B.E.

Seventh Semester Examination, Dec, 2009

OPERATION RESEARCH

Note : Attempt five questions. All questions carry equal marks.

Q. 1. Define Operation Research. What are applications and limitations of O.R. in industry?

Ans. After tracing the process of establishment and growth of Operations Research, we can consider it as a source to other new sciences. Literally, the word 'operation' may be defined as some action that we apply to some problems of hypotheses and the word 'research' is an organised process of seeking out facts about the same. In fact, it is very difficult to define O.R., mainly because of the fact that its boundaries are not clearly marked. O.R. has been variously described as the "science of use", "quantitative common sense," "scientific approach to decision making problems", etc. But only a few are commonly used and widely accepted, namely,

(i) "OR is the art of giving bad answers to problems which otherwise have worse answers."

—**T.L. Satty**

(ii) "OR is a scientific method of providing executive departments with a quantitative basis for decisions under their control."

—**P.M. Morse and G.E. Kimball**

(iii) "OR is the application of scientific methods, techniques and tools for problems involving the operations of a system so as to provide those in control of the system with optimum solutions to the problem."

—**Churchman, Ackoff and Arnoff**

(iv) "OR is applied decisions theory. It uses any scientific, mathematical, or logical means to attempt to cope with the problems that confront the executive, when he tries to achieve a thorough-going rationality in dealing with his decision problems."

—**D.W. Miller and M.K. Starr**

(v) "OR is the attack of modern science on problems of likelihood that arise in the management and control of men and machines, materials and money in their natural environment, its special technique is to invent a strategy of control by measuring, comparing and predicting probable behaviour through a scientific model of a situation."

—**Beer**

OR is mainly concerned with the techniques of applying scientific knowledge, besides the development of science. It provides an understanding which gives the expert/manager new in sights and capabilities to determine better solutions in his decision-making problems, with great speed, competence and confidence. Following are the five major areas of research that have proved amenable to the particular techniques of O.R. :

1. O.R. is useful to the Directing Authority in deciding optimum allocation of various limited resources such as men, machines, material time, money etc. for achieving the optimum goal.

2. O.R. is useful to production specialist in :

   (i) Designing, selecting and locating sites;

   (ii) Determining the number and size;

   (iii) Scheduling and sequencing the production runs by allocation of machines; and

   (iv) Calculating the optimum product mix.

3. O.R. is useful to the Marketing Manager (executive) in determining :

   (i) How to buy, how often to buy, when to buy and what buy at the minimum possible cost;

   (ii) Distribution points to sell the products and the choice the customers;

   (iii) Minimum per unit sale price;

   (iv) *The customer's preference relating to the size*, colour, paging, etc., for various products and the size of the to meet the future demand; and

   (v) The choice of different media of advertising.

4. O.R. is useful to the Personnel Administration in finding out :

   (i) Skilled persons at a minimum cost;

   (ii) The number of persons to be maintained on full time in a variable workload, like freight handling, etc.,;

   (iii) The optimum manner of sequencing personnel to a vast of jobs.

5. O.R. is useful to the financial controller .. :

   (i) Find out a profit plan for the company;

   (ii) Determine the optimum replacement policies; and

   (iii) Find out the long-range capital requirements as well as ways and means to generate these requirements.

Keeping in view the above few cited applications, it may no surprising to say that O.R. is used in almost every walk of life, when a decision is sought.

Techniques of O.R.

By this time O.R. has developed so widely that it may not be post to enumerate all the available techniques of O.R. under a common satisfaction. However, some of the commonly accepted well-defined problems of O.R. is used in almost every walk of life, where a decision is sought.

3. Techniques of O.R. :

By this time O.R. has developed so widely that it may not be to enumerate all the available techniques of O.R. under a common satisfaction. However, some of the commonly accepted well-defined problem of O.R. can be classified as follows :

1. Allocation problems
2. Competitive problems
3. Waiting line problems
4. Sequencing problems.

Limitations of O.R. :

Formulation of industrial problems may be generalised into different groups of classical problems, the package programme for which is available for mechanisation and for manual solutions.

Various problems of optimization can be brought to the model of a linear programme for which solution is available. During formulating the problem, the class of the problem is to be decided and the parameters are to be defined accordingly.

Inventory control, production planning, product mix, transportation problem, etc., are very common to the industries. The cost reduction with the help of these tools is very much powerful in comparison to any other conventional method. We can enumerate the advantages of these techniques as :

(i) Optimum use of production factors :

Linear programming techniques indicates how a manager can most effectively employ his production factors by more efficiently selecting and distributing these elements.

(ii) Improved quality of decision :

The computation table gives a clear picture of the happenings within the basic restrictions and the possibilities of compound behaviour of the elements involved in the problem. The effect on the profitability due to changes in the production pattern will be clearly indicated in the table, e.g., Simplex Table.

(iii) Preparation of future managers :

These methods of substitute a means for improving the knowledge and skill of young managers.

(iv) Modification of Mathematical Solution :

O.R. presents a possible practical solution when one exists, but it is always a responsibility of the manager to accept or modify the solution before its use. The effect of these modifications may be evaluated from the computational steps and tables.

(v) Alternative solutions :

O.R. techniques will suggest all the alternative solutions available for the same profit so that the management may decide on the basis of its strategies.

In spite of these advantages, O.R. techniques have certain limitations also, which are listed below :

(a) Practical application :

Formulation of an industrial problem to an O.R. set programme is a difficult task.

(b) Reliability of the proposed solution :

A non-linear relationship is changed to linear for fitting the problem to linear programming pattern. This may disturb the solution.

(c) Money and time cost :

Particularly when the basic data is subject to frequent changes, the cost of changing programmes manually is a costly affair.

(d) Combining two or more objective functions :

Very frequently maximum profit does not come from manufacturing the maximum quantum of the most profitable product at the most convenient machine and at the minimum cost, since this way lead to underutilization of certain lines of production.

Q. 2. (a) Solve by graphical method.

$$\text{Minimize } 4X_1 + 2X_2$$

$$\text{subject to } X_1 + X_2 \geq 3$$

$$X_1 - X_2 \geq 2;\ X_1, X_2 \geq 0$$

Ans. Mini. $4x_1 + 2x_2$

Sub to. $x_1 + x_2 \geq 3$

$x_1 - x_2 \geq 2$

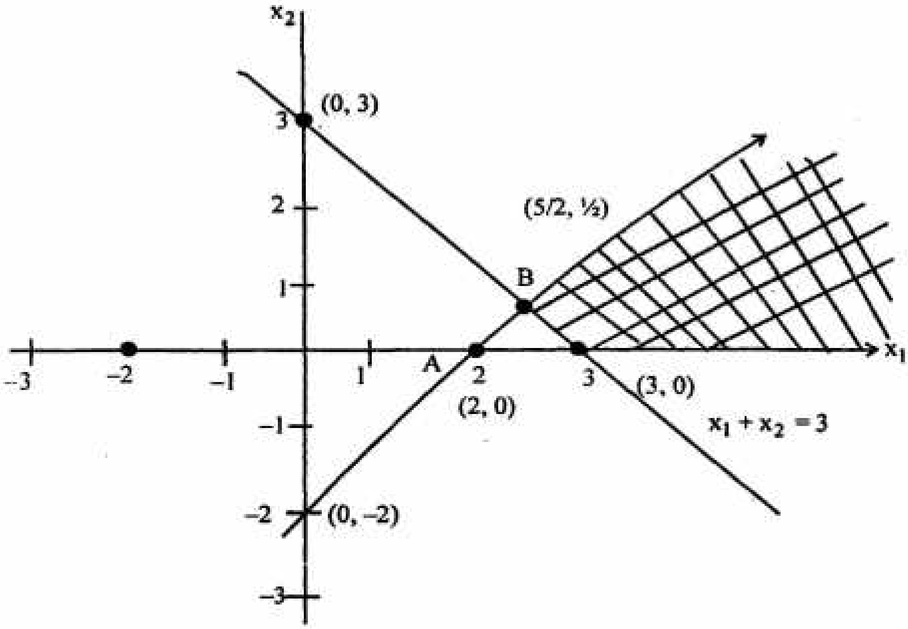
$x_1, x_2 \geq 0$

Corresponding equality is

$$x_1 + x_2 = 3 \qquad \& \qquad x_1 - x_2 = 2$$

x_1	0	0
x_2	3	0

x_1	0	2
x_2	−2	0



Optimal feasible region is unbounded corner points are $B\left(\frac{5}{2},\frac{1}{2}\right)$, $C(3,0)$

$$Z_B = 4\left(\frac{5}{2}\right)+2\left(\frac{1}{2}\right)=11$$

$$Z_C = 4(3)+2(0)=12$$

Minimum value is at $B\left(\frac{5}{2},\frac{1}{2}\right)$ is 11

Solution is $x_1 = \frac{5}{2}$, $x_2 = \frac{1}{2}$

Minimize = 11

$$\boxed{x_1 = \frac{5}{2},\ x_2 = \frac{1}{2},\ \text{mini}\ z = 11}.$$

Q. 2. (b) Write the dual of the above problem and solve the dual by simplex method.

Ans. Dual of the Q 2. (a) is

Maximum. $3y_1 + 2y_2$

Sub. to. $y_1 + y_2 \le 4$

$$y_1 - y_2 \le 2$$

$$y_1,\ y_2 \ge 0$$

To solve it by simplex method, first write it in standard form,

Max., $3y_1 + 2y_2$

Sub to. $y_1 + y_2 + s_1 = 4$

$$y_1 - y_2 + s_2 = 2$$

$$y_1, y_2 \geq 0$$

Starting simplex table is,

	$C_j = 3$	2	0	0	Mini		
C_B	Basic variable	b	y_1	y_2	s_1	s_2	
0	s_1	4	1	1	1	0	$4/1=4$
0	s_2	2	$\boxed{1}$	-1	0	1	$2/1=2$
	$\Delta_j = C_j - Z_j$	3	2	0	0		

C_B	Basic	b	y_1	y_2	s_1	s_2	Mini ratio
0	8	2	0	$\boxed{2}$	1	-1	$2/2=1$
3	y_1	2	1	-1	0	1	–
	$\Delta_j = C_j - Z_j$	0	5	0	-3		

		C_j	3	2	0	0
C_B	Basic	b	y_1	y_2	s_1	s_2
2	y_2	1	0	1	$\frac{1}{2}$	$-\frac{1}{2}$
3	y_1	3	1	0	$\frac{1}{2}$	$\frac{1}{2}$

$$\Delta_j = C_j - Z_j \qquad 0 \qquad 0 \qquad -5/2 \qquad -\frac{1}{2}$$

$\because$ all Δ_j are either –ve or zero so we get optimal solution.

$$\Rightarrow \qquad y_1 = 3,\ y_2 = 1$$

$$\text{Max. value } 3(3) + 2(1) = 11.$$

Q. 3. (a) Solve the LPP by Dual Simplex method.

$$\textbf{Maximize } -2X_1 - 2X_2 - 4X_3$$

$$\textbf{subject to } 2X_1 + 3X_2 + 5X_3 \geq 2;$$

$$3X_1 + X_2 + 7X_3 \geq 3$$

$$X_1 + 4X_2 + 6X_3 \geq 5;$$

$$X_1 \geq 0,\ X_2 \geq 0,\ X_3 \geq 0.$$

Ans.

$$\text{Maximum } z = -2x_1 - 2x_2 - 4x_3$$

$$\text{Sub. to. } 2x_1 + 3x_2 + 5x_3 \geq 2$$

$$3x_1 + x_2 + 7x_3 \geq 3$$

$$x_1 + 4x_2 + 6x_3 \leq 5$$

$$x_1,\ x_2,\ x_3 \geq 0$$

Convert the $\geq$ type constraints to $\leq$ type, we get

$$\text{Maximum. } z = -2x_1 - 2x_2 - 4x_3$$

$$\text{Sub to: } -2x_1 - 3x_2 - 5x_3 \leq -2$$

$$-3x_1 - x_2 - 7x_3 \leq -3$$

$$-x_1 - 4x_2 - 6x_3 \leq -5$$

$$\Rightarrow \quad -2x_1 - 3x_2 - 5x_3 + s_1 = 2$$

$$-3x_1 - x_2 - 7x_3 + s_2 = -3$$

$$-x_1 - 4x_2 - 6x_3 + s_3 = -5$$

	C_j	-2	-2	-4	0	0	0	
C_B	Basic	b	X_1	X_2	X_3	s_1	s_2	s_3
0	s_1	-2	-2	-3	-5	1	0	0
0	s_2	-3	-3	-1	-7	0	1	0
0	s_3	-5	-1	$\boxed{-4}$	-6	0	0	1
	$\Delta_j = C_j - z_5$	-2	-2	-4	0	0	0	

$\because$ b_3 is must –ve it becomes outgoing variable

$$\frac{-2}{-1} = 2, \frac{-2}{-4} = \frac{1}{2}, \frac{-4}{-6} = \frac{2}{3}$$

Since the smaller ratio is $\frac{1}{2}$

	C_B	Basic	b	X_1	X_2	X_3	s_1	s_2 s_3
0	s_1	7/4	-5/4	0	-1/2	1	0	-3/4
0	s_2	7/4	-11/4	0	-11/2	0	1	-1/4

–2	x_2	5/4	1/4	1	$\frac{3}{2}$	0	0	$\frac{-1}{4}$
	$\Delta_j =$	–3/2	0	–1	0	0	$\frac{1}{2}$	

$\because$ All b_j are the it becomes optimal solution.

$$x_1 = 0,\ x_2 = 5/4,\ x_3 = 0.$$

Q. 3. (b) Discuss the concept of travelling salesman problem.

Ans. Travelling salesman problem :

Suppose a salesman has to visit n cities. He wishes to start from a particular city, visit each city once, and then return to his starting point. The objective is to select the sequence in which the cities are visited in such a way that his total travelling time is minimized. Clearly, starting from a given city, the salesman will have a total of $(n-1)!$ different sequences (possible round trips). Further, since the salesman has to visit all the n cities, the optimal solution remains independent of selection of the starting point.

The problem can be represented as a network where the nodes and arcs represent the cities and the distance between them, respectively. Let in a five-city problem, a round trip of the salesman be given by the following arcs :

$$(3, 1), (1, 2), (2, 4), (4, 5), (5, 3)$$

These arcs, taken in order, the called the first, second, third, fourth and fifth directed arcs for the trip. In general the k^{th} directed arc represents the k^{th} leg of the trip, i.e., on leg k the salesman travels from city i to city j $(i, j = 1, 2, \ldots\ldots, n;\ i \neq j)$.

To formulate the problem whose solution will yield the minimum travelling time, let the variables $x_{i,k}$ be defined as

$$x_{ijk} = \begin{cases} 1, & \text{if } k^{th} \text{directed arc is from city } i \text{ to city } j, \\ 0, & \text{Otherwise} \end{cases}$$

where i, j and k are integers that vary between 1 and n.

Following are the constraints of the problem :

(a) Only one directed arc may be assign : to a specific k, thus,

$$\sum_{\substack{i\ j \\ i \neq j}} x_{ijk} = 1 \quad k = 1, 2, \dots\dots\dots, n$$

(b) Only one other city may be reached from a specific city i, thus

$$\sum_{j}\sum_{k} x_{ijk} = 1 \quad i = 1, 2, \dots\dots\dots, n$$

(c) Only one other city can initiate a direct arc to a specified city j, thus,

$$\sum_{i}\sum_{k} x_{ijk} = 1 \quad j = 1, 2, \dots\dots\dots, n$$

(d) Given the k^{th} directed arc ends a some specific city j, the (k+1)th directed arc must start at the same city j; thus

$$\sum_{\substack{i \\ i \neq j}} x_{ijk} = \sum_{\substack{r \\ r \neq j}} x_{jr}(k+1), \text{ for all j and k}$$

These constraints ensure that the round trip will consists of connected directed arcs. The objective function is to minimize,

$$z = \sum_{i}\sum_{j}\sum_{k} d_{ij}\, x_{ijk}, \quad i \neq j$$

where d_{ij} is the distance from city i to city j.

Formulation of travelling salesman problem as an assignment problem.

The travelling salesman problem is very similar to the assignment problem except that in the former, there is an additional restriction. A similar problem crisis when n items say A_i, $i = 1, 2, \dots\dots\dots$, n are to be processed on a machine in a scheduled time. The problem then becomes of choosing the sequence of these items. Let the set up cost of the machine when item A_i is followed by A, be c_{ij}. Also let $x_{ij} = 1$ if item A_t is followed by A_j directly and 0 otherwise. It is to be noticed that $c_{ij} = \infty$ when i = j, i.e., the item A_j is not processed again after A_i. It is important to note that only one $x_{ij} = 1$ for each value of i and for each value of j.

In view of above, the assignment problem can be solved and one may hope that the solution satisfies the additional restriction also.

If the solution to the assignment problem does not satisfy the additional restriction, then after solving the problem by assignment technique, we use the method of enumeration.

Q. 4. (a) Solve the initial basic feasible solution to the transportation problem by the method of NWCR and VAM. The following table gives transportation time (in hours) from factories to warehouses :

	W_1	W_2	W_3	W_4	
F_1	25	30	20	40	37
F_2	30	25	20	30	22
F_3	40	20	40	35	32
	25	20	25	21	

Ans.

	W_1	W_2	W_3	W_4	
F_1	25	30	20	40	37
F_2	30	25	20	30	22
F_3	40	20	40	35	32
	25	20	25	21	

NWCR Method :

This feasible solution is non-degenerate basic feasible solution; for the allocated cells do not form a loop. The transportation cost according to the above route is given by

$$Z = 25 \times 25 + 12 \times 30 + 8 \times 25 + 14 \times 20 + 11 \times 40 + 21 \times 35$$

$$= 625 + 360 + 200 + 280 + 440 + 735$$

$$= 2640$$

VAM Method :

$$20 \times 20 + 22 \times 20 + 40 \times 3 + 25 \times 25 + 40 \times 12 + 35 \times 9$$

$$400 + 440 + 120 + 625 + 480 + 315$$

$$= 2380$$

Q. 4. (b) Discuss the concept of assignment problems.

Ans. The assignment problem :

The assignment problem is a special case of the transportation problem in which the objective is to assign a number of origins to the equal number of destinations at a minimum cost (or maximum profit). The assignment is to be made on a one-to-one basis.

Example of an assignment problem :

There are n jobs for a factory and the factory has n machines to process the jobs. A job i (= 1, ..., n) when processed by the machine j (= 1, ..., n) is assumed to incur a cost c_{ij}. The assignment is to be made in such a way that each job can associate with one and only one machine. Determine an assignment of jobs to machines so as to minimize the overall cost.

Mathematical formulation of the problem :

Let x_{ij} be a variable defined by,

$$x_{ij} = \begin{cases} 0 & \text{if the ith job is not assigned to the jth machine} \\ 1 & \text{if the ith job is assigned to the jth machine} \end{cases}$$

then clearly, since only one job is to be assigned to each machine, we have,

$$\sum_{i=1}^{n} x_{ij} = 1$$

and
$$\sum_{j=1}^{n} x_{ij} = 1$$

Also, the total assignment cost is given by

$$z = \sum_{j=1}^{n}\sum_{i=1}^{n} x_{ij} c_{ij}$$

Thus, the assignment problem takes the following mathematical form :

Determine, $x_{ij} \geq 0$ (i, j = 1...............n) so as to

$$\text{Minimize } z = \sum_{i=1}^{n}\sum_{j=1}^{n} x_{ij} c_{ij}$$

Subject to the constraints :

$$\sum_{i=1}^{n} x_{ij} = 1 \qquad j = 1, 2, ...n$$

and

$$\sum_{j=1}^{n} x_{ij} = 1 \qquad i = 1, 2, ...n$$

$$\text{with} \qquad x_{ij} = 0 \qquad \text{or} \qquad 1$$

The special structure of Assignment Problem allows a more convenient method of solution.

Q. 5. Based on the activities given below :

(a) Draw the network diagram

(b) Determine the Critical path

(c) Determine project completion time

(d) Determine total float for each activity

Activity	A	B	C	D	E	F	G	H
Predecessor	–	A	A	B	C, B	E	D	F, D
Optimistic Time	2	8	14	4	6	6	18	8
Most likely Time	4	12	16	10	12	8	18	14

Pessimistic Time	**6**	**16**	**30**	**16**	**18**	**22**	**30**	**32**	

Ans.A project is represented by the network in Fig. 20.11 and has the following :

Task	A	B	C	D	E	F	G	H	I
Largest Time	5	18	26	16	15	6	7	7	3
Greatest Time	10	22	40	20	25	12	12	9	5
Most Likely Time	8	20	33	18	20	9	10	8	4

Determine the following :

(a) Expected task times and their variance,

(b) The earliest and latest expected times to reach each node,

(c) The critical path, and

(d) The probability of a node occurring at the proposed completion date if the marginal contract time of completing the project is 41.5 weeks.

(a) The expected task time, t_e, is calculated by using the three given estimated times in the relation,

$$t_e = \frac{t_0 + 4t_m + t_2}{6}$$

The variance, $_c{}^2$, for the tasks is calculated by the formula,

$$e^2 = \left(\frac{t_p - t_0}{6}\right)^3$$

The following table provides the required information regarding t_0 and σ^2

Table

Task	t_0	t_p	t_m	t_e	σ^2
(1, 2)	5	10	8	7.8	0.694

(1, 3)	18	22	20	20.0	0.444
(1, 4)	26	40	33	33.0	5.429
(2, 5)	16	20	18	18.0	0.443
(2, 6)	15	25	20	20.0	2.780
(3, 6)	6	12	9	9.0	1.00
(4, 7)	7	12	10	9.8	0.694
(5, 7)	7	9	8	8.0	0.111
(6, 7)	3	5	4	4.0	0.111

(b) T_e or $E\{u_1\}$, the earliest expected times for each node is obtained by taking the sum of the expected times for all the activities leading to node i. When more than one activity leads to a node i, the greatest of $E\{u_1\}$ is chosen. Thus, we have

$$E\{\mu_1\} = 0$$

$$E\{\mu_2\} = 0 + 7.8 = 7.8\text{m}$$

$$E\{\mu_3\} = 0 + 20.0 = 20.0$$

$$E\{\mu_4\} = 0 + 33.0 = 33.0$$

$$E\{\mu_5\} = 7.8 + 18.0 = 25.8$$

$$E\{\mu_6\} = \max.\{7.8 + 20.0, 20.0 + 9.0\} = 29.0$$

$$E\{\mu_7\} = \max.\{33.0 + 9.3,\ 25.8 + 8.0,\ 29.0 + 4.0\} = 42.8$$

For the latest expected times as start with T_L for the last node as equal to T_6 or $\{E\mu_1\}$. Now for each path move backwards, subtracting the "t_s" for each activity link. Thus, we have

$$E\{L_1\} = 42.8$$

$$E\{L_6\} = 42.8 - 4.0 = 38.8$$

$$E\{L_5\} = 42.8 - 8.0 = 34.8$$

$$E\{L_4\} = 42.8 - 9.8 = 33.0$$

$$E\{L_3\} = 38.8 - 9.0 = 29.8$$

$$E\{L_2\} = \min.\{34.8 - 18.0,\ 38.8 - 20.0\} = 16.8$$

$$E\{L_1\} = \min.\{16.8 - 7.8,\ 29.8 - 20.0,\ 33.0,\ 33.0\} = 0$$

(c) For the critical path, we calculate the slack time by taking the different between the earliest expected times and latest allowable times, that is $T_s = T_L - T_r$. Once the slack times are known to us, the critical path may be determined by finding the path with zero slack. The critical path for the problem under consideration is shown in fig. 20.12. This is shown by the dark double line on the activity chart. The following table gives the calculations for T_s, T_L and T_s.

Table PERT Calculations :

Node	t_s	$E\{u_i\}$	$E\{L_i\}$	T_s	$Var\{\mu_j\}$
		T_e	T_L		σ_t^2
2	78	78	16.8	9.0	0.694
3	20.0	20.0	29.8	9.8	0.444
4	33.0	33.0	33.0	0.0	5.429
5	18.0	25.8	34.8	9.0	1.137
6	9.0	29.0	38.8	9.8	1.444

7	9.8	42.8	42.8	0.0	6.123

(d) The scheduled time of completing the project is 41.5 weeks. Therefore, the distance in standard deviations, that schedule time is from T_s, is given by

$$D_t = \frac{ST_i - E\{\mu_i\}}{\sqrt{\mathrm{var}\{\mu_i\}}} = \frac{41.5 - 42.8}{\sqrt{6123}} = -0.52$$

where ST_i denotes the schedule time.

Therefore, we shall have

$$P\{z \le D_i\} = 0.30$$

which is the area under standard normal curve bounded by ordinates at x = 0 and x = 0.52.

The physical interpretation of this is that if the project is performed hundred times under the same conditions, then there will be 30 occasions when this job would take 41.5 weeks or less to complete it. In other words, only 70 times the job would take time longer than 41.5 weeks.

Q. 6. Assuming Poisson arrival rate and exponential service time for M/M/1 system, the mean arrival rate is 8 per hour and the mean service time is 6 minutes. Determine :

(a) Probability that the system is busy

(b) Average time spent by customer in queue.

(c) Average length of the queue

(d) Average number of customers in the system.

Ans. Here, $\lambda = 8$ per hour

$$\mu = \frac{1}{6} \times 60 = 10 \text{ per hour}$$

$$\delta = \frac{\lambda}{\mu} = \frac{8}{10} = .8$$

(a) Probability that the system is busy or the person arriving have to wait is

$$\Rightarrow \qquad 1-\left(1-\frac{\lambda}{\mu}\right)=\frac{\lambda}{\mu}=.8$$

(b) Average time of a customer (in a queue) is given by,

$$\frac{\lambda}{\mu(\mu-\lambda)}=\frac{8}{10(10-8)}=\frac{8}{10\times 2}=.4$$

(c) Average length of the queue

$$=\frac{\lambda^2}{\mu(\mu-\lambda)}=\frac{8^2}{10(10-8)}=\frac{64}{10(2)}=3.2$$

(d) Average no of customer to the system.

$$=\frac{\lambda}{\mu-\lambda}=\frac{8}{10-8}=4.$$

Q. 7. (a) What is simulation? Discuss its different models and applications in industry.

Ans. Introduction :

Simulation is a method of solving decision-making problems by designing, constructing and manipulating a model of the real system. It is defined to be the action of performing experiments on a model of a given system. It duplicates the essence of a system or activity without actually obtaining the reality. Here a system is defined as a collection of entities or components which act and interact together towards the accomplishment of some logical end or a goal and a model as a representation of the system.

It is easy to see that many problems in industry, business and administration in reality are extremely complex in nature. Generally, in attempting to solve them scientifically, we find that one of the following three cases arises :

(a) The problem is amenable to both description and analysis by a mathematical model.

(b) The problem is amenable to description by a mathematical model; however, correct analysis of the model is beyond the level of mathematical sophistication of the analyst.

(c) Even the description by a mathematical model is beyond the capabilities of the analyst.

It is found that in a large number of situations, the focus is sufficient to give one useful insight into the decision problem. Before deciding the use of simulation as a technique for system analysis, the following advantages should be weighed against the disadvantages and limitations of the simulation technique.

Advantages :

1. It is useful in solving problems where all values of the variables are not known, or partly known in advance and there is easy way to find these values.

2. The model of a system, once constructed, may be employed as often as desired to analyse different situations.

3. Simulation methods are handy for analysing proposed system in which information is sketchy at best.

4. The effect of using model can be observed without actually using it in the real situation.

5. Usually data for further analysis can be easily generated from a simulation model.

6. Simulation methods are easier to apply than pure analytical methods. The non-technical executives can comparehend simulation better.

Disadvantages :

1. Adequate knowledge of the parts of the system in no sense guarantees adequate knowledge of the system behaviour.

2. Simulation, model is "run" rather than solved.

3. Simulation does not produce optimal result. It provides a satisfactory approach only.

4. Each simulation run is like a single experiment conducted under a given set of conditions. A number of simulation runs are necessary and thus time consuming procedures.

5. People develop the tendency of using it even if analytical techniques are better suited in the situation.

Simulation may be defined as a quantitative technique that uses a computerized symbolic model in order to represent actual decision-making under uncertainty for determining alternative courses of action based upon facts and assumptions. To elaborate, simulation involves the construction of symbolic model that describes the systems' operation in terms of individual events and components; dividing the system into smaller component parts and combining them in their natural and logical order; analysing the effects of their interactions on one another (probably by a computer analysis); studying various specific alternatives with reference to the performance of the model and choosing the best one .

Q. 7. (b) Discuss different models of decision making.

Ans. Classification of O.R. models :

"Model building is the essence of the Operations Research approach .

Although the classification of O.R. models is a subjective probability several basic types of O.R. models may be distinguished as follows :

1. Ionic (Physical) Models are pictorial representation of systems and have the appearance of the real thing. Examples of models are : a child's toy, a photograph, a schedule of operation a histogram, a physical model such as a small-scale model of a build an engine, etc. These kinds of models are called 'Iconic' because they 'look-alike' items to understand and interpret. An ionic model is said be 'scaled-down' or 'scaled-up' according as the dimensions of the are smaller-down' or 'scaled-up' according as the dimensions of the model are smaller or greater than those of the real item. For instance, in biological the structure of a cell may be illustrated by an enlarged (scaled Ionic model for teaching purposes.

Iconic models are easy to observe, build and describe, but difficult to manipulate and not very useful for the purpose of predict. Commonly, these models represent a static event.

These models of do not include those aspects of the real system are irrelevant for the analysis. For example, in the scientific study of structure of an atom, the colour of the model is irrelevant whereas relative locations of the sphere are not relevant features of the system represented. It is possible to construct iconic models up to three dimensions (e.g., atom, globe, small aeroplane, etc.) whereas it is not possible to construct them physically for higher dimensions. This calls for separate category of models.

2. Analogue models are more abstract than the iconic ones for there is no 'look-alike, correspondence between those models and real items. They are built by utilizing one set of properties to represent another set of properties. For instance, a network of pipes through which water is running could be used as a parallel for understanding the distribution of electric currents. Graphs and maps in various colours are analogue models in which different colours correspond to different characteristics, e.g., blue representing water, brown representing land, yellow representing production, etc. Demand curves, flow charts in production control and frequency curves in statistics are analogue models of the behaviour of events. Graphs of time series, stock-market changes are other examples of analogue models. Analogue models are easier to manipulate and can represent dynamic situations. These are, generally more useful than the iconic ones because of their vast capacity to represent the characteristics of the real system under investigation.

3. Mathematical (symbolic) models are most abstract in nature. They employ a set of mathematical symbols to represent the components (and relationships between them) of the real system. These models are most general and precise. However, it is not always possible to depict a real system in mathematical formulation, sometimes it is easier to use mathematical symbols for describing the relationship of the components and sometimes an analogue model may express the pattern of this relationship in a better way.

(a) Combined analogue and mathematical models :

Sometimes, analogue models described by means of mathematical symbols may belong to both type 2 and type 3 models. For example, simulation model is of the analogue type but uses formulae. This model is very commonly used by the managers to 'simulate' their decisions, by studying the activity of the firm summarised in a scaled-down period.

(b) Function Models :

Models may also be grouped according to the function performed. For example, a function may serve to acquaint the analyst with such thing as a blueprint of layouts, tables carrying data, a schedule indicating a sequence of operations (e.g., in computer programming), etc.

(c) Quantitative models are those models that can measure the observations. A yardstick, a unit of measurement of length, value, degree of temperature, etc., are quantitative models. Other examples of quantitative models are the transformation models that help in converting a measurement of one scale into one of the other scales (e.g., Logarithmic tables, Centigrades v.s., Fahrenheit conversion scale) and the test models, that act as 'standards' against which measurements are compared (e.g., a specified standard in production control, business dealings, the quality of a medicine).

(d) Qualitative models are those that can be classified by the subjective description. Examples of these are the "economic models" and that "business models" which represent the gathering of all models pertaining to economic or business problems, respectively.

Q. 8. Write notes on :

(a) **Resource Levelling**

(b) **Design of simulation**

(c) **Float.**

Ans. (b) Design of simulation :

Step (i) : Select the measure of effectiveness

Step (ii) : Decide the variables which influence the measure of effectiveness significantly.

Step (iii) : Determine the cumulative probability distribution for each variable in step (2)

Step (iv) : Get a set of random numbers.

Step (v) : Consider each random number as a decimal value of the cumulative probability distribution.

Step (vi) : Insert the simulated values so generated into the formula derived from the chosen measure of effectiveness.

Step (vii) : Repeat step (v) and (vi), until sample is large enough for the satisfaction of the decision maker.