The finished cars are transported in a specially arranged lorry accommodating 200 cars. Using following 15 random numbers:
82, 89, 78, 24, 53, 61, 18, 45, 04, 23, 50, 77, 27, 54, 10
Simulate the process to find out:
(a) What will be the average number of cars waiting in the factory?
(b) What will be the average number of empty spaces on the lorry?

Q.6 i. What do you mean by Replacement models. Classify the different type of replacement models. also explain the term money value. **4**

ii. The data collected in running a machine, the cost of which is Rs 7,000 are given below: **6**

Year	1	2	3	4	5	6	7	8
Maintenance Cost (Rs.)	900	1200	1600	2100	2800	3700	4700	5900
Resale value (Rs.)	4000	2000	1200	600	500	400	400	400

Determine the optimum period for replacement of the machine.

OR iii. The management of a hotel having 500 rooms each having 6 bulbs, replace the bulb as they fail cost Rs. 3 each. The cost reduces by Rs. 2 per bulb by adopting periodic replacement policy. It is proposed to replace all bulbs at fixed intervals, whether or not they have fail or not, and to continue replacing individual bulb as they fail. On the basis of given information **6**

Month of use	1	2	3	4	5
Percent of bulbs failing by that month	10	25	50	80	100

What replacement policy from group and individual shall be followed?

******

Total No. of Questions: 6 *Total No. of Printed Pages:4*

Enrollment No.....................................

Faculty of Management Studies
End Sem (Even) Examination May-2019
MS5CO11 Operations Research

Programme: MBA Branch/Specialisation: Management

Duration: 3 Hrs. **Maximum Marks: 60**

Note: (a) All questions are compulsory. Internal choices, if any, are indicated. Answers of Q.1 (MCQs) should be written in full instead of only a, b, c or d.
(b) Use of non-programmable calculator is allowed.

Q.1 i. The innovative science of Operations Research was discovered during ____. **1**
(a) World War I (b) World War II
(c) Civil War (d) Industrial Revolution

ii. In maximization problem, optimal solution occurring at corner point yields the **1**
(a) Mean value of z (b) Highest value of z
(c) Modal value of z (d) None of these

iii. In an assignment problem number of tasks are m and number of machines are n, then which condition should be satisfied **1**
(a) $m < n$ (b) $m = n$ (c) $m > n$ (d) None of these

iv. When total supply is equal to total demand in a transportation problem, the problem is said to be **1**
(a) Unbalanced (b) Non-degenerate
(c) Balanced (d) None of these

v. In a Transition probability matrix of Markov process, the element a_{ij} Where $i = j$ is a **1**
(a) Gain (b) Loss (c) Retention (d) None of these

vi. Which of following characteristics are used to apply on a queuing system? **1**
(a) Arrival process (b) Service mechanism
(c) Both (a) and (b) (d) None of these

vii. What happens when maximin and minimax values of the game are same? **1**
(a) No solution exists (b) Solution is mixed
(c) Saddle point exist (d) None of these

viii. Pseudo random numbers are, the numbers that are **1**
(a) Calculator generated (b) Computer generated
(c) Both (a) and (b) (d) None of these

ix. The problem of replacement is felt when job performing units fail **1**
(a) Suddenly (b) Gradually (c) Both (a) and (b) (d) (a) but not (b)

x. If r is the rate of interest, then the discount factor is given by **1**
(a) $(1 + r)^{-1}$ (b) $(1 + r)^{2}$ (c) $(1 - r)^{3}$ (d) $(1-r)$

Q.2 i. A diet for a sick person must contains at least 4000 units of vitamins, 50 units of minerals and 1400 units of calories. Two foods A and B are available at a cost of Rs. 4 and Rs. 3 per unit respectively. If one unit of A contains 200 units of vitamins, 1 unit of mineral and 40 units of calories and one unit of B food contains 100 units of vitamins, 2 units of minerals and 40 units of calories, formulate it as a linear programming problem to minimize cost and solve it graphically. **4**

ii. Explain any three characteristics and three application of Operations Research. **6**

OR iii. Use Simplex method to solve the Linear Programming Problem **6**

$Maximize\ Z = 4x_1 + 10x_2$

Subject to $2x_1 + x_2 \leq 50$

$2x_1 + 5x_2 \leq 100$

$2x_1 + 3x_2 \leq 90\ x_1, x_2 \geq 0$

Q.3 i. Write Hungarian Algorithm to solve an assignment problem? **4**

ii. An organization wants to decide the optimal shipments of a product to four retailers from its three warehouses. The cost of shipment per unit from each warehouse to each retailer and the requirements and availability of the product are given below in the table. **6**

	Retail Outlet					
		R_1	R_2	R_3	R_4	Availabilities
Warehouses	W_1	21	16	25	13	11
	W_2	17	18	14	23	13
	W_3	32	27	18	41	19
Requirements		6	10	12	15	

Find initial basic feasible solution using VAM and then get optimal solution.

OR iii. A company four territories open and four salesmen are available for the assignment. maximize the total profit if profit matrix is given as **6**

Sales in thousand rupees					
		1	2	3	4
Salesman	A	42	35	28	21
	B	30	25	20	15
	C	30	25	20	15
	D	24	20	16	12

Q.4 i. Define Markov process, Transition probability matrix of Markov process, disciplines of a queuing system, queue length. **4**

ii. Recently, a market research team has conducted a survey of consumer buying habits with respect to three brands of talcum powder in an area. It estimates that at present 20% of customer buy brand A, 50% of customer buy brand B and 30% of the customer buy brand C. In addition, the firm has analysed its survey data and has determined the following brand switching matrix. **6**

Brand next bought

$$\text{Brand just bought}\quad \begin{array}{c} \\ A \\ B \\ C \end{array} \begin{array}{c} \begin{array}{ccc} A & B & C \end{array} \\ \begin{bmatrix} 0.6 & 0.3 & 0.1 \\ 0.4 & 0.5 & 0.1 \\ 0.2 & 0.1 & 0.7 \end{bmatrix} \end{array}$$

What will be the expected distribution of customers two time periods late?

OR iii. A branch of Punjab national Bank has only one typist. Since the typing work varies in length, the typing rate is randomly distributed approximating a poission distribution with mean service rate of 8 letters per hour. The letters arrive at a rate of 5 per hour during the entire 8 hours work day. If the typewriter is valued at rupees 150 per hour. Determine **6**

(a) Equipment utilization and the percent time that an arriving letter has to wait.

(b) Average system time.

(c) Average cost due to waiting on the part of the typewriter i.e. it is remaining idle.

Q.5 i. Write all the steps of Monte Carlo technique for simulation. **4**

ii. Solve the following 2 x 4 game by graphical method **6**

Player B					
		B_1	B_2	B_3	B_4
Player A	A_1	3	3	4	0
	A_2	5	4	3	7

OR iii. The automobile company manufactures around 200 cars. The daily production varies from 196 to 204 depending upon the availability of raw materials and other working conditions: **6**

Production (per day)	196	197	198	199	200	201	202	203	204
Probability	0.05	0.09	0.12	0.14	0.20	0.15	0.11	0.08	0.06

Faculty of Management
End Sem. May 2019.
MS5C011 Operations Research.
(MBA).

MCQ. (Solution)

Q1. (i) (b) World war II 1
(ii) (b) Highest value of Z. 1
(iii) (b) $m=n$ 1
(iv) (c) balanced 1
(v) (c) retention 1
(vi) (c) both a) and b) 1
(vii) (c) Saddle point exist 1
(viii) (b) Computer generated 1
(ix) (c) both a and b. 1
(x) (a) $(1+r)^{-1}$ 1

Q2 (i) The data can be summarised as.

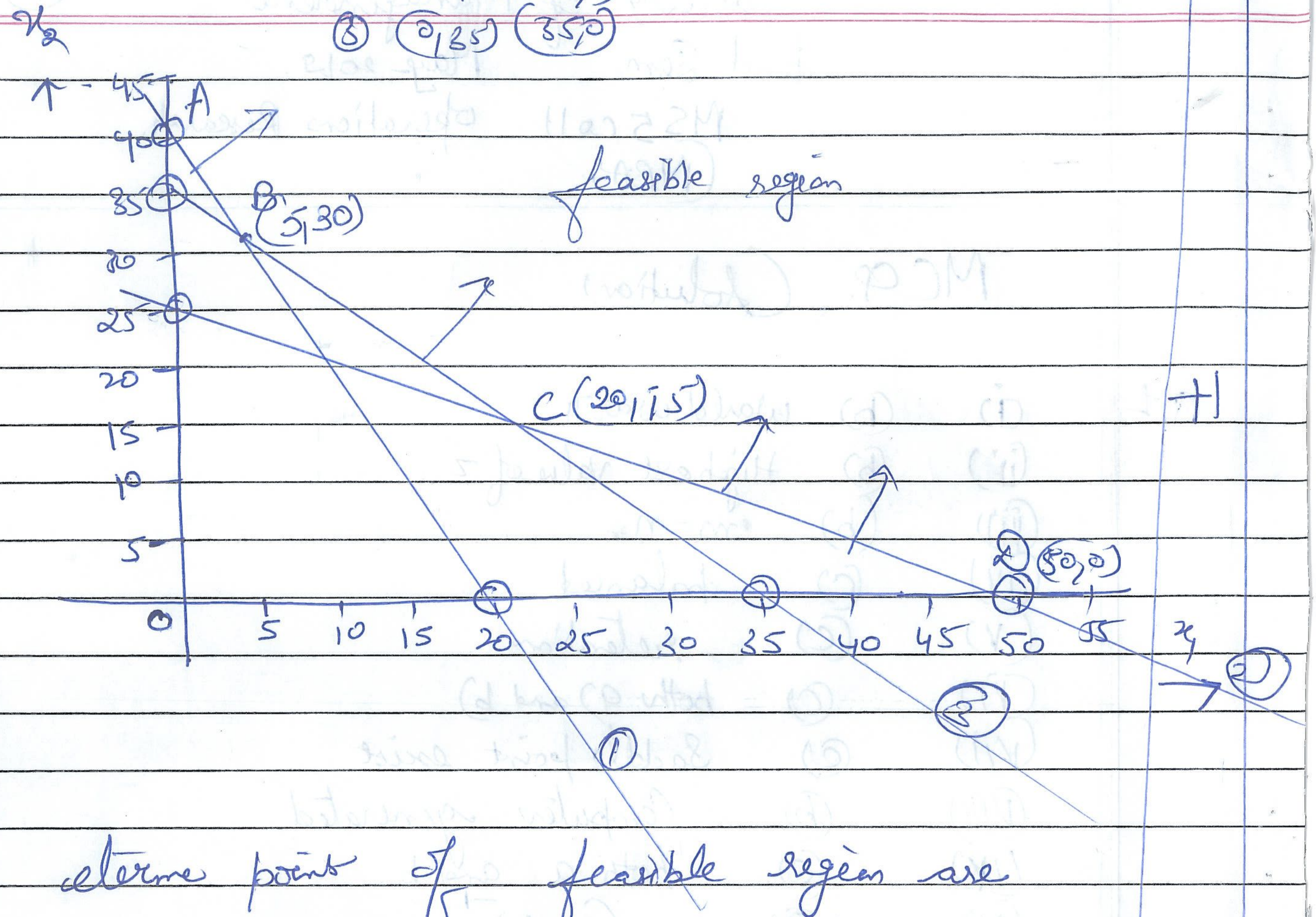
Food	Contents Vitamin	Mineral	Calories	Cost per unit
A	200	1	40	4
B	100	2	40	3
Minimum requ.	4000	50	1400	

Let x_1 denote no of units of A
x_2 " " " of B
LP Model of given problem is

$$\text{Min } Z = 4x_1 + 3x_2$$ +2

s.t. $200x_1 + 100x_2 \geq 4000$ (Vitamin)
$x_1 + 2x_2 \geq 50$ (mineral)
$40x_1 + 40x_2 \geq 1400$ (calories)
& $x_1, x_2 \geq 0$.

point on ① (0,40) (20,0)
② (0,25) (50,0)
③ (0,35) (35,0)



extreme point of feasible region are

A B C D.

Now value of objective function at each extreme point is

point		$Z = 4x_1 + 3x_2$
A	(0,40)	$Z = 4\times0 + 3\times40 = 120$
B	(5,30)	$Z = 5\times4 + 30\times3 = 110$
C	(20,15)	$Z = 20\times4 + 3\times15 = 125$
D	(50,0)	$Z = 50\times4 + 0\times3 = 200$

$\therefore$ $x_1 = 5$ $x_2 = 30$

Min $Z = 110$ units (Rupees).

2

Q2(ii) characteristics of OR [Any three]
(1) inter-diciplinary team approach
(2) System oriented
(3) Scientific approach
(4) Improvements in solutions
(5) optimization of total output

Applications
(1) In personal management
(2) In finance and accounting
(3) In purchasing
(4) In Research and development
(5) In Production management
(6) In marketing

+3

+3

revised L.P. using slack variable

OR (iii) Max $Z = 4x_1 + 10x_2 + 0.S_1 + 0.S_2 + 0.S_3$

St. $2x_1 + x_2 + S_1 + 0.S_2 + 0.S_3 = 50$

$2x_1 + 5x_2 + 0.S_1 + S_2 + 0.S_3 = 100$

$2x_1 + 3x_2 + 0.S_1 + 0.S_2 + S_3 = 90$

$x_i, S_j \geq 0$. x_1, x_2 $i = 1, 2$ $j = 1, 2, 3$ $S_1 S_2 S_3 \geq 0$

+1

Basic variable S_1, S_2, S_3

table I

	C_j		4	10	0	0	0	
C_B	X_B	X_0	x_1	x_2	S_1	S_2	S_3	X_0/Min
0	S_1	50	2	1	1	0	0	50
0	S_2	100	2	5	0	1	0	20
0	S_3	90	2	3	0	0	1	30
			+4	10	0	0	0	

+2

depart $\Rightarrow S_2$

entre $\Rightarrow x_2$

Key 5

table 2.

C_B	X_B	C_j / x_0	x_1 (4)	x_2 (10)	S_1 (0)	S_2 (0)	S_3 (0)	Minratio x_0
0	S_1	30	8/5	0	1	-1/5	0	
10	x_2	20	2/5	1	0	1/5	0	
0	S_3	30	4/5	0	0	-3/5	1	
	$C_j - Z_j$		0	0	0	-2		

+2

all $C_j - Z_j \leq 0$

$x_1 = 0$ $x_2 = 120$ Max $Z = 200$ +1

Q3 (i) Hungarian Algo

I If the no of rows are not equal to no of colum and vice versa, then a dummy row or colum must be added. with zero cost elements

II find the smallest cost in each row of the cost matrix. subtract this smallest cost element from each element in that row. Therefore, there will be at least on zero in each row of this new matrix, which is called the first reduced cost matrix

III In the reduced cost matrix, find the smallest element in each Colum. & Subtract the smallest cost element from each element in that colum. As a result there would be at least one zero in each row and colum of the second reduced cost matrix +2

IV Determi the optimum assignment by encircli zero in each row. Then colum assignment

V An optimal assignment is found. If the number of assigned cells equals the number of rows.

VI Draw the min^m no of st lines covering all zeroes by inspection.
If the minimum no of lines passing through all zeros is equal to the number of rows or column, the optimum solution is attained by another way & get optimal sol^n. +2

If not then revise the cost matrix.
(a) select min of all uncovered ele.
(b) subtract it from all uncovered ele
(c) add it intersection of two lines
(d) again repeat step VI.

Q3(ii)

balanced = 43 = 43
using VAM.

	O_1	O_2	O_3	O_4	supply
S_1	21	16	25	13	11
S_2	(6) 17	(3) 18	14	(4) 23	13
S_3	32	(7) 27	(12) 18	41	19
demand	6	10	12	15	43

+3

cost = 796

Modi- Method.

$3+4-1=6$ non-degenerate

$C_{ij} = u_i + v_j$ (occupied)

$\Delta_{ij} = C_{ij} - (u_i + v_j)$

Δ_{ij}
○

occupied

C_{ij}	d_{ij}
	u_i+v_j

unoccupied, for un-occupied cell.

–	–	–	13 (11)	$u_1 = -10$
17 (6)	18 (3)	–	23 (4)	$u_2 = 0$
–	24 (7)	18 (12)	–	$u_3 = 9$

$v_1 = 17 \quad v_2 = 18 \quad v_3 = 9 \quad v_4 = 23$

Now $\Delta_{ij} = C_{ij} - (u_i + v_j)$

21, 4, $\boxed{7}$	16, 8, $\boxed{18}$	24, 25, $\boxed{-1}$	⊙	$u_1 = -10$
⊙	⊙	14, $\boxed{9}$	⊙	$u_2 = 0$
32, 6, $\boxed{26}$	⊙	⊙	41, 9, $\boxed{32}$	$u_3 = 9$

$v_1 = 17 \quad v_2 = 18 \quad v_3 = 9 \quad v_4 = 23$

all $\Delta_{ij} \geq 0$

current solⁿ is optimal solⁿ.

is $= 796$

OR (iii) given profit matrix and balanced convert in to cost matrix
Highest element − each element of Matrix(Profit) +1

∴ Cost matrix is

	I	II	III	IV
A	0	7	14	21
B	12	17	22	27
C	12	17	22	27
D	18	22	26	30

row reduction. +2

$$\begin{array}{c|c} & \begin{array}{cccc} I & II & III & IV \end{array} \\ \begin{array}{c} A \\ B \\ C \\ D \end{array} & \begin{bmatrix} 0 & 7 & 14 & 21 \\ 0 & 5 & 10 & 15 \\ 0 & 5 & 10 & 15 \\ 0 & 4 & 8 & 12 \end{bmatrix} \end{array}$$

Colum reduction.

$$\begin{array}{c|c} & \begin{array}{cccc} I & II & III & IV \end{array} \\ \begin{array}{c} A \\ B \\ C \\ D \end{array} & \begin{bmatrix} \boxed{0} & 3 & 6 & 9 \\ \cancel{0} & 1 & 2 & 3 \\ \cancel{0} & 1 & 2 & 3 \\ \cancel{0} & 0 & 0 & 0 \end{bmatrix} \end{array}$$

not optimal

draw lines (straight) covering all zeros.

using hungarian method.

$$\begin{array}{c|cccc} & I & II & III & IV \\ A & \boxed{0} & 2 & 5 & 8 \\ B & \cancel{0} & \boxed{0} & 1 & 2 \\ C & \cancel{0} & \cancel{0} & 1 & 2 \\ D & 1 & \cancel{0} & 0 & 0 \end{array}$$

Two optimal sol^n

$$\begin{array}{c|cccc} & I & II & III & IV \\ A & \boxed{0} & 2 & 4 & 7 \\ B & \cancel{0} & \cancel{0} & \boxed{0} & 1 \\ C & \cancel{0} & \boxed{0} & \cancel{0} & 1 \\ D & 2 & 1 & \cancel{0} & \boxed{0} \end{array}$$

$$\begin{array}{c|cccc} & I & II & III & IV \\ A & \boxed{0} & 2 & 4 & 7 \\ B & 0 & \boxed{0} & 0 & 1 \\ C & 0 & 0 & \boxed{0} & 1 \\ D & 2 & 1 & 0 & \boxed{0} \end{array}$$ +2

A	– I	42
B	– III	20
C	– II	25
D	– IV	12
		99

or

A	– I	42
B	– II	25
C	– III	20
D	– IV	12
		99

+1

Q4. (i)

Markov Process: It is a method used to forecast the value of a variable whose future value is influenced only by its current position or state.
In a Markov process various states are defined. If the probabilit depends upon only on the present state referred as one stage dependence. +1

(TPM)

S_j (next state) $n=1$

S_i

$n=0$

current state

$$\begin{bmatrix} P_{11} & P_{12} & P_{13} & \cdots & P_{1m} \\ P_{21} & P_{22} & P_{23} & \cdots & P_{2m} \\ P_{31} & & & & \\ \vdots & \vdots & \vdots & & \vdots \\ P_{m1} & P_{m2} & P_{m3} & \cdots & P_{mm} \end{bmatrix}$$ +1

with two imp properties

(i) $\sum_{j=1}^{m} P_{ij} = 1$ (sum of element of each row is 1)

(ii) P_{ij} ; $0 \le P_{ij} \le 1$

queue discipline :- FCFS, LCFS, SIRO, Priority Based. +1

queue length : It represent the number of customers waiting to be served. It does not include the customer being served. +1

(ii) we are given initial probability vector

$$R_0 = [0.2 \quad 0.5 \quad 0.3]$$ +1

$$TPM = \begin{bmatrix} 0.6 & 0.3 & 0.1 \\ 0.4 & 0.5 & 0.1 \\ 0.2 & 0.1 & 0.7 \end{bmatrix}$$

After one period

$$R_1 = R_0 \times P = [0.2 \quad 0.5 \quad 0.3] \begin{bmatrix} 0.6 & 0.3 & 0.1 \\ 0.4 & 0.5 & 0.1 \\ 0.2 & 0.1 & 0.7 \end{bmatrix}$$ +2

$$= [0.38 \quad 0.34 \quad 0.28]$$

Two period later $R_2 = R_1 \times P = R_0 P^2$

$$= [0.38 \quad 0.34 \quad 0.28] \begin{bmatrix} 0.6 & 0.3 & 0.1 \\ 0.4 & 0.5 & 0.1 \\ 0.2 & 0.1 & 0.7 \end{bmatrix}$$ +3

$$= [0.42 \quad 0.312 \quad 0.268]$$

here $\lambda = 5$ per hour
4 OR.
$\mu = 8$ per hour
(5) (iii) (a) Equipment utilization

$$\rho = \frac{\lambda}{\mu} = \frac{5}{8} = 0.625$$

% time an arriving letter has to wait (i.e. busy) $= \rho \times 100 = 62.5\%$ +2

(b) $W_s = \frac{1}{\mu - \lambda} = \frac{1}{3}$ hr $= 20$ mins +2

(c) average cost due to waiting on the part of the typewriter per day +2

$$= P_0 \times 8 \times 1.50$$
$$= \left(1 - \frac{5}{8}\right) \times 8 \times 1.50 = 4.50 \text{ Rs/day}$$

Q5 (i) Steps of Monte Carlo Simulation.

1. Study the problem & formulate
2. Construct the model and develop a probability distribution for those variable which we are considering in the model
3. Determine the cumulative probability distribution of each random variable +2
4. Select random number generator and create the random numbers for simulation model
5. Determine the values of random number in the range and examine the result in appropriate table. +2
6. Evaluate the result of simulation and select best course of action.

6

$$\begin{array}{cc|cccc} & & & B & & \\ & & B_1 & B_2 & B_3 & B_4 \\ A & A_1 & 3 & 3 & 4 & 0 \\ & A_2 & 5 & 4 & 3 & 7 \end{array}$$

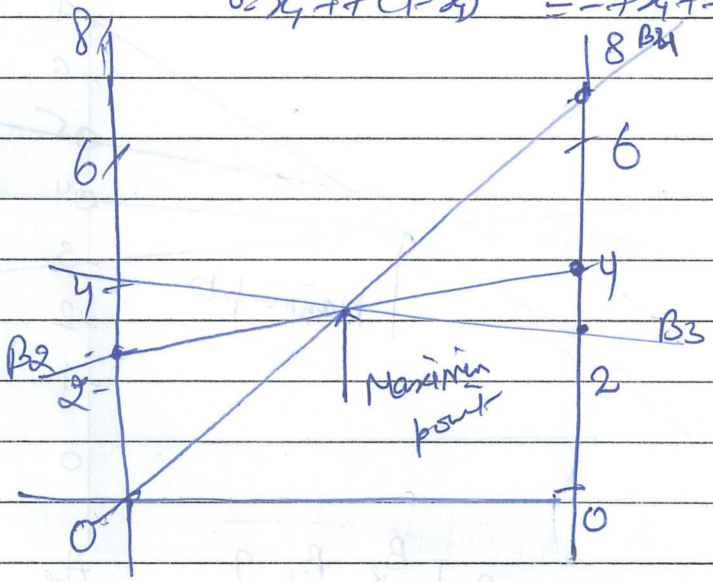
The game has no saddle point / Two ways to solve.

using dominance rule

$$\begin{array}{c|ccc} & B_2 & B_3 & B_4 \\ A_1 & 3 & 4 & 0 \\ A_2 & 4 & 3 & 7 \end{array}$$

B's pure strat.	A's expected payoff
B_2	$3x_1 + 4(1-x_1) = -x_1 + 4$
B_3	$4x_1 + 3(1-x_1) = x_1 + 3$
B_4	$0x_1 + 7(1-x_1) = -7x_1 + 7$

+2



+3

$$\begin{array}{c|cc|c} & B_2 & B_3 & \\ A_1 & 3 & 4 & 1/2 \\ A_2 & 4 & 3 & 1/2 \\ & 1/2 & 1/2 & \end{array}$$

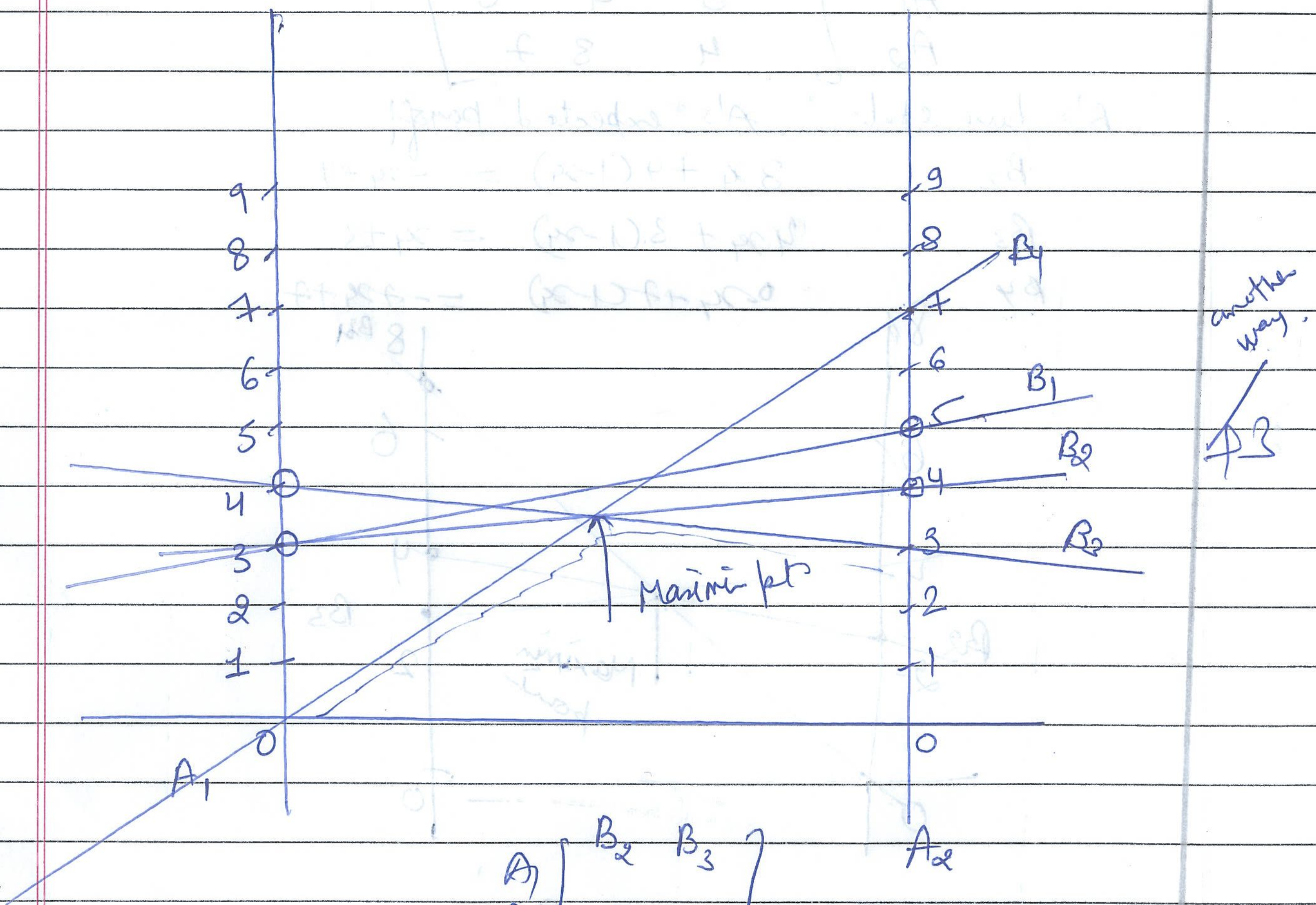
$A = (1/2\ 1/2)$ +1

$B = (0, 1/2, 1/2, 0)$

$V = \frac{7}{2}$

Or

Another graph pattern is also correct which will give same result as shown before.
if we plot directly the given data without using dominance rule



$$\begin{array}{c} \\ A_1 \\ A_2 \end{array}\begin{array}{c} \begin{matrix} B_2 & B_3 \end{matrix} \\ \left[\begin{matrix} \quad & \quad \\ \quad & \quad \end{matrix}\right] \end{array}$$

Same as given above

$A\ (1/2, 1/2)$ $\qquad V = 7/2$

$B\ (0, \frac{1}{2}, \frac{1}{2}, 0)$

Q5 OR (iii) I Table to create random number interval

Production per day	probability	Cumulative probability	Random number interval
196	.05	.05	00-04
197	.09	0.14	05-13
198	0.12	0.26	14-25
199	0.14	0.40	26-39
200	0.20	0.60	40-59
201	0.15	0.75	60-74
202	0.11	0.86	75-85
203	0.08	0.94	86-93
204	0.06	1.00	94-99

PB

Table 2 Simulation table [Can be done in two ways]

Day	Random No.	Production per day	No. of unit waiting (200 space)	Empty space in lorry
1	82	202		
2	89	203	2	–
3	78	202	5	–
4	24	198	7	–
5	53	200	5	–
6	61	201	5	–
7	18	198	6	–
8	45	~~198~~ 200	4	–
9	04	~~200~~ 196	4	–
10	23	~~202~~ 198	–	–
11	50	~~199~~ 200	–	2
12	77	~~200~~ 202	–	–
13	27	199	2	–
14	54	200	1	–
15	10	197	1	–
			– (42)	2 (4)

PB

OR

Assumption we made for this table 2 is that no of cars waiting in factory is treated opening stock of next day

Avg no of cars waiting in factory = 42/15 = 2.8 / day

Avg no of empty space in lorry = 4/15 = 0.27 / days

If we want to simulate the II way production per day for just to get excess production or short production. Then closing stock of a day need not be taken as opening stock of next day

Day	Random Number	production per day	~~unit~~ No of unit ~~transported~~ waiting	empty space
1	82	202	2	–
2	89	203	3	–
3	78	202	2	–
4	24	198	–	2
5	53	200	–	–
6	61	201	1	–
7	18	198	–	2
8	45	200	0	~~0~~ –
9	04	196	–	~~2~~ 4
10	23	198	–	2
11	50	200	–	–
12	77	202	2	–
13	27	199	–	1
14	54	200		–
15	10	197	–	3
			10	14

Avg no of unit waiting in factory = 10/15 = 0.67 / day

Avg Empty Space = 14/15 = 0.93 / day

Q6 (i) Replacement problem is concerned with the problem of replacement of certain item due to their deteriorating efficiency failure or breakdown

Broadly two types.

a) when the item deteriorate with time and value of money +2

I does not change with time

II changes with time

(b) when the item fail completely all of a sudden.

(individual + group replacement)

Money value – The quantity $(1.1)^{-n}$ is called the present or worth of one rupee spent n years from now. +2

If interest rate is r, then present value of a rupee paid at the end of one year would be $(1+r)^{-1}$.

Q6 (ii)

year (n)	Run Cost f(t)	$\Sigma f(t)$	C (7000)	(S) Resale Value	C-S	TC = C-S+$\Sigma f(t)$	ATC (n)
1	900	900	4000	3000	3900	3900	
2	1200	2100	2000	5000	7100	6050	
3	1600	3700	1200	5800	9500	3166.66	
4	2100	5800	600	6400	12,200	3050	+4
5	2800	8600	500	6500	15,100	3020	
6	3700	12,300	400	6600	18,900	3150	
7	4700	17000	400	6600	23,600	3371	
8	5900	22,900	400	6600	29,500	3687	

at the end of 5th year machine should be replaced +2

Q6 (iii) OR

I Individual replacement

Let P_i be the probability of failure of bulb in i^{th} month $(i = 1,2,3,4,5)$. Then we get following probability distribution.

$P_1 = 10\% = \frac{10}{100} = 0.1$

$P_2 = \frac{25-10}{100} = 0.15$

$P_3 = \frac{50-25}{100} = 0.25$

Sim: $P_4 = 0.30$ $P_5 = 0.20$

II Expected no of failure per month.

here $N = 500 \times 6 = 3000$ bulbs $= N_0$

Month	Expected number of failure (N_i)
1	$N_1 = N_0 P_1 = 3000 \times 0.10 = 300$
2	$N_2 = N_0 P_1 + N_1 P_1 = 3000 \times 0.15 + 300 \times 0.10 = 480$
3	$N_3 = N_0 P_3 + N_1 P_2 + N_2 P_1 = 843$
4	$N_4 = N_0 P_4 + N_1 P_3 + N_2 P_2 + N_3 P_1 = 1131.3$
5	$N_5 = N_0 P_5 + N_1 P_4 + N_2 P_3 + N_3 P_2 + N_4 P_1 = 1049.58$

III Average life of bulbs.

Life (i) month	P_i	Expected Life of bulb $i \times P_i$
1	0.1	$= 1 \times 0.1 = 0.10$
2	0.15	$2 \times 0.15 = .30$
3	0.25	$= 0.75$
4	0.30	$= 1.20$
5	0.20	$= 1.00$

average life of bulbs $= 3.35$ month

IV average no of failure $= \frac{N}{3.35} = \frac{3000}{3.35} = \begin{matrix}895.5 \approx \\ 896\end{matrix}$

V. Cost of Individual bulb replacement
Cost of individual replacement
= average number of failure x cost per bulb individually
= 896 X 3 = 2686 rupees.

Group Replacement (Along with individual replacement)
Cost of individual bulb = rupees 3
Cost of group replacement per bulb = rupees 1
Total number of pubbs, N = 3000 bulb.
Determination of Average cost.

upto month (n)	Individual replacement	Cost of replacement (I)	(G)	I+G = TC	Average Cost of group R (TC)/n
1	N_1 300 ~~X 3000~~	900	3000	3900	3900
2	480	1440	~~5~~3900	5340	2670
3	843	2529	5340	7869	2623
4	1131.3	3393.3	7869	11262.9	2815.7
5	1049.5	3148.9	11262.9	14410.8	288.2

Replacement Policy :- The minimum average cost is rupees 2623 for 3rd month. So bulbs should have a group replacement after every 3rd month. We should prefer group replacement policy because average cost of gp replacement (2623) is less than average cost of individual (2686) replacement.

(Complete)