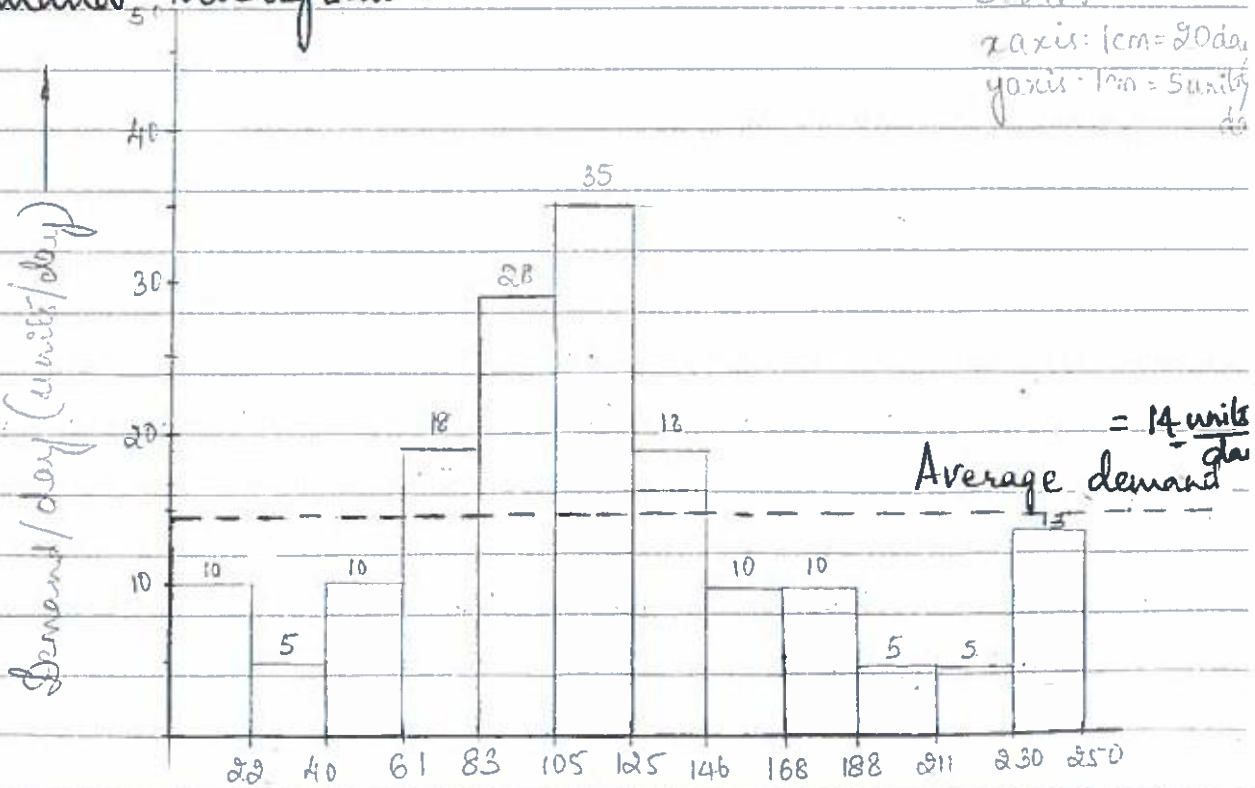
Date: / /20
Page No:

Solution: (a)

Month	Demand	Prod^n days	Demand/day	Cumulative Days	Cumm. Forecast Demand.
(1)	(2)	(3)	(4) = (2)/(3)	(5)	(6)
January	220	22	10	22	220
February	90	18	5	22+18=40	310
March	210	21	10	61	520
April	396	22	18	83	916
May	616	22	28	105	1532
June	700	20	35	125	2232
July	378	21	18	146	2610
August	220	22	10	168	2830
September	200	20	10	188	3030
October	115	23	5	211	3145
November	95	19	5	230	3240
December	260	20	13	250	3500
	3500	250			

(b) Demand histogram

Scale:
x axis: 1cm = 20 days
y axis: 1cm = 5 units/day

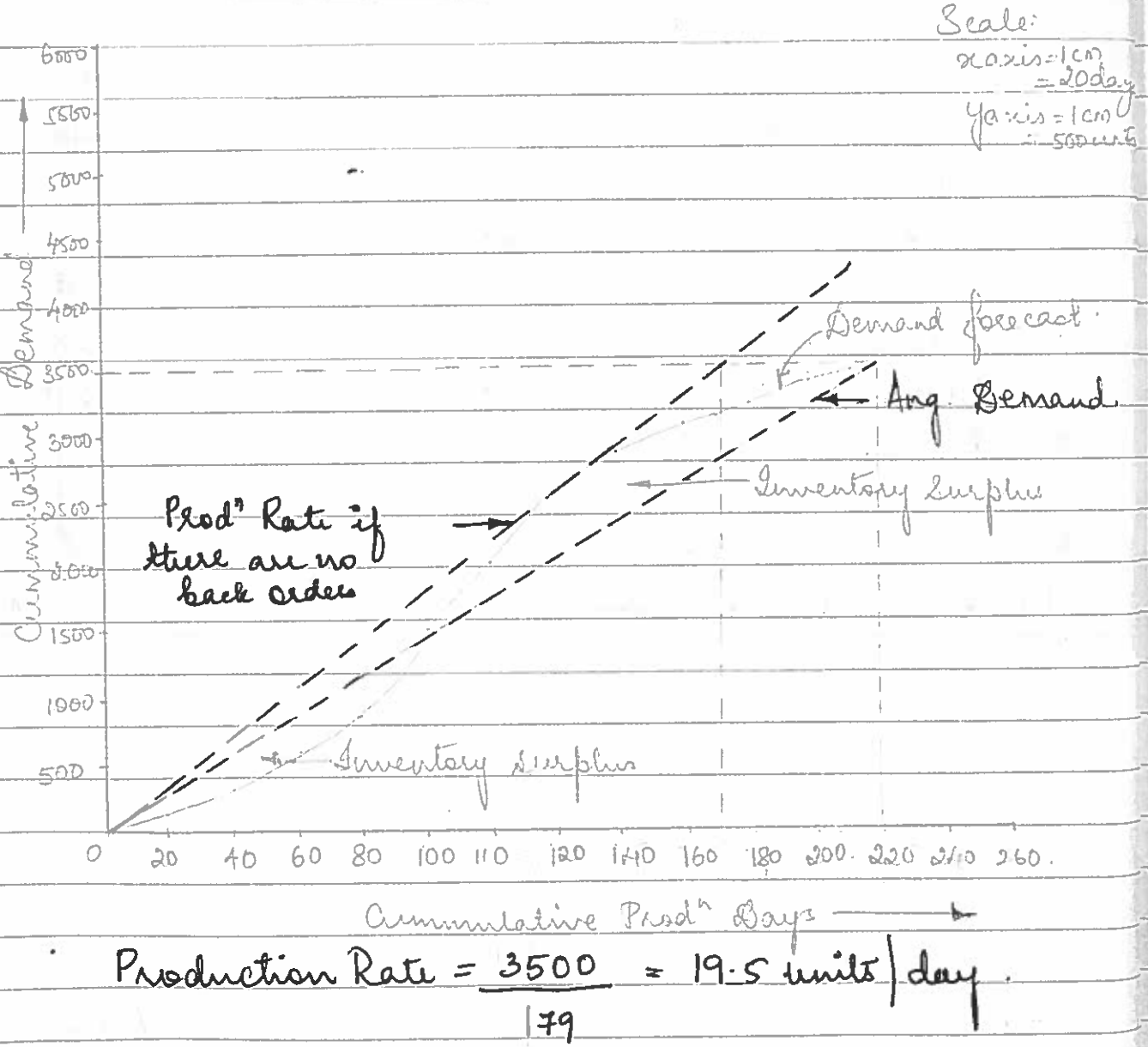


(c) Average Demand

$$\text{Avg. Demand} = \frac{\text{Total Demand}}{\text{Total Prod}^{n} \text{ Days}} = \frac{3500}{250} = 14 \text{ units/day}$$

This is plotted as a dotted line on the histogram.

(d)



$$\text{Production Rate} = \frac{3500}{179} = 19.5 \text{ units/day}$$

(e) Interpretation of 3 pure strategies

STRATEGY 1 : Vary the size of work force.

→ Hire & fire will result in prod" exactly according to the daily demand.

Date : / /20
Page No:

STRATEGY 2 : Vary the number of working hours.

No. of employees = Constant Prod^n rate = Avg. demand

then, during the months of Jan - March - less number of employed working hours & more during Apr-Jun

STRATEGY 3: Vary the inventory levels.

No of employees = fixed. Prod^n rate = Avg. demand

then,

excess prod^n in months - Jan to March this gets depleted during the subsequent months.

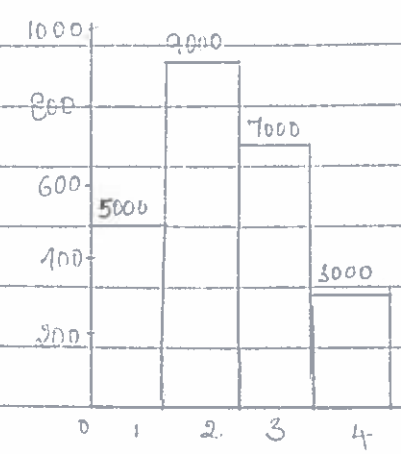
Back Ordering should be permitted.

2. A local manufacturer of water heaters has estimated its quarterly demand as shown in the table. It expects the next demand cycle to be similar to this one & wishes to restore ending inventory, employment etc., to beginning levels accordingly.

Demand table

Quarter	Units
1	5000
2	9000
3	7000
4.	3000

Demand Histogram



(a) If labour costs go up by Rs. 20,000 for every 1 Change

in 2000 water heaters produced, what is the cost associated in varying work force size?

(b) If OT usage of labour is allowed costing at ₹50/unit and IT charges costing at ₹200/unit, what would be the OT & IT costs if constant work force has to be maintained to produce 6000 units per quarter.

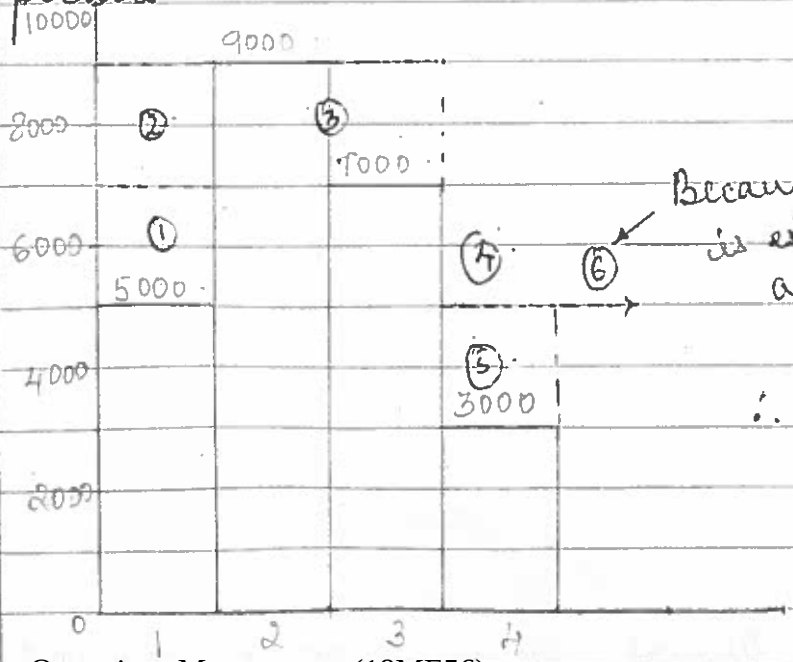
Out of Stock of items

(c) What would be the stock out cost & back ordering cost if the manufacturer decides to make 5000 steadily per quarter. Consider the back ordering cost of ₹. 20/unit & stock out cost of lost sales to be ₹200/unit.

Sol': (a) Varying the work force size.

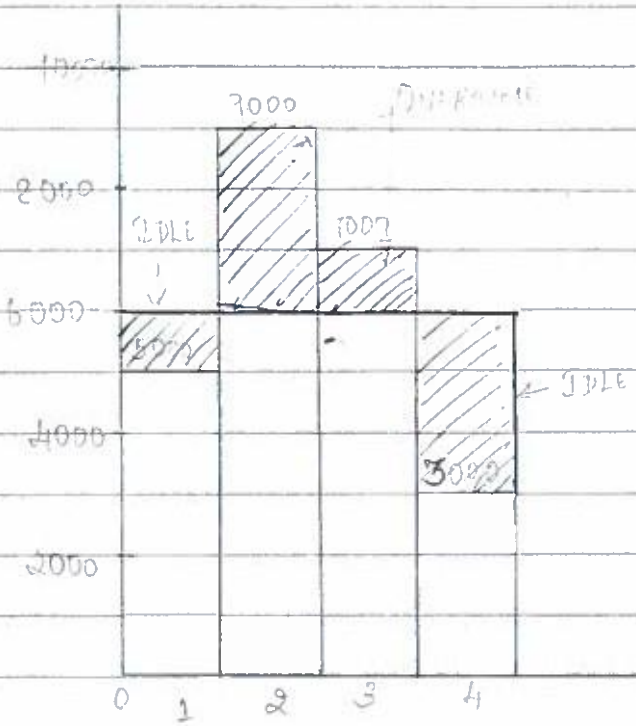
→ cost increases by ₹20,000 for every change either +2000 heaters or −2000 heaters.

→ Every time 2000 water heaters are ↑sed or ↓sed in prod' additional labour charge of ₹20,000 comes into the picture.



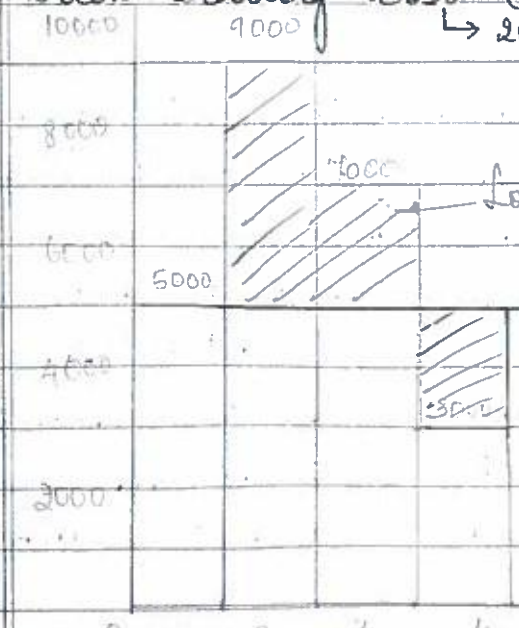
∴ Change of employment cost = 6 × 20000
= ₹ 1,20,000 /-.

(b) OT labor cost = ₹ 50/unit
Idle Time labour cost = ₹ 200/unit.
For constant work force to produce 6000 units per quarter, labour cost: ?



Over
Total Time = 3000+1000
= 4000 units
Total Idle time = 1000+3000
= 4000 units
Total OT+IT costs =
= (4000×50)+(4000×200)
= ₹ 10,00,000

(c) Steady prod^n of 5000 heaters/quarter
Back ordering cost (per unit) = ₹200/quarter = Loss cost.
↳ 20 Rs/unit



1st Quarter = 5000 produced + consumed
2nd Quarter = 5000 produced but 9000 is the demand.
∴ Loss of sales pennant
3rd quarter = 5000 produced
7000 demanded
2000 [awaited]
4th Quarter = 5000 produced.
Demand = 3000. (Surplus 2000 given to waiting customers).

→ Surplus is at a discount of ₹20/unit

∴ Surplus (Back order) = 2000 × 20

= ₹40,000

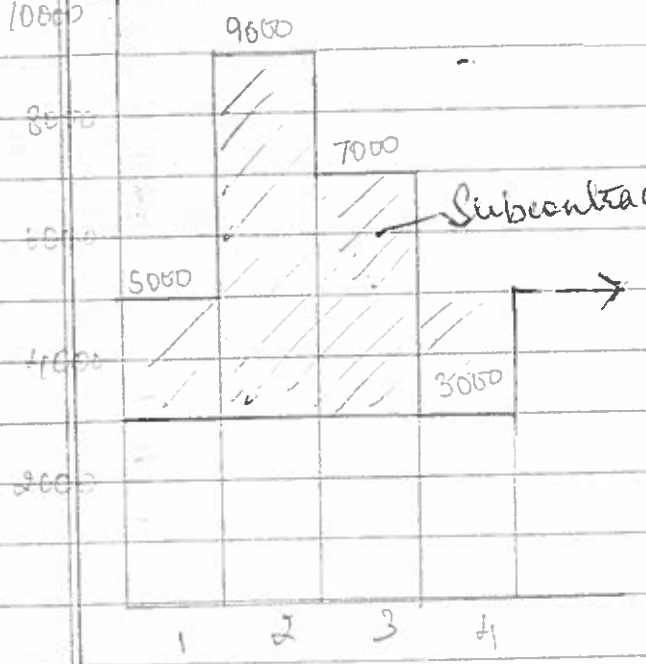
Out of stock loss of sale = Total sales lost × 200

= 4000 × 200

= ₹8,00,000

(a) Subcontracting

→ Produce the least + subcontract the rest



Total Subcontracting units

= 5000 + 9000 + 7000 + 3000 − (3000 × 4)

= 12000 units

Total cost = 12000 × 80

= ₹ 9,60,000

3. The supply, demand, cost + inventory data for a company which is a constant work force is given for 4 months in the following table. The company wishes to meet all the demand without permitting backordering. Allocate the prod^n capacity to satisfy demand so as to minimize total costs. Also find minimum basic cost for meeting the demand using least cost method of the transportation model.

Month	Regular Time (RT)	Overtime (OT)	Subcontract (SC)
Jan	60	20	1000
Feb	50	15	1000
March	60	20	1000
April	65	30	1000

Supply Capacity (units)

Date: / / 20
Page No:

Demand Forecasts (units).

Months	Demand.	Inventory
Jan	100	
Feb	50	
March	70	
April	80.	

Initial inventory available = 20 units SC cost/unit = ₹15
Final " needed = 25 units. Carrying cost/unit/period = ₹5.
Regular time cost/unit = ₹100.
OT cost/unit = ₹125
Cost of unused RT labour/unit = ₹50.

Sol^n.

	Supply Units From.		Demand Jan	Feb	March	Apr. + Final inv.	Supply Max. availability
Initial Inv.			0	5	10	15	20
		RT	100	105	110	115	60
Jan		OT	125	130	135	140.	20.
		SC	150	155	160	165.	1000
		RT		100	105	110	50
Feb		OT		125	130	135	15
		SC		150	155	160	1000.
		RT			100	105	60
March		OT			125	130	20
		SC.			150	155	1000
		RT				100	65
April		OT				125	30
		SC.				150.	1000
Demand.			100.	50	70.	80+25 = 105	4340.

→ Transportation models require the cost matrix to be a square matrix. Here, no of rows = 5 (Supply total) no of columns = 4 (Demand Total) (4340 ≠ 4015)

→ Add a dummy column (with a cost of unused RT labour/unit ₹ = ₹50 in this case) else an entry of '0' to balance the problem.
* If back ordering is allowed @ ₹10

Supply units from		Demand Jan	Feb	March	April + Final Inv	Dummy	Supply Max.
Initial Inventory		0	5	10	15	20	20
Jan	RT	100 (60)	105	110	115	50	60
	OT	125	130	135	140	0	20
	SC	150	155	160	165	0	1000
Feb	RT	110	100 (50)	105	110	50	50
	OT	135	125	130	135	0 (15)	15
	SC	160	150	155	160	0 (1000)	1000
March	RT	120	110	100 (60)	105	50	60
	OT	145	135	125 (10)	130 (10)	0	20 (10)
	SC	170	160	150	155	0 (1000)	1000
April	RT	130	120	110	100 (65)	50	65
	OT	150	140	135	125 (30)	0	30
	SC	170	165	160	150	0 (1000)	1000
Demand		~~100~~ 80 20	50	~~70~~ 10	80 + 25 = 105 ~~40~~ 10	~~4015~~ ~~2015~~ ~~3000~~ ~~1000~~ ~~1000~~ 150	4340

Total cost = 0×20 + 60×100 + 20×125 + 1000×0 + 50×100 + 15×0 + 1000×0 + 60×100 + 10×125 + 10×130 + 0×1000 + 65×100 + 125×30 + 1000×0 = ₹ 32300.

Date : / /20
Page No:

(4) The supply, demand, cost and inventory data for a company, which has a constant workforce is given below.

Demand Forecast

Period	Demand
1	100
2	70
3	70
4	80

Initial Inventory = 20 Final Inventory = 25

Supply Capacity (in units).

Period	RT	OT	SC.
1	60	18	1000
2	50	15	1000
3	60	18	1000
4	65	20	1000.

RT cost/unit = ₹100
OT cost/unit = ₹125
SC cost/unit = ₹130
Carrying costs/f unit/period = ₹2.

Using TLP, allocate prodⁿ to satisfy demand at minimum cost.

Solⁿ.

Total Demand = 300
Total Supply = 4306
Total Demand ≠ Total Supply.
∴ Add a dummy column with demand entry as = 4000.

Sol^n :

SUPPLY FROM	DEMAND 1	2	3	4	DUMMY	MAX. AVAILABLE SUPPLY
Initial Inventory	[0] 20	2	4	6	8	20
1 RT	[100] 60	102	104	106	108 0	60 0
1 OT	[125] 18	127	129	131	133 0	18 0
1 SC	[130] 2	132	134	136	138 0	1000 990
2 RT		[100] 50	102	104	106 0	50 0
2 OT		125	127	12 [129]	131 0	15 3
2 SC		130	132	134	136 0	1000
3 RT			60 [100]	102	104 0	60 0
3 OT			10 [125]	8 [127]	129 0	18 8 0
3 SC			130	132	134 0	1000
4 RT				65 [100]	102 0	65
4 OT				20 [125]	127 0	20
4 SC				130	132 0	1000
Demand	100	50	70	80+25	4001	4306
	80 20 2 0	0	+0 0	105 40 20 18 0		

Total AP cost = $(0\times20) + (60\times100) + (125\times18) + (130\times2) + (100\times50) + (12\times129) + (60\times100) + (10\times125) + (8\times127) + (65\times100) + (20\times125)$

$= ₹\ 32,324/-$

(5) A company uses an MRP system & plans to adjust the capacity when cumulative deviation exceeds 1½ of the forecasted average/week. They have calculated capacity requirements/week over the next 8 weeks as shown. Graph the capacity requirements showing average planned

Date : / / 20
Page No:

requirement as a dotted line. Assume actual requirement for the last 5 weeks were 390, 460, 280, 510 & 350, compute the cumulative deviation (actual - planned) & comment whether any adjustment is needed.

Week No.	1	2	3	4	5	6	7	8
Hours reqd.	400	380	210	530	420	410	500	350.