SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

**SCHOOL OF MECHANICAL ENGINEERING**

# Subject Title: Resource Management Techniques Subject Code: SPR1307 Course: B.E (Common to all Engineering Branches)

**UNIT – II – TRANSPORTATION AND ASSIGNMET MODEL TRANSPORTATION**

# INTRODUCTION

The transportation problem is a special type of LPP in which the objective is to determine the quantities to be shifted from each source to destination, so that the total transportation cost is minimum.

Suppose a factory owns ware houses in 3 different locations in a city and has to despatch the monthly requirement of the product manufactured by them to 5 different wholesale markets located in the same city. The cost of transporting one unit of the product from the i-th warehouse to the j-th market is known and is cij. It is assumed that the total cost is a linear function so that the total transportation cost of transporting xij, units of the product from the i-th warehouse to the j-th market is given by ∑cijxij.

It is clear that the factory management will be interested in obtaining a solution that minimizes the total cost of transportation. During the process of transportation they will also face the constraints that from a warehouse they cannot transport more than what is stored or available in the warehouse (supply) and that they need to transport to a market the total monthly requirement of the market (demand).

# ASSUMPTIONS

* Quantity of supply at each source is known.
* Quantity demanded at each destination is known.
* The cost of transportation of a commodity from each source to destination is known.

# PROCEDURE TO SOLVE TRANSPORTATION PROBLEM

Step I : Deriving the initial basic feasible solution. Step II : Deriving the final optimal solution.

# DERIVING THE INITIAL BASIC FEASIBLE SOLUTION

* North West corner method.
* Matrix minimum method.
* Vogel’s approximation method (VAM Method) penalty method.

# DERIVING THE FINAL SOLUTION

Modified distribution method / Modi method / UV method.

* If total demand = total supply, then it is a balanced transportation problem.
* If the total supply not equal to total demand, then the transportation problem is unbalanced transportation problem.

# NORTH WEST CORNER METHOD

1. Check if Demand=Supply. If not add dummy row or column.
2. Select the North west (upper left hand) corner cell.
3. Allocate as large as possible in the north west corner cell.
4. If demand is satisfied , strike off the respective column and deduct supply accordingly If supply is exhausted ,strike off the respective row and deduct demand accordingly
5. From the resultant array, locate the north west corner cell and repeat the procedure Note : The assignment done is not taking cost into consideration.
6. Continue allocation until all demand is satisfied and all supply is exhausted.
7. Multiply the allocated quantity \*cost of transportation for each occupied cell and add it to find the total cost.

# LEAST COST METHOD

* 1. Check if Demand=Supply. If not add a dummy row /column.
  2. The lowest cost cell in the matrix is allocated as much as possible based on demand and supply requirement.
     + If there are more than one least cost cell , select the one where maximum units can be allocated.
     + If the tie exist, follow the serial order.
  3. If demand is satisfied, strike off the respective column and deduct supply accordingly. If supply is exhausted, strike off the respective row and deduct demand accordingly.
  4. From the resultant array, locate the least cost cell and repeat the procedure.
  5. Continue allocation until all demand is satisfied and all supply is exhausted.
  6. Find total cost.

# OGEL’S APPROXIMATION METHOD (VAM)

This method gives better initial solution in terms of less transportation cost through the concept of ‘penalty numbers’ which indicate the possible cost penalty associated with not assigning an allocation to given cell.

* + 1. Check if demand = supply, if not add a dummy row or column.
    2. Calculate penalty of each row & column by taking the difference between the lowest unit transportation cost. This difference indicates the penalty or extra cost which has to be paid for not assigning an allocation to the cell with the minimum transportation cost.
    3. Select the row or column which has got the largest penalty number.(If there is a tie it can be broken by selecting the cell where the maximum allocation can be made.)
    4. In that row or column choose the minimum cost cell and allocate accordingly.
       - If there are more than one minimum cost cell, select the one where maximum units can be allocated.
       - If the tie exists, follow the serial order.
    5. If demand is satisfied , strike off the respective column and deduct supply accordingly. If supply is exhausted, strike off the respective row and deduct demand accordingly.
    6. From the resultant array, calculate penalty and repeat the procedure.
    7. Continue allocation until all demand is satisfied and all supply is exhausted.
    8. Find the total cost.

# OPTIMAL SOLUTION

Work out the basic feasible solution using by any one method

1. Northwest corner method
2. Least cost method
3. VAM/Penalty method. (preferably VAM)

**STEP 1**:

Check if the number of occupied cells is m+n-1 (i.e., number of rows +number of columns-1) Note : Rows & columns include dummy rows & columns.

* + If number of occupied cells = m+n-1, then the solution to the transportation problem is

# basic feasible solution.

* + If number of occupied cells < m+n-1, then the solution is **degenerate solution**. Degeneracy may occur either at the initial stage or at an intermediate stage at some subsequent iteration.
  + In case of degeneracy, we allocate an extremely small amount, close to zero [(ξ) epsilon] to one or more empty cells of the transportation table (unoccupied least cost cell). So that total no of occupied cells equals to m+n-1.

**STEP 2**:

If the basic feasible solution is achieved then MODI method is used to obtain final optimal solution

* + - Defining the occupied cells.

cij= ui +vj where, cij cost. ui row.

Vj column.

* + - Assume any one ui or vj is to be zero such that max. no of allocations are done in that row(i) or column (j) & find value of all other ui’s & vj’s

**STEP 3**:

* + - Evaluate the unoccupied cells. dij= ui +vj - cij
    - If all evaluation values are either negative or zero,then the initial solution is optimal solution.
    - If any positive value exist, initial solution is not an optimal solution.

**STEP 4**:

* + - Identify the **entering variable.**

The highest **positive** evaluated value(dij) cell is treated as entering variable cell.

**STEP 5**:

* + - Identify leaving variable.
      * To identify the leaving variable, construct a closed loop.
      * Loop starts at the entering variable cell.
      * Loop can go clockwise or anticlockwise.
      * The turning point should be occupied cell.
      * Loop can cross each other.

**STEP 6**:

* Start assigning positive & negative.
* Assign positive (+) for the entering variable & negative (-) alternatively.
* Where is the **minimum allocation quantity** among the negative cells.
* Add to the allocated value in the positive cells and deduct to the allocated value in the negative cells.
* Cell/cells which have zero allocation (after deducting ) is the leaving variable.

**STEP 7**:

* Prepare a new transportation table.
* The values in the loop will get changed as per the step 6 and all other allocations not in the loop remains the same.

**STEP 8:**

* Check for optimality using step 1 to step 3
  + If the solution is optimal calculate the minimum transportation cost from the allocations and the unit costs given.
  + Repeat the procedure from step 4 to step 8, if the solution is not optimal.

# ASSIGNMENT

In a printing press there is one machine and one operator is there to operate. How would you employ the worker? Your immediate answer will be, the available operator will operate the machine. Again suppose there are two machines in the press and two operators are engaged at different rates to operate them. Which operator should operate which machine for maximizing profit?

Similarly, if there are n machines available and n persons are engaged at different rates to operate them. Which operator should be assigned to which machine to ensure maximum efficiency? While answering the above questions we have to think about the interest of the press, so we have to find such an assignment by which the press gets maximum profit on minimum investment. Such problems are known as "assignment problems".

Assignment problem is a particular case of the transportation problem in which objective is to assign number of task to equal number of facilities at minimum cost and maximum profit. Suppose there are ‘m’ facilities and ‘n’ jobs and the effectiveness of each facility for each job are given, the objective is to assign one facility to one job so that the given measure of effectiveness is optimized.

If the matrix contains the cost involved in assignment the aim is to **minimize the cost**. If the matrix contains revenue or profit the aim is to **maximize the revenue or profit**. Ex.:

JOBS

a b c d

1. C1a C1b C1c C1d
2. C2a C2b C2c C2d

FACILITIES 3 C3a C3b C3c C3d

4 C4a C4b C4c C4d

1,2,3,4 indicates the facilities and a, b, c, d indicates the jobs. The matrix entries are the cost associated with the assignment of facilities with the jobs. The objective is to assign one facility to one job, so that the total cost is minimum.

Ex.:

Facility Job

1. d
2. c
3. a
4. b

Total cost = C1d + C2c +C3a +C4b

# HUNGARIAN METHOD OR ASSIGNMENT ALGORITHM

**STEP 1**: **Balancing the problem**

* Check if the No. of Rows is equal to the No. of Columns, if not add a dummy row or a dummy column.

# STEP 2: Row wise calculation (row reduced matrix)

* Select the min cost element from each row and subtract it from all the elements in the same row.

# STEP 3: Column wise calculation (column reduced matrix)

* From the resultant matrix, select the minimum cost element from each column and subtract it from all the other elements in the same column.

# STEP 4: Assigning the zeroes

* Starting with first row of the resultant matrix received in first step, examine the rows one by one until a row containing exactly one zero is found. Then an experimental assignment indicated by ‘ ’ is marked to that zero. Now cross all the zeros in the column in which the assignment is made. This procedure should be adopted for each row assignment.
* When the set of rows has been completely examined, an identical procedure is applied successively to columns. Starting with column 1, examine all columns until a column containing exactly one zero is found. Then make an experimental assignment in that position and cross other zeros in the row in which the assignment was made. Continue these successive operations on rows and columns until all zero’s have either been assigned or crossed-out.
* If all the zeros are assigned or crossed out, i.e., we get the maximal assignment.

Note: In case, if two zeros are remained by assignment or by crossing out in each row or column. In this situation we try to exclude some of the zeros by trial and error method.

# STEP 5: Check for optimality

.

* If each job is assigned to each facility, then assignment is optimal. If any job or facility is left without assignment move to step 6

# STEP 6: Draw of minimum lines to cover zeros

Draw the minimum possible straight lines covering all the zeros in the matrix by the following procedure

* Mark () rows in which the assignment has not been done.
* Locate zero in marked () row and then mark () the corresponding column.
* In the marked () column, locate assigned zeros & then mark () the corresponding rows.
* Repeat the procedure, till the completion of marking.
* Draw the lines through **unmarked rows and marked columns**.

**Note:** If the above method does not work then make an **arbitrary assignment**. If the number of these lines is equal to the order of the matrix then it will be an optimal solution and then go to step9 Otherwise proceed to step 7.

# STEP 7: Modified Matrix

* Identify covered elements, uncovered elements and junction point
  + **covered elements –** where the lines passes through
  + **uncovered elements –** where the line does not pass through.
  + **junction point-** where the lines intersects
* Select the smallest element from the uncovered elements.
* Subtract this smallest element from the uncovered elements.
* Add this smallest element to the junction point
* Covered elements remain untouched Thus we have increased the number of zero’s

# STEP: 8

* Repeat the procedure of assigning the zeroes as step 4.
* Repeat the procedure of checking for optimality as step 5.
* If optimality is arrived move to step 9 otherwise repeat steps 6 to 8.

# STEP : 9

* Write separately the assignment (ONE TO ONE) and calculate the total cost taking corresponding values from the problem data.

NOTE:

Multiple optimal solutions

* If the final matrix (for zero assignment) is having more than one zero on rows and columns at independent positions (not possible to assign or cancel row-wise or column-wise) choose arbitrarily one zero for assignment and cancel all zeros in the corresponding rows and columns.
* Repeat the procedure by choosing another zero for assignment till all such zeroes are considered.
* Each assignment by this procedure will provide different set of assignments keeping the total minimum cost as constant. This implies multiple optimal solutions with the same optimal assignment cost.

# SOLVING MAXIMISATION PROBLEMS IN ASSIGNMENT USING HUNGARIAN METHOD

* The maximization problem can be converted in to a minimization problem by subtracting all the elements of the matrix from the highest value.
* Follow the steps 1 to 9 of Hungarian Algorithm.

**Note:** While calculating the total profits take corresponding values from initial assignment problem (data before conversion of the problem)

# RESTRICTED ASSIGNMENT PROBLEMS

The assignment technique assumes that the problem is free from practical restrictions and any task could be assigned to any facility. But in some cases, it may not be possible to assign a

particular task to a particular facility due to space, size of the task, process capability of the facility, technical difficulties or other restrictions. This can be overcome by assigning a very high processing time of cost element ( infinity) to the corresponding cell.

* Use Hungarian method for assignment steps 1 to 9.

**NOTE:**

* For maximization problems in restricted assignments, convert the problem in to a minimization problems given in the procedure above.
* Substitute  (infinity) in the matrix for the restricted assignments.
* Use Hungarian method for assignment steps 1 to 9.

# TRAVELLING SALESMAN PROBLEM

A salesman normally visits numbers of cities starting from high head quarters. The distance (or time or cost) between every pair of cities are assumed to be known. If a salesman has to visit ‘n’ cities, then he will have a total of (n-1)! Possible round trips. The problem of finding the shortest distance (or minimum time or minimum cost) if the salesman starts from his headquarters and passes through each city under his jurisdiction exactly once and returns to the headquarters is called the Travelling salesman problem or A Travelling Salesperson problem.

A travelling salesman problem is very similar to the assignment problem with the additional constraints.

# Route Conditions:

* + The salesman should go through every city exactly once except the starting city (headquarters).
  + The salesman starts from one city (headquarters) and comes back to that city (headquarters).

1. Obviously going from any city to the same city directly is not allowed (i.e., no assignments should be made along the diagonal line).

# Steps to solve travelling salesman problem:

1. Assigning an infinitely large element () in each of the squares along the diagonal line in the cost matrix.
2. Solving the problem as a routine assignment problem.
3. Scrutinizing the solution obtained under (ii) to see if the ‘route’ conditions are satisfied.
4. If not, making adjustments in assignments to satisfy the condition with minimum increase in total cost (i.e. to satisfy route condition, ‘next best solution’ may require to be considered).

# QUESTIONS BANK

**TRANSPORTATION INITIAL SOLUTION**

# NORTH WEST CORNER METHOD

1.

Destination Supply

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sources | D1 | D2 | D3 | D4 |  |
| S1 | 2 | 4 | 6 | 2 | 100 |
| S2 | 8 | 6 | 5 | 2 | 60 |
| S3 | 9 | 10 | 7 | 5 | 40 |
| Demand | 40 | 60 | 80 | 20 |  |

Destination Supply

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 2. Sources | D1 | D2 | D3 | D4 |  |
| S1 | 2 | 4 | 6 | 2 | 70 |
| S2 | 8 | 6 | 5 | 2 | 30 |
| S3 | 9 | 10 | 7 | 5 | 50 |
| Demand | 80 | 10 | 20 | 30 |  |

# LEAST COST METHOD

3.

Destination Supply

ly

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Sources | D1 | D2 | D3 | D4 |  |
| S1 | 2 | 4 | 6 | 2 | 100 |
| S2 | 8 | 6 | 5 | 2 | 60 |
| S3 | 9 | 10 | 7 | 5 | 40 |
| Demand | 40 | 60 | 80 | 20 |  |
| 4. . |  |  |  |  |  |  |
| Sources | | Desti D1 | nation D2 | D3 | D4 | Supp |
| S1 | | 6 | 1 | 9 | 3 | 70 |
| S2 | | 11 | 5 | 2 | 8 | 55 |
| S3 | | 10 | 12 | 14 | 7 | 70 |
| Demand | | 85 | 35 | 50 | 45 |  |

# VOGEL’S APPROXIMATION METHOD

1. Destination Supply

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sources | D1 | D2 | D3 | D4 |  |
| S1 | 7 | 3 | 6 | 8 | 60 |
| S2 | 4 | 2 | 5 | 0 | 100 |
| S3 | 2 | 6 | 5 | 1 | 40 |
| Demand | 20 | 50 | 50 | 80 |  |

6.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Destination Supply | | | | | | |
|  | Sources | D1 | D2 | D3 | D4 |  |
|  | S1 | 6 | 1 | 9 | 3 | 70 |
|  | S2 | 11 | 5 | 2 | 8 | 55 |
|  | S3 | 10 | 12 | 14 | 7 | 70 |
|  | Demand | 85 | 35 | 50 | 45 |  |
| 7. |  |  |  |  |  |  |
| Destination Supply | | | | | | |
| Sources | | D1 | D2 | D3 |  | |
| S1 | | 2 | 7 | 4 | 5 | |
| S2 | | 3 | 3 | 1 | 8 | |
| S3 | | 5 | 4 | 7 | 7 | |
| S4 | | 1 | 6 | 2 | 14 | |
| Demand | | 7 | 9 | 18 |  | |

# FINAL OPTIMAL SOLUTION (UV METHOD)

8.

Destination Supply

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Sources | D1 | D2 | D3 | D4 |  |
| S1 | 7 | 3 | 8 | 6 | 60 |
| S2 | 4 | 2 | 5 | 10 | 100 |
| S3 | 2 | 6 | 5 | 1 | 40 |
| Demand | 20 | 50 | 50 | 80 |  |
| 9. |  |  |  |  |  |  |
| Destination Supply | | | | | | |
|  | Sources | D1 | D2 | D3 |  | |
|  | S1 | 5 | 1 | 7 | 10 | |
|  | S2 | 6 | 4 | 6 | 80 | |
|  | S3 | 3 | 2 | 5 | 15 | |
|  | S4 | 5 | 3 | 2 | 40 | |
|  | Demand | 75 | 20 | 50 |  | |
| 10. |  |  |  |  |  | |
| Destination Supply | | | | | | |
| Sources | | D1 | D2 | D3 | D4 |  |
| S1 | | 6 | 1 | 9 | 3 | 70 |
| S2 | | 11 | 5 | 2 | 8 | 55 |
| S3 | | 10 | 12 | 4 | 7 | 70 |
| Demand | | 85 | 35 | 50 | 45 |  |

11.

Destination Supply

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Sources | D1 | D2 | D3 | D4 | D5 |  |
| S1 | 3 | 5 | 8 | 9 | 11 | 20 |
| S2 | 5 | 4 | 10 | 7 | 10 | 40 |
| S3 | 2 | 5 | 8 | 7 | 5 | 30 |
| Demand | 10 | 15 | 25 | 30 | 40 |  |

# DEGENERACY

12.

Destination Supply

ly

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Sources | D1 | D2 | D3 |  | |
| S1 | 16 | 20 | 12 | 50 | |
| S2 | 14 | 8 | 18 | 50 | |
| S3 | 26 | 24 | 16 | 50 | |
| Demand | 50 | 50 | 50 |  | |
| 13. |  |  |  |  |  | |
|  | Sources | Desti D1 | nation D2 | D3 | D4 | Supp |
|  | S1 | 13 | 25 | 12 | 21 | 18 |
|  | S2 | 18 | 23 | 14 | 9 | 27 |
|  | S3 | 23 | 15 | 12 | 16 | 21 |
|  | Demand | 14 | 12 | 23 | 27 |  |
| 14. |  |  |  |  |  |  |
| Sources | | Desti D1 | nation D2 | D3 | D4 | Suppl |
| S1 | | 42 | 48 | 38 | 37 | 160 |
| S2 | | 40 | 49 | 52 | 51 | 150 |
| S3 | | 39 | 38 | 40 | 43 | 190 |
| Demand | | 80 | 90 | 110 | 160 |  |

y

# ASSIGNMENT

* 1. Persons

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| JOBS | | 1 | 2 | 3 | 4 |
|  | A | 10 | 5 | 13 | 15 |
|  | B | 3 | 9 | 18 | 3 |
|  | C | 10 | 7 | 3 | 2 |
|  | D | 5 | 11 | 9 | 7 |
| 2. | JOBS | 1 | Persons 2 | 3 | 4 |
|  | A | 5 | 8 | 4 | 2 |
|  | B | 1 | 4 | 6 | 3 |
|  | C | 0 | 4 | 2 | 6 |
|  | D | 4 | 7 | 5 | 4 |
| 3. | JOBS | 1 | Persons 2 | 3 | 4 |
|  | A | 8 | 8 | 4 | 3 |
|  | B | 4 | 2 | 1 | 6 |
|  | C | 6 | 8 | 10 | 12 |
|  | D | 14 | 18 | 20 | 22 |

# UNBALANCED ASSIGNMENT MODELS

4.

Persons

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| JOBS | 1 | 2 | 3 | 4 |
| A | 24 | 27 | 18 | 20 |
| B | 26 | 23 | 20 | 31 |
| C | 24 | 22 | 34 | 26 |
| D | 19 | 21 | 21 | 22 |
| E | 30 | 25 | 28 | 27 |

# MAXIMIZATION CASE IN ASSIGNMENT PROBLEMS

5.

Territories

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | T1 | T2 | T3 | T4 |
| P1 | 60 | 50 | 40 | 30 |
| P2 | 40 | 30 | 20 | 15 |
| P3 | 40 | 20 | 35 | 10 |
| P4 | 30 | 30 | 25 | 20 |

6. Territories

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | T1 | T2 | T3 | T4 |
| P1 | 10 | 22 | 12 | 4 |
| P2 | 16 | 18 | 22 | 10 |
| P3 | 24 | 20 | 12 | 18 |
| P4 | 16 | 14 | 24 | 20 |

# RESTRICTED ASSIGNMENT MODEL

7.

Territories

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | T1 | T2 | T3 | T4 |
| R1 | 4 | - | - | 8 |
| R2 | 9 | - | 4 | 3 |
| R3 | 8 | 1 | 2 | - |

# TRAVELLING SALESMAN PROBLEM

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 8. | A | TO B | C | D |
| A | - | 46 | 16 | 40 |
| B | 41 | - | 50 | 40 |
| FROM C | 82 | 32 | - | 60 |
| D | 40 | 40 | 36 | - |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 9. | A | TO B | C | D | E |
| A | - | 3 | 6 | 2 | 3 |
| B | 3 | - | 5 | 2 | 3 |
| FROM C | 6 | 5 | - | 6 | 4 |
| D | 2 | 2 | 6 | - | 6 |
| E | 3 | 3 | 4 | 6 | - |

**PROBLEMS FOR PRACTICE**

10.

Persons

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | JOBS | 1 | 2 | 3 | 4 | 5 |
| A | 8 | 4 | 2 | 6 | 1 |
| B | 0 | 9 | 5 | 5 | 4 |
| C | 3 | 8 | 9 | 2 | 6 |
| D | 4 | 3 | 1 | 0 | 3 |
| E | 9 | 5 | 8 | 9 | 5 |
| 11. |  | 1 | Persons 2 | 3 | 4 |  |
|  | JOBS  A | 8 | 3 | 2 | 1 |  |
|  | B | 4 | 5 | 6 | 3 |  |
|  | C | 2 | 2 | 9 | 4 |  |
|  | D | 1 | 3 | 6 | 5 |  |
|  | E | 9 | 3 | 6 | 5 |  |

# MAXIMIZATION CASE IN ASSIGNMENT PROBLEMS

1. Territories

|  |  |  |  |
| --- | --- | --- | --- |
|  | T1 | T2 | T3 |
| S1 | 80 | 40 | 30 |
| S2 | 20 | 10 | 10 |
| S3 | 40 | 40 | 60 |
| S4 | 90 | 30 | 40 |

1. Territories

|  |  |  |  |
| --- | --- | --- | --- |
|  | T1 | T2 | T3 |
| P1 | 20 | 26 | 42 |
| P2 | 24 | 32 | 50 |
| P3 | 32 | 34 | 44 |

# RESTRICTED ASSIGNMENT MODEL

Territories

R1 R2 R3 R4

C1 4000 5000 - -

C2 - 4000 - 4000

C3 3000 - 2000 -

C4 - - 4000 5000

# TRAVELLING SALESMAN PROBLEM

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 15. | A | TO B | C | D | E |
| A | - | 4 | 7 | 3 | 4 |
| B | 4 | - | 6 | 3 | 4 |
| FROM C | 7 | 6 | - | 7 | 5 |
| D | 3 | 3 | 7 | - | 7 |
| E | 4 | 4 | 5 | 7 | - |

**UNIT – II – TRANSPORTATION AND ASSIGNMET MODEL MODEL QUESTION PAPER**

# PART - A

* 1. Define and specify the objective of transportation model.
  2. What is meant by unbalanced problem in transportation? How will you convert unbalanced problem into balanced problem in transportation?
  3. List the methods used to find initial solution in transportation?
  4. What is degeneracy in transportation?
  5. Define and list out the objectives of assignment?
  6. Specify the route conditions in travelling salesman problem.
  7. How to convert maximization problem into minimization problem in assignment?
  8. Differentiate between assignment problem and transportation problem.
  9. Find the initial solution for the given transportation problem using North-West corner method.

Destination

D1 D2 D3 D4 Supply O1 6 1 9 3 100

Origins O2 11 5 2 8 60

O3 10 12 4 7 40

Demand 40 60 80 20

* 1. A Computer centre has got 4 programmers. The centre needs 4 application programmes to be developed. The centre head, after studying carefully the programmes to be developed, estimates the computer time (in minutes) required by the respective experts to develop the application programmes as follows:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | A | Progr  B | ammes  C | D |
|  | 1 | 120 | 100 | 80 | 90 |
| Programmers | 2 | 80 | 90 | 110 | 70 |
|  | 3 | 110 | 140 | 120 | 100 |
|  | 4 | 90 | 90 | 80 | 90 |

Assign the programmers to the programmes in such a way that the total computer time gets minimized.

# PART - B

1. What is meant by transportation? Specify the objectives of transportation tool. Write the procedure for making unbalanced problem into balanced problem with an example.

# OR

1. Solve the transportation problem using MODI method.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sources | D1 | D2 | Destination D3 | D4 | Supply |
| S1 | 7 | 3 | 8 | 6 | 60 |
| S2 | 4 | 2 | 5 | 10 | 100 |
| S3 | 2 | 6 | 5 | 1 | 40 |
| Demand | 20 | 50 | 50 | 80 |  |

1. Write the procedure to solve transportation problem using MODI method.

# OR

1. For the given transportation problem, find the initial solution using North-west corner method and final optimal solution using MODI method.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sources |  | Desti  D1 | nation  D2 | D3 | D4 Supply |
| S1 | 6 | 1 | 9 | 3 | 70 |
| S2 | 11 | 5 | 2 | 8 | 55 |
| S3 | 10 | 12 | 4 | 7 | 70 |
| Demand | 85 | 35 | 50 | 45 |  |

1. Write the procedure for a) North-West corner method b) Least-Cost method c) Vogel’s

approximation method.

# OR

1. Using U-V method, solve the given transportation problem.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Destination | | | |
| Sources | D1 | D2 | D3 | Supply |
| S1 | 5 | 1 | 7 | 10 |
| S2 | 6 | 4 | 6 | 80 |
| S3 | 3 | 2 | 5 | 15 |
| S4 | 5 | 3 | 2 | 40 |
| Demand | 75 | 20 | 50 |  |

1. Write Hungarian algorithm.

# OR

1. Given are the costs for assigning jobs to the persons working in an organization, find the minimum cost using the given information.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | Persons | | | |
|  | P1 | P2 | P3 | P4 |
|  | A | 8 | 8 | 4 | 3 |
| Jobs | B | 4 | 2 | 1 | 6 |
|  | C | 6 | 8 | 10 | 12 |
|  | D | 14 | 18 | 20 | 22 |

1. Write the procedure for a) Maximization problem in assignment with an example b) Restricted assignment problem with an example c) Conditions to solve Travelling salesman assignment problem.

# OR

1. Solve the given assignment problem in which profits are given for various territories.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | Territories | | | |
|  | T1 | T2 | T3 | T4 |
| P1 | 10 | 22 | 12 | 4 |
| Profits | P2 | 16 | 18 | 22 | 10 |
|  | P3 | 24 | 20 | 12 | 18 |
|  | P4 | 16 | 14 | 24 | 20 |