Solutions Manual

# Module B: The Transportation Models

1.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *To*  *From* | *A* | *B* | *C* | *Capacity* |
| *1* | 30 |  |  | 30 |
| *2* | 40 |  |  | 40 |
| *3* | 30 | 30 | 20 | 80 |
| Demand | 100 | 30 | 20 | 150 |

The northwest corner rule is optimal at $1,020.

Cognitive Domain: Knowledge

Difficulty Level: Easy

2.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *To*  *From* | *A* | *B* | *C* | *Capacity* |
| *1* | 0 | 0 | 14 | 14 |
| *2* | 1 | 15 | 0 | 16 |
| *3* | 11 | 0 | 7 | 18 |
| Demand | 12 | 15 | 21 |  |

The total cost is $146.

Cognitive Domain: Knowledge

Difficulty Level: Easy

3.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *To*  *From* | *A* | *B* | *C* | *Capacity* |
| *1* | 1 | 0 | 26 | 27 |
| *2* | 0 | 25 | 0 | 25 |
| *3* | 23 | 0 | 0 | 23 |
| Demand | 24 | 25 | 26 | 75 |

The total cost is $9,170.

Cognitive Domain: Knowledge

Difficulty Level: Easy

4a.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *To*  *From* | *X* | *Y* | *Z* | *Capacity* |
| A | 280 | 20 |  | 300 |
| B |  | 200 | 60 | 260 |
| C |  |  | 190 | 190 |
| Warehouse Demand | 280 | 220 | 250 | 750 |

Northwest corner rule = $9,850

4b.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *To*  *From* | *X* | *Y* | *Z* | *Capacity* |
| A | 50 |  | 250 | 300 |
| B | 40 | 220 |  | 260 |
| C | 190 |  |  | 190 |
| Warehouse Demand | 280 | 220 | 250 | 750 |

Matrix least-cost method = $10,310

4c.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *To*  *From* | *X* | *Y* | *Z* | *Capacity* |
| A | 240 | 0 | 60 | 300 |
| B | 40 | 220 | 0 | 260 |
| C | 0 | 0 | 190 | 190 |
| Warehouse Demand | 280 | 220 | 250 | 750 |

Optimal solution = $9,170

Cognitive Domain: Comprehension

Difficulty Level: Medium

5a.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *To*  *From* | *Chennai* | *New Delhi* | *Chandigarh* | *Mill Capacity (in tons)* |
| Jodhpur | 30 |  |  | 30 |
| Bhopal | 5 | 35 | 5 | 45 |
| Nagpur |  |  | 35 | 35 |
| Warehouse Demand (in tons) | 35 | 35 | 40 | 110 |

Northwest corner rule = $520

5b.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *To*  *From* | *Chennai* | *New Delhi* | *Chandigarh* | *Mill Capacity (in tons)* |
| Jodhpur | 0 | 0 | 30 | 30 |
| Bhopal | 35 | 0 | 10 | 45 |
| Nagpur | 0 | 35 | 0 | 35 |
| Warehouse Demand (in tons) | 35 | 35 | 40 | 110 |

Matrix least-cost method = $520

5c.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *To*  *From* | *Chennai* | *New Delhi* | *Chandigarh* | *Mill Capacity (in tons)* |
| Jodhpur | 0 | 0 | 30 | 30 |
| Bhopal | 0 | 35 | 10 | 45 |
| Nagpur | 35 | 0 | 0 | 35 |
| Warehouse Demand (in tons) | 35 | 35 | 40 | 110 |

Optimal solution = $485

Cognitive Domain: Comprehension

Difficulty Level: Medium

6a.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *To*  *From* | *X* | *Y* | *Z* | *Capacity (in truck loads)* |
| A | 40 |  |  | 40 |
| B | 10 | 35 |  | 45 |
| C |  | 5 | 30 | 35 |
| Demand (in truckloads) | 50 | 40 | 30 | 120 |

Northwest corner rule = $1,910

6b.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *To*  *From* | *X* | *Y* | *Z* | *Capacity (in truck loads)* |
| A | 15 | 25 |  | 40 |
| B |  | 15 | 30 | 45 |
| C | 35 |  |  | 35 |
| Demand (in truckloads) | 50 | 40 | 30 | 120 |

Matrix least-cost method = $1,670

6c.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *To*  *From* | *X* | *Y* | *Z* | *Capacity (in truck loads)* |
| A | 35 | 5 | 0 | 40 |
| B | 15 | 0 | 30 | 45 |
| C | 0 | 35 | 0 | 35 |
| Demand (in truckloads) | 50 | 40 | 30 | 120 |

Optimal solution = $1,525

Cognitive Domain: Comprehension

Difficulty Level: Medium

7.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *To*  *From* | *Dallas* | *Erie* | *Fargo* | *Capacity* |
| Cleveland | $10  400 | $4 | $12 | 400 |
| Calgary | $18 | $12  700 | $8 | 700 |
| Tucson | $12  100 | $10 | $14   * 800 | * 900 |
| * Demand | * 500 | * 700 | * 800 | * 2000 |

Tucson to Dallas: +$12 + $12 – $18 – $10 = -$4. Shift 100 units from the Calgary-to-Dallas allocation to the Tucson-to-Dallas route, and move 100 units from the Tucson-to-Erie allocation to the Calgary-to-Erie route. This reduces the cost by $400.

Cognitive Domain: Comprehension

Difficulty Level: Medium

8.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| * *To*   *From* | *W* | *X* | *Y* | *Z* | *Capacity* |
| 1 | $8  200 | $3 | $2 | $5 | 200 |
| 2 | $10  200 | $7  200 | $6  200 | $8 | 600 |
| 3 | $9 | $4 | $4  100 | $7  200 | 300 |
| Demand | 400 | 200 | 300 | 200 | 1,100 |

Allocating a shipment from 3 to X results in +$4 + $6 – $4 – $7 = -$1, which is an improvement. Shift 100 units from the 3Y allocation to the 3X path, and shift 100 units from the 2X route to the 2Y path. The improvement is $100, from $8,000 to $7,900.

Cognitive Domain: Comprehension

Difficulty Level: Medium

9.



All variables ≥0

Cognitive Domain: Analysis

Difficulty Level: Medium

10. Cognitive Domain: Analysis

Difficulty Level: Medium

11. A Cleveland plant has an optimal system cost of $37,400.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | *Warehouse* | | |  |  |
| *Plant* | *Boston* | *Tucson* | *Denver* | *Dummy* | *Capacity* |
| Chicago | 0 | 0 | 190 | 10 | 200 |
| Baton Rouge | 0 | 110 | 0 | 40 | 150 |
| Cleveland | 160 | 140 | 0 | 0 | 300 |
| Demand | 160 | 250 | 190 | 50 |  |

An Atlanta plant has an optimal system cost of $43,600; Hari should choose Cleveland.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | *Warehouse* | | |  |  |
| *Plant* | *Boston* | *Tucson* | *Denver* | *Dummy* | *Capacity* |
| Chicago | 0 | 0 | 190 | 10 | 200 |
| Baton Rouge | 0 | 110 | 0 | 40 | 150 |
| Atlanta | 160 | 140 | 0 | 0 | 300 |
| Demand | 160 | 250 | 190 | 50 |  |

Cognitive Domain: Analysis

Difficulty Level: Medium

12.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *To*  *From* | *Erie* | *Franklin* | *Venango* | *Supply Available* |
| Energy efficient |  |  | 400 | 400 |
| Northeast gas |  | 350 |  | 350 |
| Western gas | 500 |  |  | 500 |
| Dummy gas |  | 50 |  | 50 |
| Demand | 500 | 400 | 400 |  |

A dummy supply source is needed to balance supply and demand. The total cost is $20,850.

Cognitive Domain: Comprehension

Difficulty Level: Medium

13.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *To*  *From* | *Buffalo* | *Atlanta* | *New Orleans* | *Seattle* | *Capacity* |
| Colorado Springs | 1,500 | 2,500 |  | 500 | 4,500 |
| Dayton |  | 1,500 | 3,500 |  | 5,000 |
| Dummy Springs |  |  |  | 1,500 | 1,500 |
| Demand | 1,500 | 4,000 | 3,500 | 2,000 |  |

A dummy supply source is required to balance the model; the optimal cost is $386,000.

Cognitive Domain: Comprehension

Difficulty Level: Medium

14.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| *To*  *From* | *Cleveland* | *Orlando* | *Denver* | *San Diego* | *New York* | *Mill Capacity (in tons)* |
| San Jose | 0 | 0 | 25 | 20 | 0 | 45 |
| Dayton | 25 | 20 | 5 | 0 | 0 | 50 |
| Boston | 0 | 0 | 5 | 0 | 30 | 35 |
| Demand (in tons) | 25 | 20 | 35 | 20 | 30 | 130 |

The optimal cost is $1,065.

Cognitive Domain: Comprehension

Difficulty Level: Medium

15.



Cognitive Domain: Analysis

Difficulty Level: Medium

16.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | *Destinations* | | |  |
| *Existing Plants* | *Miami* | *Seattle* | *Houston* | *Capacity* |
| Raleigh | 60 | 290 | 0 | 350 |
| Akron | 0 | 0 | 250 | 250 |
| Cedar Rapids | 50 | 0 | 150 | 200 |
| Atlanta | 200 | 0 | 0 |  |
| Demand | 310 | 290 | 400 |  |

The optimal cost is $22,730.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | *Destinations* | | |  |
| *Existing Plants* | *Miami* | *Seattle* | *Houston* | *Capacity* |
| Raleigh | 60 | 290 | 0 | 350 |
| Akron | 0 | 0 | 250 | 250 |
| Cedar Rapids | 50 | 0 | 150 | 200 |
| Mobile | 200 | 0 | 0 | 200 |
| Demand | 310 | 290 | 400 |  |

The optimal cost is $23,130.

Add the plant in Atlanta.

Cognitive Domain: Analysis

Difficulty Level: Medium

17. The condition is degeneracy, and it can be overcome by creating an artificially occupied cell that allows a complete path to be traced. Placing a negligible amount in the Calgary-to-Dallas route permits application of the stepping stone method.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *To*  *From* | *Dallas* | *Erie* | *Fargo* | *Capacity* |
| Cleveland | $9  400 | $6 | $10 | 400 |
| Calgary | $20  **0** | $10  700 | $8  200 | 900 |
| Tucson | $14 | $16 | $15  600 | 600 |
| Demand | 400 | 700 | 800 | 2,000 |

The optimal solution costs $18,600.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *To*  *From* | *Dallas* | *Erie* | *Fargo* | *Capacity* |
| Cleveland | $9  0 | $6  400 | $10  0 | 400 |
| Calgary | $20  0 | $10  100 | $8  800 | 900 |
| Tucson | $14  400 | $16  200 | $15  0 | 600 |
| Demand | 400 | 700 | 800 | 2,000 |

Cognitive Domain: Analysis

Difficulty Level: Hard

18.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *To*  *From* | *W* | *X* | *Y* | *Z* | *Capacity* |
| 1 | $7  200 | $4 | $3 | $6 | 200 |
| 2 | $9  200 | $8  200 | $5 | $7 | 400 |
| 3 | $8  **0** | $5 | $4  300 | $6  200 | 500 |
| Demand | 400 | 200 | 300 | 200 | 1,100 |

Add a negligible amount to the 3W shipping route to permit completion of the stepping stone analysis. One improvement would be to divert a shipment to the 1X cell, which improves the solution by $400.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *To*  *From* | *W* | *X* | *Y* | *Z* | *Capacity* |
| 1 | $7  0 | $4  200 | $3 | $6 | 200 |
| 2 | $9  400 | $8  0 | $5 | $7 | 400 |
| 3 | $8  **0** | $5 | $4  300 | $6  200 | 500 |
| Demand | 400 | 200 | 300 | 200 | 1,100 |

Cognitive Domain: Analysis

Difficulty Level: Hard

19a. The matrix is unbalanced, so a dummy source must be added as Plant 6 with a capacity of 200.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *To*  *From* | *Warehouse* | | | | | | | | *Capacity* |
| *A* | | *B* | *C* | | *D* | | *E* |
| Plant-1 | 400 | 400 | | 400 |  | |  | | 1,200 |
| Plant-2 | 1000 |  | |  | 500 | |  | | 1,500 |
| Plant-3 |  |  | |  | 900 | |  | | 900 |
| Plant-4 |  | 200 | |  |  | | 900 | | 1,100 |
| Plant-5 |  |  | | 1300 |  | |  | | 1,300 |
| Plant-6 |  | 200 | |  |  | |  | | 200 |
| Demand | 1400 | 800 | | 1700 | 1400 | | 900 | | 6,000  6,200 |

19b.The minimum cost solution is $37,800.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *To*  *From* | *Warehouse* | | | | | | | | *Capacity* |
| *A* | | *B* | *C* | | *D* | | *E* |
| Plant-1 | 400 |  | |  |  | | 800 | | 1,200 |
| Plant-2 | 100 |  | |  | 1,400 | |  | | 1,500 |
| Plant-3 | 900 |  | |  |  | |  | | 900 |
| Plant-4 |  | 800 | | 200 |  | | 100 | | 1,100 |
| Plant-5 |  |  | | 1,300 |  | |  | | 1,300 |
| Plant-6 |  | 200 | | 200 |  | |  | | 200 |
| Demand | 1,400 | 800 | | 1700 | 1400 | | 900 | | 6,000  6,200 |

Cognitive Domain: Analysis

Difficulty Level: Hard

20.



Cognitive Domain: Analysis

Difficulty Level: Hard