Q.2a. What are the various techniques available for solving OR problems?

Ans . Refer Taha (Sec 1.2) page 4

b. Sandow limited has two products, Rose and Lotus. To produce one unit of Rose, 2 units of material X and 4 units of material Y are required and to produce one unit of Lotus 3 units of X and 2 units of material Y are required. At least 16 units of each material must be used in order to meet the committed sales of the two products. Cost per unit of material X and material Y are Rs. 2.50 and Rs. 0.25 respectively. Formulate the problem as LPP and solve it graphically to minimize the total cost.

Ans.2(b) Let A units of Rose and B units of Lotus are being produced by the Sandow Ltd. The table below gives the requirement of X and Y by the two products and their cost.

Material	Rose	Lotus	Cost/Unit
X	2	3	2.50
Y	4	2	0.25

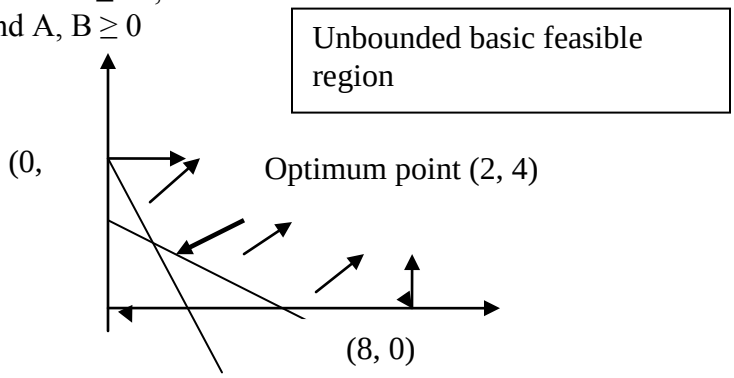
Thus, the total cost = (2A + 3B)*2.50 + (4A + 2B)*0.25

So minimum Z = 6A + 8B

Subject to; 2A + 3B ≥ 16

4A + 2B ≥ 16, as minimum of 16 units of each material should be used.

and A, B ≥ 0



Intersection point of the two lines A/8 + B/5.33 = 1 and A/4 + B/8 = 1 is (2, 4). The feasible region is unbounded but a minimum value can be obtained at one of the three extreme points of the solution space i.e; (8, 0), (0, 8) and (2, 4).

Extreme points	Z = 6A + 8B
(8, 0)	Z = 48
(0, 8)	Z = 64
(2, 4)	Z = 44

Thus the minimum value of Z is 44 at A = 2 and B = 4.

Q.3a. Write the dual of the following LPP:

Minimum $z = 4x_1 + 6x_2 + 18x_3$

Subject to: $x_1 + 3x_2 \geq 3$

$x_2 + 2x_3 \geq 5$ and $x_j \geq 0$, j = 1, 2, 3

Ans.3(a) Let y_1 and y_2 be the dual variables. Then the dual of the given primal is:

Max $w = 3y_1 + 5y_2$

Subject to: $y_1 \leq 4$

$3y_1 + y_2 \leq 6$

$2y_2 \leq 18$

Non-negative: $y_1, y_2 \geq 0$

b. Solve the following LPP:

Minimize $z = 8x_1 - 2x_2$

Subject to: $-4x_1 + 2x_2 \leq 1$

$5x_1 - 4x_2 \leq 3$

$x_1, x_2 \geq 0$

Ans Refer Taha page-93

Q.4 a. Build the mathematical model for the following transportation problem, where the objective is to minimize the costs involved in transporting goods from factory to warehouses.

	W_1	W_2	W_3	W_4	supply
F_1	1	2	4	4	6
F_2	4	3	2	0	8
F_3	0	2	2	1	10
	4	5	8	6	

Ans.4(a) Let x_{ij} is the allocation to each (i, j)th cell. Cost c_{ij} each cell is given in the cost matrix, then the objective function is written as:

$$\text{Minimum } Z = \sum_{i=1}^{n}\sum_{j=1}^{m} x_{ij}c_{ij}$$

Min $Z = 1.x_{11} + 2.x_{12} + 4.x_{13} + 4.x_{14} + 4.x_{21} + 3.x_{22} + 2.x_{23} + 0.x_{24} + 0.x_{31} + 2.x_{32} + 2.x_{33} + 1.x_{34}$

Subject to : Row Constraints: $x_{11} + x_{12} + x_{13} + x_{14} = 6$

$x_{21} + x_{22} + x_{23} + x_{24} = 8$

$x_{31} + x_{32} + x_{33} + x_{34} = 10$

Column Constraints: $x_{11} + x_{21} + x_{31} = 4$

$$x_{12} + x_{22} + x_{32} = 5$$
$$x_{13} + x_{23} + x_{33} = 8 \text{ and}$$
$$x_{14} + x_{24} + x_{34} = 6$$

Non-negativity condition: all $x_{ij} \geq 0$; i = 1, 2, 3 and j = 1, 2, 3, 4.

b. Five lathers are to be allotted to five operators (one for each). The following table gives weekly output figures (in pieces):

			Weekly Output			
		L_1	**L_2**	**L_3**	**L_4**	**L_5**
	P	**20**	**22**	**27**	**32**	**36**
Operators	**Q**	**19**	**23**	**29**	**34**	**40**
	R	**23**	**28**	**35**	**39**	**34**
	S	**21**	**24**	**31**	**37**	**42**
	T	**24**	**28**	**31**	**36**	**41**

Profit per piece is Rs. 25. Find the maximum profit per week.

Ans.4(b) The given matrix is:

			Weekly Output			
		L_1	L_2	L_3	L_4	L_5
	P	20	22	27	32	36
Operators	Q	19	23	29	34	40
	R	23	28	35	39	34
	S	21	24	31	37	42
	T	24	28	31	36	41

To solve it for maximization, subtract each cell from the largest value cell of the matrix which is 42 here. The resulting matrix is:

	L_1	L_2	L_3	L_4	L_5
P	22	20	15	10	6
Q	23	19	13	8	2
R	19	14	7	3	8
S	21	18	11	5	0
T	18	14	11	6	1

Apply row wise and column wise operations, the resulting matrix is:

	L_1	L_2	L_3	L_4	L_5
P	0	3	5	4	0
Q	5	6	7	6	0
R	0	0	0	0	5
S	5	7	7	5	0
T	1	2	6	5	0

.

Total no of lines covering all zeroes = 3 < the order of the matrix 5. Select the minimum value cell and subtract from the remaining, the matrix will be (2 is the minimum):

	L_1	L_2	L_3	L_4	L_5
P	0	1	3	2	0
Q	5	4	5	4	0
R	2	0	0	0	7
S	5	5	5	3	0
T	1	0	4	3	0

Again the no of lines covering all zeros is less than the order of the matrix, so repeating the above procedure 2-times, the resulting matrix will be:

	L_1	L_2	L_3	L_4	L_5
P	0	1	1	0	1
Q	4	3	2	1	0
R	4	2	0	0	10
S	4	4	2	0	0
T	1	0	2	1	1

Now the total no lines covering all zeroes = 5. Allocations can be made now as:

	L_1	L_2	L_3	L_4	L_5
P	0				
Q					0
R			0		
S				0	
T		0			

Thus the overall production per week is: $a_{11} + a_{25} + a_{33} + a_{44} + a_{52} = 20 + 40 + 35 + 37 + 28 = 160$ and the maximum profit is = 160*25 = Rs. 4000.

Q.5 a. Distinguish between total float and free float.

Ans.5(a) Total float:- The total amount of time that a schedule activity may be delayed from its early start without delaying the project finish date, or violating a schedule constraint. Calculated using the critical path method technique and determining the difference between the early finish dates and late finish dates. Total Float = LS – ES, where LS is late start time and ES is early start time.

Free float:- The amount of time that a schedule activity can be delayed without delaying the early start date of any immediately following schedule activities. FF = ES – EF, where ES is early start and EF is for early finish time.

Independent float:- Independent float is that portion of the total float within which an activity can be delayed for start without affecting the float of the preceding activities. It is computed for an activity by subtracting the tail event slack from its total float.

Thus, independent float can be calculated as under:

Independent Float = Total Float – Tail Event Slack

Note: In case negative value is obtained, it is taken as zero.

b. A project consists of eight activities with the following time estimates:

Activity	Immediate Predecessor	Time (days)		
		Optimistic	Most Likely	Pessemistic
A	---	1	1	7
B	---	1	4	7
C	---	2	2	8
D	A	1	1	1
E	B	2	5	14
F	C	2	5	8
G	D, E	3	6	15
H	F, G	1	2	3

(i) Draw a PERT network with the above information.

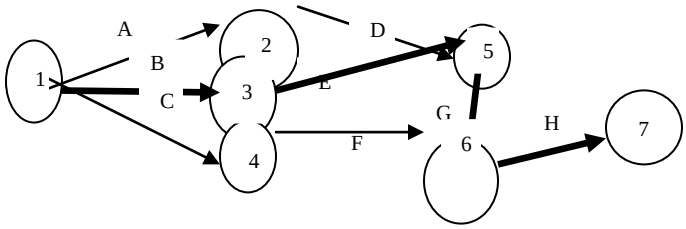
(ii) Determine the critical path

(iii) Find Earliest Start, Earliest Finish, Latest Start, Latest Finish times for

each activity

(iv) Also find Total Float

Ans.5(b) (i) PERT network is given below:



(ii) The computation of critical path is as follows:

Activity	Time (days)			$t_e = (t_0 + 4t_m + t_p) / 6$	Earliest Time		Latest Time		Total Float
	Optimistic t_o	Most Likely t_m	Pessimistic t_p		Start	Finish	Start	Finish	
A(1-2)	1	1	7	2	0	2	7	9	2
B(1-3)	1	4	7	4	0	4	0	4	0
C(1-4)	2	2	8	3	0	3	9	12	9
D(2-5)	1	1	1	1	3	4	9	10	4
E(3-5)	2	5	14	6	4	10	4	10	0
F(4-6)	2	5	8	5	3	8	12	17	9
G(5-6)	3	6	15	7	10	17	10	17	0
H(6-7)	1	2	3	2	17	19	17	19	0

Hence the critical path would be B----E----G----H with duration of 19 days.

Q.6 a. Define saddle point in a two-player zero-sum game. Find out the saddle point for the given pay-off matrix:

$$A = \begin{bmatrix} 3 & 4 & 1 & -2 \\ 2 & 5 & 2 & 4 \\ -5 & 2 & 1 & 0 \end{bmatrix}$$

Ans.6 (a) (i) Saddle point:- In a two-person Zero-sum game a pay-off matrix A = (a_{ij}) is given then the matrix has a saddle point (i, j) if $\min_j \max_i a_{ij} = \max_i \min_j a_{ij}$.

For the given pay-off matrix the saddle point is calculated as:

Player II chooses j

Player I chooses i	Strategy	1	2	3	4	Row min	
	1	3	4	1	−2	−2	
	2	2	5	**[2]**	4	2	←
	3	−5	2	1	0	−5	
	Col. max	3	5	2	4		
				↑			

By taking the maximum of the row minima we see that Player I is guaranteed not to get less than the amount 2 by choosing strategy 2, while, by considering the minimum of the column maxima, Player II is guaranteed not to lose more than 2 by choosing his strategy 3. The upshot is that they will settle on the (2,3) element which is worth 2 to Player I (-2 to Player II) and either player may be worse off if they deviate from the strategies indicated. The amount that they settle on, here 2, is known as the **value** of the game and the element (2,3) of the matrix is a **saddle point**.

b.Arrivals at a telephone booth are considered to be following Poisson distribution with an average time of 10 minutes between one arrival and the next. Length of a phone call is assumed to be distributed exponentially with mean 3 minutes. Find:

(i) What is the probability that a person arriving at the booth will have to wait? (ii) What is the average length of the queue that is formed time to time?
(iii) The telephone department will install a second booth when convinced that an arrival would expect waiting for at least 3 minutes for phone. By how much should the flow of arrivals increase in order to justify a second booth?

Ans. 6(b) Here $\lambda = 1/10 = 0.10$ and $\mu = 1/3 = 0.33$ person per minute

(i) The probability that a person has to wait is given by
$P(w > 0) = 1 - P_0 = 1 - (1 - \lambda / \mu) = \lambda / \mu = 0.10/ 0.33 = 0.3030.$

(ii) Length of the queue that form time to time is given by

$E(m/m > 0) = \frac{\mu}{\mu - \lambda} = \frac{0.33}{0.33 - 0.10} = 1.4348$, that is approximately 1 to 2 person in the queue.

(iii) The installation of second booth will be justified if the arrival rate is greater than the waiting time. Then the length of the queue will go on increasing.

Now, $E(w) = \frac{\lambda}{\mu(\mu-\lambda)} \Rightarrow 3 = \frac{\lambda'}{0.33(0.33-\lambda')}$ where λ' is the arrival rate for the second booth and 3 is the expected waiting time. On solving we obtained λ' = 0.1642. Hence the arrival rate should become 0.1642 person per minute to justify the second booth.

Q.7 a. Justify 'Management is an art or science'.

Ans.7(a) Management is an Art: Harnold Koontz has defined management as "the art of getting things done through people". Art is an born talent and refers to creative skills and talent which people require to conduct certain activities in order to accomplish certain goals.
It is an art because:

(i) Creative: Managers have to come with creative ideas to handle unique business problems.
(ii) Individual approach: Every manager need to adopt his individual approach of managing situations.
(iii) Application and dedication: Management requires not only skills and knowledge but there is also need for discipline, dedication and commitment.
(iv) Initiative: Managers take initiative in doing the right things at right time.
(v) Intelligence: Managers should possess mental intelligence, social intelligence, inter personal intelligence and emotional intelligence.

Management is a science: According to Taylor, who is the father of scientific management: "management has to be scientific". Beacause it deals with human beings, it is categorized as social science. Some of its features are:

(i) Systematic decision making: Before taking any decision right information from right source and at right time is to be collected.
(ii) Situational output: The output of management process may vary without change in the input. This is possible by providing some resources, tools, incentive and by motivation.
(iii) Universal management process: Each organization (large or small) follows same management process which includes planning, organizing, staffing etc.
(iv) Universally accepted management principles: Like science, principles of management are universally accepted by all organizations.

b. Define the principles of management given by Henry Fayol.

Ans.7(b) Management Principles developed by Henri Fayol:

1. **DIVISION OF WORK**: Work should be divided among individuals and groups to ensure that effort and attention are focused on special portions of the task. Fayol presented work specialization as the best way to use the human resources of the organization.

2. **AUTHORITY**: The concepts of Authority and responsibility are closely related. Authority was defined by Fayol as the right to give orders and the power to exact obedience. Responsibility involves being accountable, and is therefore naturally associated with authority. Whoever assumes authority also assumes responsibility.

3. **DISCIPLINE**: A successful organization requires the common effort of workers. Penalties should be applied judiciously to encourage this common effort.

4. **UNITY OF COMMAND**: Workers should receive orders from only one manager.

5. **UNITY OF DIRECTION**: The entire organization should be moving towards a common objective in a common direction.

6. **SUBORDINATION OF INDIVIDUAL INTERESTS TO THE GENERAL INTERESTS**: The interests of one person should not take priority over the interests of the organization as a whole.

7. **REMUNERATION**: Many variables, such as cost of living, supply of qualified personnel, general business conditions, and success of the business, should be considered in determining a worker's rate of pay.

8. **CENTRALIZATION**: Fayol defined centralization as lowering the importance of the subordinate role. Decentralization is increasing the importance. The degree to which centralization or decentralization should be adopted depends on the specific organization in which the manager is working.

9. **SCALAR CHAIN**: Managers in hierarchies are part of a chain like authority scale. Each manager, from the first line supervisor to the president, possess certain amounts of authority. The President possesses the most authority; the first line supervisor the least. Lower level managers should always keep upper level managers informed of their work activities. The existence of a scalar chain and adherence to it are necessary if the organization is to be successful.

10. **ORDER:** For the sake of efficiency and coordination, all materials and people related to a specific kind of work should be treated as equally as possible.

11. **EQUITY**: All employees should be treated as equally as possible.

12. **STABILITY OF TENURE OF PERSONNEL**: Retaining productive employees should always be a high priority of management. Recruitment and Selection Costs, as well as

increased product-reject rates are usually associated with hiring new workers.

13. **INITIATIVE**: Management should take steps to encourage worker initiative, which is defined as new or additional work activity undertaken through self direction.

14. **ESPIRIT DE CORPS**: Management should encourage harmony and general good feelings among employees.

Q.8 a. Define the various steps involved in the process of decision making.

Ans.8(a) Steps of Decision Making Process:

Following are the important steps of the decision making process. Each step may be supported by different tools and techniques.

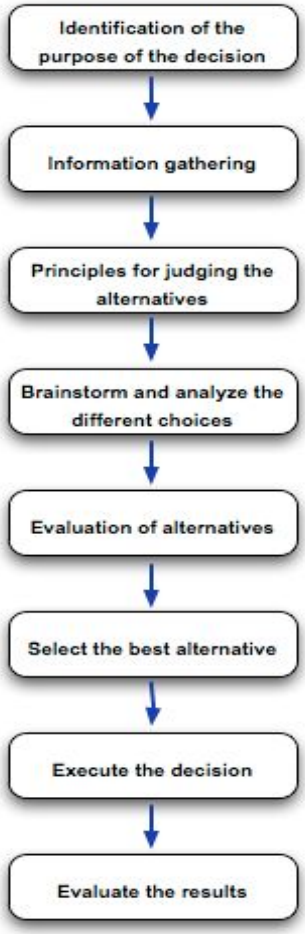
Step 1: Identification of the purpose of the decision:

In this step, the problem is thoroughly analysed. There are a couple of questions one should ask when it comes to identifying the purpose of the decision.

- What exactly is the problem?
- Why the problem should be solved?
- Who are the affected parties of the problem?
- Does the problem have a deadline or a specific time-line?

Step 2: Information gathering:

In the process of solving the problem, you will have to gather as much as information related to the factors and stakeholders involved in the problem. For the process of information gathering, tools such as 'Check Sheets' can be effectively used.



Step 3: Principles for judging the alternatives:

In this step, the baseline criteria for judging the alternatives should be set up. When it comes to defining the criteria, organizational goals as well as the corporate culture should be taken into consideration.

Step 4: Brainstorm and analyze the different choices:

For this step, brainstorming to list down all the ideas is the best option. Before the idea generation step, it is vital to understand the causes of the problem and prioritization of causes.

For this, you can make use of Cause-and-Effect diagrams and Pareto Chart tool. Cause-and-Effect diagram helps you to identify all possible causes of the problem and Pareto chart helps you to prioritize and identify the causes with highest effect.

Then, you can move on generating all possible solutions (alternatives) for the problem in hand.

Step 5: Evaluation of alternatives:

Use your judgment principles and decision-making criteria to evaluate each alternative. In this step, experience and effectiveness of the judgment principles come into play. You need to compare each

alternative for their positives and negatives.

Step 6: Select the best alternative:

Once you go through from Step 1 to Step 5, this step is easy. In addition, the selection of the best alternative is an informed decision since you have already followed a methodology to derive and select the best alternative.

Step 7: Execute the decision:

Convert your decision into a plan or a sequence of activities. Execute your plan by yourself or with the help of subordinates.

Step 8: Evaluate the results:

Evaluate the outcome of your decision. See whether there is anything you should learn and then correct in future decision making. This is one of the best practices that will improve your decision-making skills.

b.Differentiate between qualitative methods and quantitative methods of forecasting.

Ans.8(b) ***Forecasting Methods***: Methods of forecasting fall into two basic categories -- qualitative methods and quantitative methods.

Qualitative Methods are used for long-term strategic planning. The methods make use of

- Management judgment
- Expertise, opinion
- Market research based on surveys, demographics, and focus groups
- Management, marketing, purchasing, and engineering knowledge of trends in their disciplines

The Delphi method:

- It is a procedure to solicit forecasts from experts
- A series of questionnaires is developed and sent to several anonymous experts. Questions are developed specifically to assess predictions of future events.
- The experts answer the questions. The answers are compiled and sent to all the experts along with a new set of questions to refine their responses.
- The process goes through several rounds until some of level of consensus is reached about the likely events of the future.
- Informed judgments are useful in some instances, but the results of the Delphi technique are generally mixed.

Quantitative Methods - two basic types exist.

(i) **Times series** methods use past data to predict the future. Time is the only predictor.

(ii) **Causal forecasting** methods attempt to develop a mathematical relationship, in the form of a regression model, between demand and factors that cause it to behave the way it does.

Time Series: y = f(t); demand is a function of time (alone). Types include:

- Moving Average
- Simple Moving Average
- Weighted Moving Average
- Exponential Smoothing
- Adjusted exponential smoothing
- Linear trend line with t (time) as predictor

Q.9 Write short notes on any <u>TWO</u> of the following:

(i) Leadership styles

(ii) Market segmentation

(iii) Types of Communication

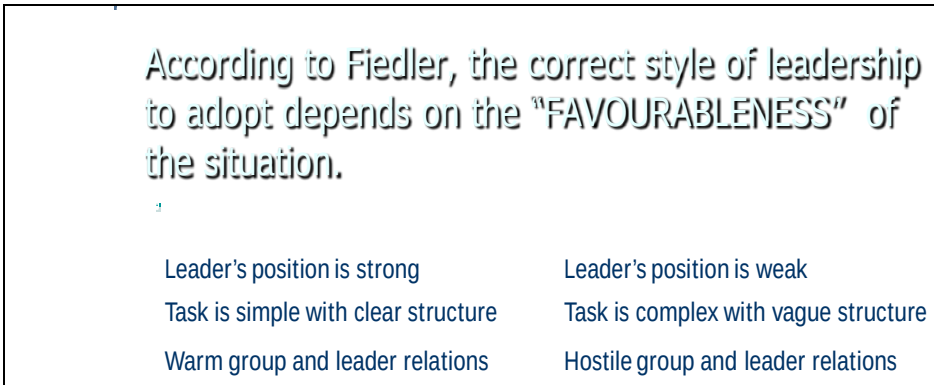
Ans.9(a): Fiedler identified two types of leadership in his contingency model:

1. Task-orientated or Autocratic leaders: Makes ALL the decisions and is motivated to complete the task as quickly and effectively as possible. This leadership style does not take into account the opinions or preferences of the group.

This style would be most effective when quick decisions are needed for large groups of people, and in potentially dangerous situations that could be life threatening.

2. Social or Person-orientated leaders also referred to as Democratic leaders: Shares the decisions with the group and is often ready to share responsibility.

This type of leader believes in consultation and is interested in developing meaningful inter-personal relationships within the team. This style would be effective in co-active games with no time constraints and where personal support may be required.



Ans.9(b) The process of defining and subdividing a large homogenous market into clearly identifiable segments having similar needs, wants, or demand characteristics. Its objective is to design a marketing mix that precisely matches the expectations of customers in the targeted segment. Few companies are big enough to supply the needs of an entire market; most must breakdown the total demand into segments and choose those that the company is best equipped to handle.

Four basic factors that affect market segmentation are

1. clear identification of the segment,
2. measurability of its effective size,
3. its accessibility through promotional efforts, and
4. Its appropriateness to the policies and resources of the company.

The four basic market segmentation-strategies are:

Geographic segmentation: It focuses on:

- **climate** - beer / Schnapps
- **city size -** number of franchise outlets, Foodplus / McDonalds
- **population density -** building industry, retail industry.

Demographic segmentation

Demographic segmentation focuses on:

- **age -** relevant to the nature of the product, eg. pensioners' insurance, barbie dolls
- **gender -** eg. lingerie, Marlboro/Alpine
- **income -** Club Med Lindeman Island, American Express Gold Card
- **education -** Financial Review / Herald Sun
- **family life cycle -** HBA singles, Parents magazine, Bride, Tarago
- **occupation -** marketing magazines, 4 WD Hi-ace.

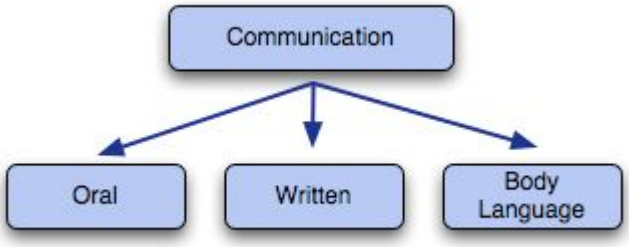
Psychographic segmentation:
State of mind characteristics includes:

- **social class -** old money / new money
- **personality -** sportsgirl / new woman
- **lifestyles -** activities, interest, opinion; beliefs, attitudes;

Behavior segmentation
Behavior segmentation focuses on:

- **occasion -** Christmas / Mother's Day / Easter
- **benefit segmentation -** healthy / low calories / great taste; taste / Macleans 'Smile' / Colgate tartar control
- **user status -** non-users, trialists, regular users
- **usage rate -** light, medium, heavy
- **loyalty status -** brand loyals, brand switchers, new or non-category users

Ans.9(c) Types of Communication



Oral Communication:

Oral communication could be said to be the most used form of communication. Whether it is to present some important data to your colleagues or lead a boardroom meeting, these skills are vital. We are constantly using words verbally to inform our subordinates of a decision, provide information, and so on. This is done either by phone or face-to-face.

The person on the receiving end would also need to exercise much caution to ensure that he/she clearly understands what is being said. This shows therefore that you would need to cultivate both your listening

and speaking skills, as you would have to carry out both roles in the workplace, with different people.

Written Communication:

Writing is used when you have to provide detailed information such as figures and facts, even while giving a presentation. It is also generally used to send documents and other important material to stakeholders which could then be stored for later use as it can be referred to easily as it is recorded. Other important documents such as contracts, memos and minutes of meetings are also in written form for this purpose. It can be seen in recent years, however, that verbal communication has been replaced to a great extent by a faster form of written communication and that is email. You could also use videoconferencing and multiple way phone calls with several individuals simultaneously. Apart from a few glitches that could occur, these methods of communication have helped organizations come a long way.

Body Language:

Although the most common methods of communication are carried out orally or in writing, when it comes to management techniques, the power of non-verbal communication must never be underestimated. Your smile, your gestures and several other body movements send out a message to the people around you. You need to be mindful of this while dealing with your employees and customers. Always remember to maintain eye contact. This would show that you are serious and confident about what is being said.

Textbook

1. Operations Research, An Introduction, Hamdy A. Taha, Eight Edition, PHI, 2007

2. Engineering Management, Fraidoon Mazda, Low Price Indian Edition, Addison-Wesley