Chapter 4

Assignment Problem

An assignment problem is a particular case of transportation problem where the objective is to assign a number of resources to an equal number of activities so as to minimize total cost or maximize total profit of allocation. Some of the problems where the assignment technique may be useful are assignment of workers to machines, salesmen to different sales areas, clerks to various checkout counters, classes to rooms, vehicles to routes etc.

Mathematical Model of Assignment Problem:

The mathematical model of the assignment problem can be stated as

$$Min. Z = \sum_{i=1}^{n} \sum_{j=1}^{n} c_{ij}\, x_{ij} \qquad i = 1,2,\dots,n \ , \quad j = 1,2,\dots,n$$

Subject to the constraints

$$\sum_{j=1}^{n} x_{ij} = 1 \ , \qquad \forall\, i \ (resource\ availabilaty)$$

$$\sum_{i=1}^{n} x_{ij} = 1 \ , \qquad \forall\, j \ (activity\ requirement)$$

And $$x_{ij} = \begin{cases} 1, & if\ facility\ i\ assigned\ to\ activity\ j \\ 0, & otherwise \end{cases}$$

Where x_{ij} denotes the j^{th} activity is to be assigned to the i^{th} resource and c_{ij} represents the cost of assignment of resource i to activity j.

The assigned table is given below

Resources person	Activity (Job)				Supply
	J_1	J_2	$\cdots$	J_n	
1	c_{11}	c_{12}	$\cdots$	c_{1n}	1
2	c_{21}	c_{22}	$\cdots$	c_{2n}	1
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
n	c_{n1}	c_{n2}	$\cdots$	c_{nn}	1
Demand	1	1	$\cdots$	1	

Hungarian Assignment Method

Step1. Subtract the minimum of each row of the effectiveness matrix, from all the elements of the respective rows.

Step2. Further, modify the resulting matrix by subtracting the minimum element of each column from all the elements of the respective columns. Thus obtain the first modified matrix.

Step3. Then, draw the minimum number of horizontal and vertical lines to cover all the zeros in the resulting matrix. Let the minimum number of lines be N. Now there may be two possibilities:

(i) If N=n , the number of rows(columns) of given matrix, then an optimal assignment can be made. So make the zero assignment to get the required solution.

(ii) If N<n , then proceed to step 4

Step4. Determine the smallest element in the matrix, not covered by the N lines. Subtract this minimum element from all uncovered elements and add the same element at the intersection of horizontal and vertical lines. Thus, the second modified matrix is obtained.

Step5. Again repeat Steps 3 &4 until minimum number of lines become equal to the number of rows(columns) of the given matrix i.e. N=n

Step6. (**To make zero-assignment**) Examine the rows successively until a row-wise exactly single zero is found, mark this zero by ‘ $\square$ ’ to make the assignment. Then, mark a cross (×) over all zeros if lying in the column of the marked ‘ $\square$ ’ zero, showing that they cannot be considered for future assignment. Continue in this manner until all the rows have been examined. Repeat the same procedure for columns.

Step7. Repeat the step 6 successively until one of the following situations arise:

(i) If no unmarked zero is left, then the process ends; or

(ii) If there lies more than one of the unmarked zeros in any column or row , then mark ‘$\square$’ one of the unmarked zeros arbitrarily and mark a cross in the cells of remaining zeros in its row and column. Repeat the process until no unmarked zero is left in the matrix.

Step8. Thus exactly one marked ‘ $\square$ ’ zero in each row and each column of the matrix is obtained. The assignment corresponding to these marked ‘$\square$’ zeros will give the optimal assignment.

Q1. Solve the following assignment problem

Work \ Man	1	2	3	4
I	12	30	21	15
II	18	33	9	31
III	44	25	24	21
IV	23	30	28	14

Solution: The Hungarian method is used to obtain an optimal solution

Step1. The minimum element in row 1, 2, 3 &4 is 12, 9, 21 &14 resp. Subtract these elements from all elements in their respective row

$$\begin{array}{c|cccc|} & 1 & 2 & 3 & 4 \\ \hline \text{I} & 0 & 18 & 9 & 3 \\ \text{II} & 9 & 24 & 0 & 22 \\ \text{III} & 23 & 4 & 3 & 0 \\ \text{IV} & 9 & 16 & 14 & 0 \\ \hline \end{array}$$

Step2. The minimum element in column 1, 2, 3 & 4 is 0, 4, 0 & 0 resp. Subtract these elements from all elements in their respective column

$$\begin{array}{c|cccc|} & 1 & 2 & 3 & 4 \\ \hline \text{I} & 0 & 14 & 9 & 3 \\ \text{II} & 9 & 20 & 0 & 22 \\ \text{III} & 23 & 0 & 3 & 0 \\ \text{IV} & 9 & 12 & 14 & 0 \\ \hline \end{array}$$

Step3. Examine all the rows successively until a row-wise exactly single zero is found, mark this zero by ' $\boxed{}$ ' to make the assignment. Then, mark a cross '×' over all zeros. Here rows 1, 2, & 4 have one zero in the cells (I, 1), (II, 3) and (IV, 4) assigned these zeros.

$$\begin{array}{c|cccc|} & 1 & 2 & 3 & 4 \\ \hline \text{I} & \boxed{0} & 14 & 9 & 3 \\ \text{II} & 9 & 20 & \boxed{0} & 22 \\ \text{III} & 23 & 0 & 3 & \cancel{0} \\ \text{IV} & 9 & 12 & 14 & \boxed{0} \\ \hline \end{array}$$

Now examine each column starting from 1. There is one zero in column 2 in the cell (III, 2). Assign this cell

$$\begin{array}{c|cccc|} & 1 & 2 & 3 & 4 \\ \hline \text{I} & \boxed{0} & 14 & 9 & 3 \\ \text{II} & 9 & 20 & \boxed{0} & 22 \\ \text{III} & 23 & \boxed{0} & 3 & \cancel{0} \\ \text{IV} & 9 & 12 & 14 & \boxed{0} \\ \hline \end{array}$$

Solution I→ 1, II→ 3, III→ 2, IV→ 4. $Min. cost = 12 + 9 + 25 + 14 = 60$

Q2. Solve the following assignment problem

Operators (rows) / Jobs (columns)

	I	II	III	IV
A	8	26	17	11
B	13	28	4	26
C	38	19	18	15
D	19	26	24	10

Answer: 41

Q3. Solve the following assignment problem

Operators (rows) / Jobs (columns)

	I	II	III	IV
A	10	12	9	11
B	5	10	7	8
C	12	14	13	11
D	8	15	11	9

Solution: The Hungarian method is used to obtain an optimal solution

Step1. The minimum element in row 1, 2, 3 &4 is 9, 5, 11 &8 resp. Subtract these elements from all elements in their respective row

	I	II	III	IV
A	1	3	0	2
B	0	5	2	3
C	1	3	2	0
D	0	7	3	1

Step2. The minimum element in column 1, 2, 3 & 4 is 0, 3, 0 & 0 resp. Subtract these elements from all elements in their respective column

	I	II	III	IV
A	1	0	0	2
B	0	2	2	3
C	1	0	2	0
D	0	4	3	1

Step3. Examine all the rows successively until a row-wise exactly single zero is found, mark this zero by ' $\boxed{}$ ' to make the assignment. Then, mark a cross '×' over all zeros.

	I	II	III	IV
A	1	0	0	2
B	$\boxed{0}$	2	2	3
C	1	0	2	0
D	$\cancel{0}$	4	3	1

Now examine each column starting from 1. There is one zero in column III & IV in the cell (A, III) and (C, IV). Assign these cells

	I	II	III	IV
A	1	$\cancel{0}$	$\boxed{0}$	2
B	$\boxed{0}$	2	2	3
C	1	0	2	0
D	$\cancel{0}$	4	3	1

	I	II	III	IV
A	1	$\cancel{0}$	$\boxed{0}$	2
B	$\boxed{0}$	2	2	3
C	1	$\cancel{0}$	2	$\boxed{0}$
D	$\cancel{0}$	4	3	1

Number of assignments is not equal to the number of rows. So the solution is not optimal.

Step4. Mark (√) row D since it has no assignment.

$$\begin{array}{c|cccc|l}
 & I & II & III & IV & \\
\hline
A & 1 & \cancel{0} & \boxed{0} & 2 & \\
B & \boxed{0} & 2 & 2 & 3 & \\
C & 1 & \cancel{0} & 2 & \boxed{0} & \\
D & \cancel{0} & 4 & 3 & 1 & \surd\ (1) \\
\hline
\end{array}$$

Mark (√) column I since row D has zero in this column

$$\begin{array}{c|cccc|l}
 & I & II & III & IV & \\
\hline
A & 1 & \cancel{0} & \boxed{0} & 2 & \\
B & \boxed{0} & 2 & 2 & 3 & \\
C & 1 & \cancel{0} & 2 & \boxed{0} & \\
D & \cancel{0} & 4 & 3 & 1 & \surd\ (1) \\
\hline
 & \surd\,(2) & & & & \\
\end{array}$$

Mark (√) row B since column I has an assignment in the row B

$$\begin{array}{c|cccc|l}
 & I & II & III & IV & \\
\hline
A & 1 & \cancel{0} & \boxed{0} & 2 & \\
B & \boxed{0} & 2 & 2 & 3 & \surd\,(3) \\
C & 1 & \cancel{0} & 2 & \boxed{0} & \\
D & \cancel{0} & 4 & 3 & 1 & \surd\ (1) \\
\hline
 & \surd\,(2) & & & & \\
\end{array}$$

Since no other rows and columns can be marked, therefore draw straight lines through the unmarked row A and C and marked column I

	I	II	III	IV	
A	1	$\cancel{0}$	$\boxed{0}$	2	
B	$\boxed{0}$	2	2	3	√ (3)
C	1	$\cancel{0}$	2	$\boxed{0}$	
D	$\cancel{0}$	4	3	1	√ (1)
	√ (2)				

Develop the new revised cost table by selecting the smallest element among all uncovered element by the lines. Subtract this element from all uncovered elements including itself and add it to elements in the cells (A, I) and (C, I) resp. which lies at the intersection of two lines.

	I	II	III	IV
A	2	$\cancel{0}$	$\boxed{0}$	2
B	$\boxed{0}$	1	1	2
C	2	$\cancel{0}$	2	$\boxed{0}$
D	$\cancel{0}$	3	2	0

	I	II	III	IV
A	2	0	0	2
B	0	1	1	2
C	2	0	2	0
D	0	3	2	0

Again, repeat the procedure to find a new solution

	I	II	III	IV
A	2	0	0	2
B	$\boxed{0}$	1	1	2
C	2	0	2	0
D	$\cancel{0}$	3	2	0

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

Examine through column-wise

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

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

Solution: $A \to III\ ,\ B \to I\ ,\ C \to II\ ,\ D \to IV$ $\qquad Min.cost = 9 + 5 + 14 + 9 = 37$

Q4. A car hire company has one car at each of five depots a, b, c, d and e. a customer requires a car in each town namely A, B, C, D and E. Distance (in kms) between deports (origins) and towns (destinations) are given in the following distance matrix:

	a	b	c	d	e
A	160	130	175	190	200
B	135	120	130	160	175
C	140	110	155	170	185
D	50	50	80	80	110
E	55	35	70	80	105

Solution: The Hungarian method is used to obtain an optimal solution

Step1. The minimum element in row 1, 2, 3, 4 &5 is 130, 120, 110, 50 &35 resp. Subtract these elements from all elements in their respective row

	a	b	c	d	e
A	30	0	45	60	70
B	15	0	10	40	55
C	30	0	45	60	75
D	0	0	30	30	60
E	20	0	35	45	70

Step2. The minimum element in column 1, 2, 3 & 4 is 0, 0, 10, 30& 55 resp. Subtract these elements from all elements in their respective column

	a	b	c	d	e
A	30	0	35	30	15
B	15	0	0	10	0
C	30	0	35	30	20
D	0	0	20	0	5
E	20	0	25	15	15

Step3. Examine all the rows successively until a row-wise exactly single zero is found, mark this zero by ' $\boxed{}$ ' to make the assignment. Then, mark a cross '×' over all zeros.

	a	b	c	d	e
A	30	$\boxed{0}$	35	30	15
B	15	$\cancel{0}$	0	10	0
C	30	$\cancel{0}$	35	30	20
D	0	$\cancel{0}$	25	0	5
E	20	$\cancel{0}$	25	15	15

Now examine each column starting from 1.

	a	b	c	d	e
A	30	$\boxed{0}$	35	30	15
B	15	$\cancel{0}$	$\boxed{0}$	10	$\cancel{0}$
C	30	$\cancel{0}$	35	30	20
D	$\boxed{0}$	$\cancel{0}$	25	$\cancel{0}$	5
E	20	$\cancel{0}$	25	15	15

	a	b	c	d	e	
A	30	$\boxed{0}$	35	30	15	√ (4)
B	15	$\cancel{0}$	$\boxed{0}$	10	$\cancel{0}$	
C	30	$\cancel{0}$	35	30	20	√ (1)
D	$\boxed{0}$	$\cancel{0}$	25	$\cancel{0}$	5	
E	20	$\cancel{0}$	25	15	15	√ (2)
		√ (3)				

	a	b	c	d	e	
A	30	$\boxed{0}$	35	30	15	√ (4)
B	15	$\cancel{0}$	$\boxed{0}$	10	$\cancel{0}$	
C	30	$\cancel{0}$	35	30	20	√ (1)
D	$\boxed{0}$	$\cancel{0}$	25	$\cancel{0}$	5	
E	20	$\cancel{0}$	25	15	15	√ (2)
		√ (3)				

	a	b	c	d	e
A	15	0	20	15	0
B	15	15	0	10	0
C	15	0	20	15	5
D	0	15	25	0	5
E	5	0	10	0	0

Again, repeat the procedure to find a new solution

	a	b	c	d	e
A	15	$\cancel{0}$	20	15	$\boxed{0}$
B	15	15	$\boxed{0}$	10	$\cancel{0}$
C	15	$\boxed{0}$	20	15	5
D	$\boxed{0}$	15	25	$\cancel{0}$	5
E	5	$\cancel{0}$	10	$\boxed{0}$	$\cancel{0}$

Solution: $A \rightarrow e\ ,\ B \rightarrow c\ ,\ C \rightarrow b\ ,\ D \rightarrow a, E \rightarrow d$

$$Min. cost = 200 + 130 + 110 + 50 + 80 = 570\ kms$$

Multiple optimal solutions: While making an assignment in the reduced assignment matrix, it is possible to have two or more ways to strike off a certain number of zero. Such a situation indicates multiple optimal solution with the same optimal value of objective function.

Q1. Solve the following cost minimizing assignment problem

	M_1	M_2	M_3	M_4
J_1	2	5	7	9
J_2	4	9	10	1
J_3	7	3	5	8
J_4	8	2	4	9

Solution: The Hungarian method is used to obtain an optimal solution

Step1. The minimum element in row 1, 2, 3 &4 is 2, 1, 3 &2 resp. Subtract these elements from all elements in their respective row

	M_1	M_2	M_3	M_4
J_1	0	3	5	7
J_2	3	8	9	0
J_3	4	0	2	5
J_4	6	0	2	7

Step2. The minimum element in column 1, 2, 3 & 4 is 0, 0, 2 & 0 resp. Subtract these elements from all elements in their respective column

$$\begin{array}{c|cccc|} & M_1 & M_2 & M_3 & M_4 \\ \hline J_1 & 0 & 3 & 3 & 7 \\ J_2 & 3 & 8 & 7 & 0 \\ J_3 & 4 & 0 & 0 & 5 \\ J_4 & 6 & 0 & 0 & 7 \\ \hline \end{array}$$

Step3. Examine all the rows successively until a row-wise exactly single zero is found, mark this zero by ' $\boxed{}$ ' to make the assignment. Then, mark a cross '×' over all zeros.

$$\begin{array}{c|cccc|} & M_1 & M_2 & M_3 & M_4 \\ \hline J_1 & \boxed{0} & 3 & 3 & 7 \\ J_2 & 3 & 8 & 7 & \boxed{0} \\ J_3 & 4 & 0 & 0 & 5 \\ J_4 & 6 & 0 & 0 & 7 \\ \hline \end{array}$$

Here it is observed that row 3 has two zeros. Now arbitrary make an assignment to one of these zeros and cross other zeros in row 3 and column 2

$$\begin{array}{c|cccc|} & M_1 & M_2 & M_3 & M_4 \\ \hline J_1 & \boxed{0} & 3 & 3 & 7 \\ J_2 & 3 & 8 & 7 & \boxed{0} \\ J_3 & 4 & \boxed{0} & \xcancel{0} & 5 \\ J_4 & 6 & \xcancel{0} & 0 & 7 \\ \hline \end{array}$$

$$\begin{array}{c|cccc|} & M_1 & M_2 & M_3 & M_4 \\ \hline J_1 & \boxed{0} & 3 & 3 & 7 \\ J_2 & 3 & 8 & 7 & \boxed{0} \\ J_3 & 4 & \boxed{0} & \xcancel{0} & 5 \\ J_4 & 6 & \xcancel{0} & \boxed{0} & 7 \\ \hline \end{array}$$

Answer: $J_1 \to M_1,\ J_2 \to M_4,\ J_3 \to M_2,\ J_4 \to M_3 \quad Min.cost = 2+1+3+4 = 10$

Another optimal assignment is

	M_1	M_2	M_3	M_4
J_1	$\boxed{0}$	3	3	7
J_2	3	8	7	$\boxed{0}$
J_3	4	$\cancel{0}$	$\boxed{0}$	5
J_4	6	$\boxed{0}$	$\cancel{0}$	7

$Min.\, cost = 10$

Q2. Solve the following cost minimizing assignment problem

	I	II	III	IV	V
A	45	30	65	40	55
B	50	30	25	60	30
C	25	20	15	20	40
D	35	25	30	30	20
E	80	60	60	70	50

Unbalanced Assignment Problem: When the given cost matrix of an assignment problem is not square matrix, the assignment problem is called unbalanced assignment problem.

Q1. Solve the following cost minimizing assignment problem

	I	II	III	IV	V
1	6	2	5	2	6
2	2	5	8	7	7
3	7	8	6	9	8
4	6	2	3	4	5
5	9	3	8	9	7
6	4	7	4	6	8

Answer: 16

Q2. A company has 4 machines on which to do 3 jobs. Each job can be assigned to one and only one machine. The cost of each job on each machine is given in the following table:

		Machine			
		W	X	Y	Z
	A	18	24	28	32
	B	8	13	17	19
Work	C	10	15	19	22

Answer: min cost=50

Maximization in Assignment Problem: In maximization assignment problem objective is to maximize the profit. To solve this we first convert the given profit matrix into the loss matrix by subtracting all the elements from the highest element of given profit matrix. The transformed assignment problem so obtained can be solved by using the Hungarian method.

Q1. A marketing manager has five salesmen and five sales districts. Considering the capabilities of the salesmen and the nature of districts, the marketing manager estimates that sales per month (in hundreds rupees) for each salesman in each district would be as follows:

	A	B	C	D	E
1	32	38	40	28	40
2	40	24	28	21	36
3	41	27	33	30	37
4	22	38	41	36	36
5	29	33	40	35	39

Find the assignment to districts that will result in maximum sales.

Solution: The given maximization problem can be converted into a minimization problem by subtracting all elements from largest element 41

	A	B	C	D	E
1	9	3	1	13	1
2	1	17	13	20	5
3	0	14	8	11	4
4	19	3	0	5	5
5	12	8	1	6	2

Step1. The minimum element in row 1, 2, 3, 4&5 is 1, 1, 0, 0 &1 resp. Subtract these elements from all elements in their respective row

	A	B	C	D	E
1	8	2	0	12	0
2	0	16	12	19	4
3	0	14	8	11	4
4	19	3	0	5	5
5	11	7	0	5	1

Step2. The minimum element in column 1, 2, 3, 4& 5 is 0, 2, 0, 5& 0 resp. Subtract these elements from all elements in their respective column

	A	B	C	D	E
1	8	0	0	7	0
2	0	14	12	14	4
3	0	12	8	6	4
4	19	2	0	0	5
5	11	6	0	0	1

Step3. Examine all the rows successively until a row-wise exactly single zero is found, mark this zero by ' $\boxed{}$ ' to make the assignment. Then, mark a cross '×' over all zeros.

	A	B	C	D	E
1	8	$\boxed{0}$	$\cancel{0}$	7	$\cancel{0}$
2	$\boxed{0}$	14	12	14	4
3	$\cancel{0}$	12	8	6	4
4	19	2	$\boxed{0}$	$\cancel{0}$	5
5	11	6	$\cancel{0}$	$\boxed{0}$	1

Number of assignments is not equal to the number of rows. So the solution is not optimal.

Step4. Mark (√) row 3 since it has no assignment. Mark (√) column A since row 3 has zero in this column. Mark (√) row 2 since column I has an assignment in the row 2

	A	B	C	D	E	
1	8	$\boxed{0}$	$\cancel{0}$	7	$\cancel{0}$	
2	$\boxed{0}$	14	12	14	4	√ (3)
3	$\cancel{0}$	12	8	6	4	√ (1)
4	19	2	$\boxed{0}$	$\cancel{0}$	5	
5	11	6	$\cancel{0}$	$\boxed{0}$	1	
	√ (2)					

	A	B	C	D	E
1	8	$\boxed{0}$	$\cancel{0}$	7	$\cancel{0}$
2	$\boxed{0}$	14	12	14	4
3	$\cancel{0}$	12	8	6	4
4	19	2	$\boxed{0}$	$\cancel{0}$	5
5	11	6	$\cancel{0}$	$\boxed{0}$	1

Develop the new revised cost table by selecting the smallest element among all uncovered element by the lines. Subtract this element from all uncovered elements including itself and add it to elements in the intersection of lines

	A	B	C	D	E
1	12	0	0	7	0
2	0	10	8	10	0
3	0	8	4	2	0
4	23	2	0	0	5
5	15	6	0	0	1

	A	B	C	D	E
1	12	$\boxed{0}$	$\cancel{0}$	7	$\cancel{0}$
2	$\boxed{0}$	10	8	10	$\cancel{0}$
3	$\cancel{0}$	8	4	2	$\boxed{0}$
4	23	2	$\boxed{0}$	$\cancel{0}$	5
5	15	6	$\cancel{0}$	$\boxed{0}$	1

$$1 \to B, 2 \to A, 3 \to E, 4 \to C, 5 \to D \qquad total\ profit = 191$$

The alternate solution is

	A	B	C	D	E
1	12	$\boxed{0}$	$\cancel{0}$	7	$\cancel{0}$
2	$\cancel{0}$	10	8	10	$\boxed{0}$
3	$\boxed{0}$	8	4	2	$\cancel{0}$
4	23	2	$\cancel{0}$	$\boxed{0}$	5
5	15	6	$\boxed{0}$	$\cancel{0}$	1

$total\ profit = 191$

Q2. A company has team of four salesmen and there are four districts where the company wants to start its business. After taking into account the capabilities of salesmen and the name of districts, the company estimates that the profit per day in rupees for each salesman in each districts is as below. Find the assignments of salesperson to various districts, which will yield maximum profit.

	D_1	D_2	D_3	D_4
S_1	16	10	14	11
S_2	14	11	15	15
S_3	15	15	13	12
S_4	13	12	14	15

Total profit=Rs 61

Restrictions on Assignments: Sometimes it may happen that a particular resource cannot be assigned to perform a particular activity. In such cases, the cost of performing that particular activity by a particular resource is considered to be very large (written as M or ∞)

Q1. In the modification of a plant layout for new machinesM_1, M_2, M_3 and M_4 are to be installed in a machine shop. There are five vacant places A, B, C, D and E available. Because of limited space, machine M_2 cannot be placed at C and M_3 cannot be placed at A. The cost of locating a machine at a place is as follows

	A	B	C	D	E
M_1	9	11	15	10	11
M_2	12	9	-	10	9
M_3	-	11	14	11	7
M_4	14	8	12	7	8

Find the optimal assignment schedule.

Answer: 32

Q2. Consider a problem of assigning four clerks to four tasks. The time (hours) required to complete the task is given below

		tasks			
		A	B	C	D
clerks	1	4	7	5	6
	2	-	8	7	4
	3	3	-	5	3
	4	6	6	4	2

Find the optimal assignment schedule.

Answer: 18