materials and other working conditions :

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Production (per day) | 146 | 147 | 148 | 149 | 150 | 151 | 152 | 153 | 154 |
| Probability | 0.04 | 0.09 | 0.12 | 0.14 | 0.11 | 0.10 | 0.20 | 0.12 | 0.08 |

The finished mopeds are transported in a specially arranged lorry accommodating 150 mopeds. Using following 15 random numbers:
80, 81, 76, 75, 64, 43, 18, 26, 10, 12, 65, 68, 69, 61, 57
Simulate the process to find out:
(a) What will be the average number of mopeds waiting in the factory?
(b) What will be the average number of empty space on the lorry?

Q.6 i. A machine costs Rs. 10,000. Its operating cost and resale value are given below. At what year replacement due? **3**

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Operating costs | 1000 | 1200 | 1400 | 1700 | 2000 | 2500 | 3000 | 3500 |
| Resale value | 6000 | 4000 | 3200 | 2600 | 2500 | 2400 | 2000 | 1600 |

ii. The cost of a new machine is Rs. 4000. The maintenance cost during the nth year is given by $R_n$ = Rs. 500 (n -1), where n = 1, 2, 3…. If the discount rate per year is 0.05, after how many years will it be economical to replace the machine by a new one? **7**

OR iii. The following mortality rates have been observed for a certain type of light bulbs in an installation with 1000 bulbs: **7**

| End of week | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Probability of failure to date | 0.09 | 0.25 | 0.49 | 0.85 | 0.97 | 1 |

There are a large number of such bulbs which are to be kept in working order. If a bulb fails in service, it costs Rs. 3 to replace but if all the bulbs are replaced in the same operation, it can be done for only Rs. 0.70 a bulb. It is proposed to replace all bulbs at fixed intervals, whether they have burnt out or not, and to continue replacing burnt out bulbs as they fail.
(a) What is the best interval between group replacements?
(b) Which policy you adopt individual replacement or group replacement?
Assume that the bulbs failing during a week might fail at any time of the week and that the group replacements are made at the end of the week.

******

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

**Enrollment No......................................**

# Faculty of Management

## End Sem (Even) Examination May-2018

## MS5CO11 Operations Research

Programme: MBA Branch/Specialisation: Management

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

Note: 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. Use of non programmable calculator is allowed.

Q.1 i. --------------- are the representation of reality **1**
(a) Models (b) Phases (c) Both (a) and (b) (d) None of these

ii. The best use of Linear Programming techniques is to find an optimal use of **1**
(a) Money (b) Manpower (c) Machine (d) All of these

iii. To test optimality by MODI method, the Initial Basic Feasible Solution of transportation problem should be **1**
(a) Degenerate (b) Feasible (c) Non-degenerate (d) Both (a) and (b)

iv. Minimum number of lines to cover all the zero in assignment problem is equal to number of **1**
(a) Assignment (b) Row (c) Column (d) All of these

v. In a matrix of transition probability in the Markov chain , the probability values should add up to one in each **1**
(a) Row (b) Column (c) Diagonal (d) All of these

vi. Customer behaviour in which he moves from one queue to another in multiple situation channel is **1**
(a) Balking (b) Reneging (c) Jockeying (d) Alternating

vii. In a mixed strategy game **1**
(a) Saddle point exist
(b) No saddle point exist
(c) Each player have same strategy
(d) All of these

viii. The size of the payoff matrix of a game can be reduced by using the principle of **1**
(a) Game inversion (b) Dominance
(c) Rotation reduction (d) None of these

ix. If r is the rate of interest , then the present value of one rupee spent in n year is **1**
(a) $(1 + r)^{-n}$ (b) $(1 - r)^{n}$ (c) $(1 - r)^{-n}$ (d) None of these

x. The sudden failures among items is seen as **1**
(a) Progressive (b) Retrogressive
(c) Random (d) All of these

Q.2 i. Discuss any three scope of Operations Research? **3**

ii. Obtain the dual of the following Linear Programming Problem **7**

Minimize : $Z = x_1 + 2x_2$

Subject to: $2x_1 + 4x_2 \leq 160$

$x_1 - x_2 = 30$

$x_1 \geq 10$

$x_1, x_2 \geq 0$

OR iii. Use Simplex method to solve the Linear Programming Problem **7**

Maximize $Z = 2x_1 + 5x_2$

Subject to

$x_1 + 4x_2 \leq 24$

$3x_1 + x_2 \leq 21$

$x_1 + x_2 \leq 9$

and $x_1, x_2 \geq 0$

Q.3 i. Explain Unbalanced Transportation Problem. How do you start in this case? **3**

ii. Solve the following transportation problem for profit maximization first. Find initial basic feasible solution by Vogel's Approximation Method. **7**

| Warehouse | $W_1$ | $W_2$ | $W_3$ | Supply |
|---|---|---|---|---|
| $F_1$ | 8 | 7 | 5 | 20 |
| $F_2$ | 3 | 4 | 6 | 20 |
| $F_3$ | 7 | 9 | 6 | 30 |
| Demand | 30 | 15 | 15 | |

OR iii. A department has five employees with five jobs to be performed. The time (In hours) each men will take to perform each job is given in the effectiveness matrix. **7**



| | | Employees | | | | |
|---|---|---|---|---|---|---|
| | | I | II | III | IV | V |
| | A | 10 | 5 | 13 | 15 | 16 |
| | B | 3 | 9 | 18 | 13 | 6 |
| Jobs | C | 10 | 7 | 2 | 2 | 2 |
| | D | 7 | 11 | 9 | 7 | 12 |
| | E | 7 | 9 | 10 | 4 | 12 |

How should the jobs be allocated, one per employee, so as to minimize the total man – hours?

Q.4 i. Discuss Kendall's Notation for the Identification or classification of Queuing Models. **3**

ii. In a Bank, every 15 minutes one customer arrives for cashing the cheque. The staff in the only payment counter takes 10 minutes for serving a customer on an average. Find **7**
(a) The average queue length.
(b) The waiting time of customers in the system.

OR iii. The School of international studies for population found out by its survey that the mobality of the population ( in percent ) of a state to a village, town and city is in the following percentage: **7**

To

$$\text{From}\quad \begin{array}{c} \\ Village \\ Town \\ City \end{array} \begin{array}{c} \begin{array}{ccc} Village & Town & City \end{array} \\ \begin{bmatrix} 0.6 & 0.3 & 0.1 \\ 0.4 & 0.5 & 0.1 \\ 0.2 & 0.1 & 0.7 \end{bmatrix} \end{array}$$

What will be the proportion in village, town and city after two years, given that the present population has proportion of 0.7, 0.2 and 0.1 in the village, town and city respectively?

Q.5 i. Define Pure and Mixed Strategy in a game. **3**

ii. Solve the following $2 \times 4$ game by graphical method **7**

| A's Strategy | | $B_1$ | $B_2$ | $B_3$ | $B_4$ |
|---|---|---|---|---|---|
| | $A_1$ | 3 | 3 | 4 | 0 |
| | $A_2$ | 5 | 4 | 3 | 7 |

OR iii. The automobile company manufactures around 150 mopeds. The daily production varies from 146 to 154 depending upon the availability of raw **7**

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

**Enrollment No....................................**

# Faculty of Management

## End Sem (Even) Examination May-2018

## MS5CO11 Operations Research

Programme: MBA Branch/Specialisation: Management

MCQ

Q.1 i. ---------------- are the representation of reality

a)Models

ii. The best use of Linear Programming techniques is to find an optimal use of

d)all of these

iii. To test optimality by MODI method, the Initial Basic Feasible Solution of transportation problem should be

c) non-degenerate

iv. Minimum number of lines to cover all the zero in assignment problem is equal to number of

a)assignment

v. In a matrix of transition probability in the Markov chain , the probability values should add up to one in each

a) row

vi. Customer behaviour in which he moves from one queue to another in multiple situation channel is

c) jockeying

vii. In a mixed strategy game

b) no saddle point exist

viii. The size of the payoff matrix of a game can be reduced by using the principle of

b) dominance

ix. If r is the rate of interest , then the present value of one rupee spent in n year is

a) $( 1 + r)^{-n}$

x. The sudden failures among items is seen as

d) all of these

Faculty of Management
End Sem (Even) Examination May - 2018
MS5CO11 Operations Research

MBA MAX. Marks.

Q.2 (i) Each scope is of 1 mark each. +3

Q.2 (ii) Canonical form

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

Subject to

$$-2x_1 - 4x_2 \geq -160$$
$$x_1 - x_2 \geq 30$$
$$-x_1 + x_2 \geq -30$$
$$x_1 \geq 10$$

and, $x_1, x_2 \geq 0$ +3

Dual is

$$\text{Max. } Z = -160y_1 + 30y_2 + 10y_3$$

Subject to

$$-2y_1 + y_2 + y_3 \leq 1$$
$$-4y_1 - y_2 \leq 2$$ +4

$y_1, y_3 \geq 0$, $y_2$ is unrestricted.
$[y_2 = y_2' - y_2'']$

or

Q.2 (iii) Standard form of LPP

$$\text{Maximize } z = 2x_1 + 5x_2 + 0S_1 + 0S_2 + 0S_3$$

Subject to

$$x_1 + 4x_2 + S_1 = 24$$
$$3x_1 + x_2 + S_2 = 21$$
$$x_1 + x_2 + S_3 = 9$$ +1

$$x_1, x_2, S_1, S_2, S_3 \geq 0$$

## Initial Simplex Table

| Coeff. of Basic var. in obj. $f^n$ $(C_B)$ | $C_j$ / Basis | $2$ $x_1$ | $5$ $x_2$ | $0$ $S_1$ | $0$ $S_2$ | $0$ $S_3$ | Value of Basic variable (b) | Min. +ive ratio $\theta = \frac{b}{kc}$ |
|---|---|---|---|---|---|---|---|---|
| 0 | $S_1$ | 1 | 4 | 1 | 0 | 0 | 24 | $24/4 = 6 \rightarrow$ |
| 0 | $S_2$ | 3 | 1 | 0 | 1 | 0 | 21 | $21/1 = 21$ |
| 0 | $S_3$ | 1 | 1 | 0 | 0 | 1 | 9 | $9/1 = 9$ |
| | $Z_j$ | 0 | 0 | 0 | 0 | 0 | | |
| | $C_j - Z_j$ | 2 | 5 $\uparrow$ kc | 0 | 0 | 0 | | |

+2

All value of $C_j - Z_j$ is not less than zero, so Solution is not optimal.

Improve solution
(a) Incoming Variable $\rightarrow x_2$
(b) Outgoing variable $\rightarrow S_1$
key element $= 4$

## IInd Simplex Table

| Coeff. of Basic var. in obj. $f^n$ $(C_B)$ | $C_j$ / Basis | $2$ $x_1$ | $5$ $x_2$ | $0$ $S_1$ | $0$ $S_2$ | $0$ $S_3$ | Value of Basic variable (b) | Min. +ive ratio $\theta = \frac{b}{kc}$ |
|---|---|---|---|---|---|---|---|---|
| 5 | $x_2$ | $1/4$ | 1 | $1/4$ | 0 | 0 | 6 | 24 |
| 0 | $S_2$ | $11/4$ | 0 | $-1/4$ | 1 | 0 | 15 | $60/11$ |
| 0 | $S_3$ | $3/4$ | 0 | $-1/4$ | 0 | 1 | 3 | $4 \rightarrow$ |
| | $Z_j$ | $5/4$ | 5 | $5/4$ | 0 | 0 | | |
| | $C_j - Z_j$ | $3/4$ $\uparrow$ | 0 | $-5/4$ | 0 | 0 | | |

+2

All value of $C_j - Z_j$ is not less than zero. So solution is not optimal.

Improve solution
(a) Incoming variable $\rightarrow x_1$ key element $= 3/4$
(b) outgoing variable $\rightarrow S_3$

## $III^{rd}$ Simplex Table

(3)

| Coeff. of Basic var. in obj. fn ($C_B$) | $C_j$ / Basis | 2 $x_1$ | 5 $x_2$ | 0 $S_1$ | 0 $S_2$ | 0 $S_3$ | Value of Basic variable (b) |
|---|---|---|---|---|---|---|---|
| 5 | $x_2$ | 0 | 1 | 1/3 | 0 | -1/3 | 5 |
| 0 | $S_2$ | 0 | 0 | 2/3 | 1 | -11/3 | 4 |
| 2 | $x_1$ | 1 | 0 | -1/3 | 0 | 4/3 | 4 |
| | $Z_j$ | 2 | 5 | 1 | 0 | 1 | |
| | $C_j - Z_j$ | 0 | 0 | -1 | 0 | -1 | |

All value of $C_j - Z_j \leq 0$, so, solution is optimal.

$x_1 = 4$

$x_2 = 5$

Maximize $Z = 33$ Ans +2

Ans.3 (i) Unbalanced Transportation Problem → +1

For Both Case $\boxed{+1}$ for each case +3

(ii) Total Supply > Total Demand

$20+20+30 > 30+15+15$

$70 > 60$

So, Problem is unbalanced. So we add one dummy column with Profit 0 and demand = $70-60 = 10$. +1

~~And Correct~~

| | $W_1$ | $W_2$ | $W_3$ | $W_4$ (Dummy) | Supply |
|---|---|---|---|---|---|
| $F_1$ | 8 | 7 | 5 | 0 | 20 |
| $F_2$ | 3 | 4 | 6 | 0 | 20 |
| $F_3$ | 7 | 9 | 6 | 0 | 30 |
| Demand | 30 | 15 | 15 | 10 | |

+1

Now convert profit matrix into loss matrix by substracting all element of profit matrix by highest profit = 9.

| | $W_1$ | $W_2$ | $W_3$ | $W_4$ | supply |
|---|---|---|---|---|---|
| $F_1$ | 9−8 = 1 | 9−7 = 2 | 9−5 = 4 | 9−0 = 9 | 20 |
| $F_2$ | 9−3 = 6 | 9−4 = 5 | 9−6 = 3 | 9−0 = 9 | 20 |
| $F_3$ | 9−7 = 2 | 9−9 = 0 | 9−6 = 3 | 9−0 = 9 | 30 |
| Demand | 30 | 15 | 15 | 10 | 70 |

+1

IBFS by VAM

| | $W_1$ | $W_2$ | $W_3$ | $W_4$ | supply |
|---|---|---|---|---|---|
| $F_1$ | 1 (20) | 2 | 4 | 9 | 20 |
| $F_2$ | 6 | 5 | 3 (10) | 9 (10) | 20 |
| $F_3$ | 2 (10) | 0 (15) | 3 (5) | 9 | 30 |
| Demand | 30 | 15 | 15 | 10 | 70 |

+2

Total profit:-

$= 20\times 8 + 10\times 6 + 10\times 0 + 10\times 7 + 15\times 9 + 5\times 6$

$= 455$

Optimality test by MODI method

no. of +ive Indendependent allocation $x_{ij} = m+n-1$

$6 = 3+4-1 = 6$

So, solution is non-degenerate.

Apply MODI method.

(5)

Step. 1, 2, 3 and 4 of MODI method.

**5.** Compute $d_{ij} = c_{ij} - (u_i + v_j)$ for unoccupied cell.

| | | | |
|---|---|---|---|
| — | $2-(-1) = 3$ | $4-(+2) = 2$ | $9-8 = 1$ |
| $6-2 = 4$ | $5-0 = 5$ | — | — |
| — | — | — | $9-0 = 9$ |

Since all value of $d_{ij} > 0$ so solution is optimal.

$x_{11} = 20$, $x_{23} = 10$, $x_{24} = 10$, $x_{31} = 10$

$x_{32} = 15$, $x_{33} = 5$

and Maximum Profit = 455 +2

**Q.3** or

(iii) (I) matrix is square.

(II) Reduce matrix and make assignment.

| | I | II | III | IV | V | |
|---|---|---|---|---|---|---|
| A | 5 | $\boxed{0}$ | 8 | 10 | 11 | |
| B | $\boxed{0}$ | 6 | 15 | 10 | 3 | ✓③ |
| C | 8 | 5 | $\boxed{0}$ | $\cancel{0}$ | $\cancel{0}$ | |
| D | $\cancel{0}$ | 4 | 2 | $\cancel{0}$ | 5 | ✓① |
| E | 3 | 5 | 6 | $\boxed{0}$ | 8 | ✓③ |
| | ✓② | | | ✓② | | |

+3

No. of assignment = 4 < 5 = order of matrix.

So, Solution is not optimal.

Revise and Develop new matrix.

| | I | II | III | IV | V |
|---|---|---|---|---|---|
| A | 7 | $\boxed{0}$ | 8 | 12 | 11 |
| B | $\boxed{0}$ | 4 | 13 | 10 | 1 |
| C | 10 | 5 | $\cancel{0}$ | 2 | $\boxed{0}$ |
| D | $\cancel{0}$ | 2 | $\boxed{0}$ | $\cancel{0}$ | 3 |
| E | 3 | 3 | 4 | $\boxed{0}$ | 6 |

+3

no. of assignment = 5 = order of matrix.
so, solution is optimal.

| Job | Employees | Time (in hrs) |
|---|---|---|
| A | II | 5 |
| B | I | 3 |
| C | V | 2 |
| D | III | 9 |
| E | IV | 4 |

Minimum Time = 23 hrs    +1

Q.4 (i) Kendall's Notation

(a|b|c) : (d|e)    +1

meaning of a, b c, d, e    +1

Symbol used for a, b, c, d, e    +1    +3

(ii) Arrival rate, $\lambda = \frac{1}{15}$ customer/min = 4 customers/hrs

Service rate, $\mu = \frac{1}{10}$ customer/min = 6 customer/hrs    +1

(a) Average Queue Length

$$L_q = \left(\frac{\lambda}{\mu}\right)\left(\frac{\lambda}{\mu-\lambda}\right) = \left(\frac{4}{6}\right)\times\left(\frac{4}{6-4}\right)$$    +3

$$L_q = \frac{16}{12} = 1.33 \text{ customers}$$ Ans

(b) Waiting time of customers in the system

$$W_s = \frac{1}{\mu-\lambda} = \frac{1}{6-4} = \frac{1}{2} = 0.5 \text{ hr.}$$    +3

or 30 min.

Ans

Q.4 or (iii) Give, Transition Probability matrix

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

Initial Probability vector

$$\begin{array}{cccc} & V & T & C \\ R_0 = & [0.7 & 0.2 & 0.1] \end{array}$$ +1

Proportion of population After $I^{st}$ year.

$$R_1 = R_0 \times P$$

$$R_1 = [0.7 \quad 0.2 \quad 0.1]_{1\times3} \begin{bmatrix} 0.6 & 0.3 & 0.1 \\ 0.4 & 0.5 & 0.1 \\ 0.2 & 0.1 & 0.7 \end{bmatrix}$$

$$R_1 = [0.52 \quad 0.32 \quad 0.16]$$ +3

Village = 52%, Town = 32%, City = 16%

Proportion of Population After $II^{nd}$ year.

$$R_2 = R_1 \times P$$

$$R_2 = [0.52 \quad 0.32 \quad 0.16]_{1\times3} \begin{bmatrix} 0.6 & 0.3 & 0.1 \\ 0.4 & 0.5 & 0.1 \\ 0.2 & 0.1 & 0.7 \end{bmatrix}$$

$$\begin{array}{cccc} & V & T & C \\ R_2 = & [0.472 & 0.332 & 0.196] \end{array}$$

After 2nd year, Proportion will be

Village = 47.2%

Town = 33.2%

City = 19.6% +3

Ans

Q.5 (i) Pure strategy → Definition +1.5 marks (8) +3

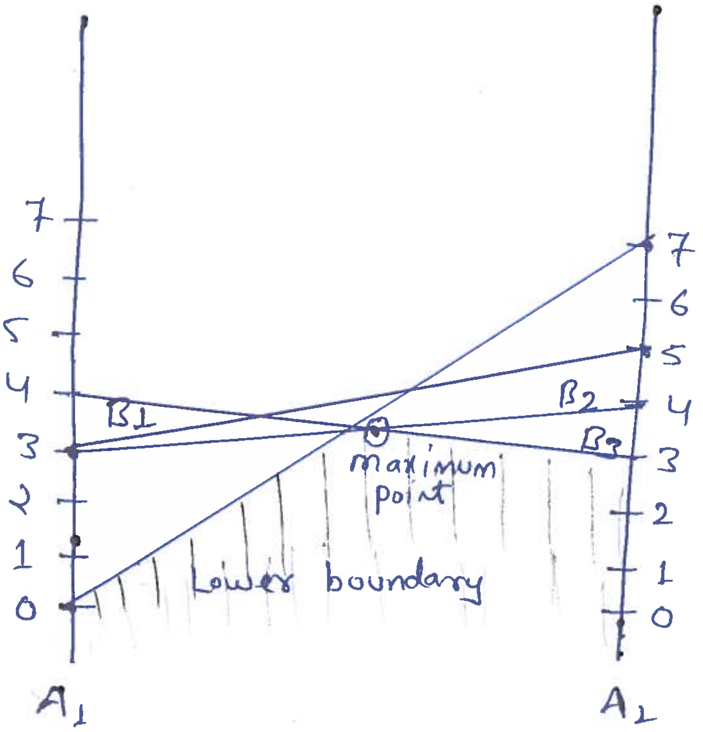
Mixed strategy → Definition +1.5 marks.

(ii)

| | $B_1$ | $B_2$ | $B_3$ | $B_4$ |
|---|---|---|---|---|
| $A_1$ | 3 | 3 | 4 | 0 |
| $A_2$ | 5 | 4 | 3 | 7 |

optimal strategy for A are $A_1$ and $A_2$ with Probabilities $P_1$ and $P_2$.

Plot various strategies on graph.




+2

Two strategies passing through maximum point on Lower boundary are $B_2$ and $B_3$ retained. So game reduces to 2×2 game.

| | $B_2$ | $B_3$ |
|---|---|---|
| $A_1$ | 3 | 4 |
| $A_2$ | 4 | 3 |

+2

optimal strategy for A = $\begin{pmatrix} P_1 & P_2 \\ 1/2 & 1/2 \end{pmatrix}$ +1

optimal strategy for B = $\begin{pmatrix} q_1 & q_2 & q_3 & q_4 \\ 0 & 1/2 & 1/2 & 0 \end{pmatrix}$ +1

Value of game, $V = \frac{7}{2}$ Ans +1

Q.5 or

(iii) Sum of Probability = 1, so we take 100 random no. of two digit i.e. 00 to 99. (9)

Calculation of cumulative Probability and Random number interval.

| Production (Per day) | Probabilities | Cumulative probabilities | Random number interval |
|---|---|---|---|
| 146 | 0.04 | 0.04 | 00 – 03 |
| 147 | 0.09 | 0.13 | 04 – 12 |
| 148 | 0.12 | 0.25 | 13 – 24 |
| 149 | 0.14 | 0.39 | 25 – 38 |
| 150 | 0.11 | 0.50 | 39 – 49 |
| 151 | 0.10 | 0.60 | 50 – 59 |
| 152 | 0.20 | 0.80 | 60 – 79 |
| 153 | 0.12 | 0.92 | 80 – 91 |
| 154 | 0.08 | 1 | 92 – 99 |

+2

Simulated Production for next 15 days

| Days | Random Number | Simulated Production | No. of scooter waiting | No. of empty space in lorry |
|---|---|---|---|---|
| 1 | 80 | 153 | 3 | — |
| 2 | 81 | 153 | 3 | — |
| 3 | 76 | 152 | 2 | — |
| 4 | 75 | 152 | 2 | — |
| 5 | 64 | 152 | 2 | — |
| 6 | 43 | 150 | 0 | — |
| 7 | 18 | 148 | — | 2 |
| 8 | 26 | 149 | — | 1 |
| 9 | 10 | 147 | — | 3 |
| 10 | 12 | 147 | — | 3 |
| 11 | 65 | 152 | 2 | — |
| 12 | 68 | 152 | 2 | — |
| 13 | 69 | 152 | 2 | — |
| 14 | 61 | 152 | 2 | — |
| 15 | 57 | 151 | 1 | — |
| | | | 21 | 09 |

+3

(a) Average no. of scooter waiting = $\frac{21}{15} = 1.4$ scooters. (10) +1

(b) Average no. of empty space on the lorry = $\frac{9}{15} = 0.6 \simeq 1$ Space. +1

2.6 (i) Capital cost of machine, C = 10,000

| Year (n) | Running cost f(t) | Cumulative Running cost $\Sigma f(t)$ | Capital cost (C) | Resale value (S) | Capital − Resale (C−S) | TC=C−S +Σf(t) | Average = TC/(n) |
|---|---|---|---|---|---|---|---|
| 1 | 1000 | 1000 | 10,000 | 6000 | 4000 | 5000 | 5000 |
| 2 | 1200 | 2200 | 10,000 | 4000 | 6000 | 8200 | 4100 |
| 3 | 1400 | 3600 | 10,000 | 3200 | 6800 | 10,400 | 3466.6 |
| 4 | 1700 | 5300 | 10,000 | 2600 | 7400 | 12,700 | 3175 |
| 5 | 2000 | 7300 | 10,000 | 2500 | 7500 | 14,800 | 2960 |
| 6 | 2500 | 9800 | 10,000 | 2400 | 7600 | 17,400 | 2900 |
| 7 | 3000 | 12,800 | 10,000 | 2000 | 8000 | 20,800 | 2971.4 |
| 8 | 3500 | 16,300 | 10,000 | 1600 | 8400 | 24,700 | 3087.5 |

+2

Replacement Policy :- Replace the machine at the end of 6th year because average annual cost is minimum in 6th year (2900). +1

Ans

2.6

(ii) cost of machine, C = 4000

rate of interest, $r = 0.05$

Discount factor, $V = \frac{1}{1+r} = \frac{1}{1+0.05} = \frac{1}{1.05} = 0.9523$ +1

Maintenance cost, $R_n = 500(n-1)$ where $n = 1, 2, 3, \ldots$

Calculation of weighted average cost (11)

| Year (n) | Running cost ($R_n$) | Discount factor $V^{n-1}$ | Discounted Running cost $R_n V^{n-1}$ | Cumulative Discounted Running cost $\Sigma R_n V^{n-1}$ | Cumulative Discount factor $\Sigma V^{n-1}$ | $TC = C + \Sigma R_n V^{n-1}$ $4000 + \Sigma R_n V^{n-1}$ | weighted Average cost $= TC / \Sigma V^{n-1}$ |
|---|---|---|---|---|---|---|---|
| 1 | 0 | $V^0 = 1$ | 0 | 0 | 1 | 4000 | 4000 |
| 2 | 500 | $V = 0.9523$ | 476 | 476 | 1.9523 | 4476 | 2292.6 |
| 3 | 1000 | 0.9670 | 907 | 1383 | 2.8593 | 5383 | 1882.6 |
| 4 | 1500 | 0.8638 | 1296 | 2679 | 3.7231 | 6679 | 1793.9 |
| 5 | 2000 | 0.8227 | 1645 | 4324 | 4.5458 | 8324 | 1831.1 |

+5

Replacement Policy :- Replacement the machine at the endof 4th year because weighted average cost is minimum in 4th year (1793.9). +1

.6 or
(iii)(1) Let $P_i$ be the probability of failure of bulbs in $i^{th}$ week $(i = 1, 2, 3, 4, 5)$

$P_1 = 0.09$ , $P_2 = 0.25 - 0.09 = 0.16$

$P_3 = 0.24$ , $P_4 = 0.36$ , $P_5 = 0.12$ , $P_6 = 0.03$ +1

(2) Expected No. of failure per week

| week ($i$) | Expected No. of failure |
|---|---|
| 0 | $N_0 = N = 1000$ |
| 1 | $N_1 = 90$ |
| 2 | $N_2 = 168$ |
| 3 | $N_3 = 269$ |
| 4 | $N_4 = 432$ |
| 5 | $N_5 = 274$ |
| 6 | $N_6 = 260$ |

+1

(3) Average life of Bulb.

| Life (i) in week | Prob. of failure ($P_i$) | Expected life of bulb ($i \times P_i$) |
|---|---|---|
| 1 | 0.09 | 0.09 |
| 2 | 0.16 | 0.32 |
| 3 | 0.24 | 0.72 |
| 4 | 0.36 | 1.44 |
| 5 | 0.12 | 0.6 |
| 6 | 0.03 | 0.18 |
| | Average life of bulb | = 3.35 week |

+1

(4) Average No. of failure per week $= \frac{1000}{3.35} = 299$ bulbs +1

(5) Cost of Individual bulb Replacement

$= \text{Rs. } 3 \times 299 = \text{Rs. } 897$ −1 +1

- Group Replacement Policy

| up to week | Individual Replacement | Cost of Replacement Individual | Group | Total cost of Group | Average cost of Group = TC/no. of week |
|---|---|---|---|---|---|
| 1 | 90 | 90×3=270 | 1000×0.7=700 | 970 | 970 |
| 2 | 168 | 168×3=504 | 774+700 | 1474 | 737 |
| 3 | 269 | 269×3=807 | 1581+700 | 2281 | 760.3 |
| 4 | 432 | 432×3=1296 | 2877+700 | 3577 | 894.25 |
| 5 | 274 | 274×3=822 | 3699+700 | 4399 | 879.8 |
| 6 | 260 | 260×3=780 | 4479+700 | 5179 | 863.1 |

+1

Replacement Policy

1. Replace all bulbs in group after 2nd weeks because average cost is min. in 2nd week.
2. follow Group replacement because cost of Group is min. (737) Compare to Individual (897). +1