(Easting house) Easting house sells air conditioners. The annual demand for air conditioners in each region of the country is as follows: East, 100,000; South, 150,000; Midwest, 110,000; and West, 90,000. Easting house is considering building its air conditioners in four different cities: New York, Atlanta, Chicago, and Los Angeles. The cost of producing an air conditioner in a city and shipping it to a region of the country is given in the file P06_57.xlsx. Any factory can produce up to 150,000 air conditioners per year. The annual fixed cost of operating a factory in each city is given in the same file. At least 50,000 units of the Midwest demand for air conditioners must come from New York, and at least 50,000 units of the Midwest demand must come from Atlanta. Determine how Easting house can minimize the annual cost of meeting demand for air conditioners.

P06_57.xlsx

From\To	East	South	Midwest	West
NY	$206	$225	$230	$290
Atlanta	$225	$206	$221	$270
Chicago	$230	$221	$208	$262
LA	$290	$270	$262	$215

	Annual fixed costs
NY	$6,000,000
Atlanta	$5,500,000
Chicago	$5,800,000
LA	$6,200,000

Discussion: -

In this problem, our objective is to minimize the total cost. Total cost is summation of annual fixed cost and shipping cost. To calculate the Annual fixed cost, we need to decide on the cities where production needs to be done. So, our first decision variable is binary which will decided the cities which were used for production of air conditioners. To calculate the shipping cost we need to decide on the units that were shipped from each city to location.

Mathematical Model: -

Parameters (Inputs):

$i \in 1,2,3,4$ (i: $Index\ for\ cities\ \{NY, Atlanta, Chicago, LA\}$)
$j \in 1,2,3,4$ (i: $Index\ for\ regions\ \{East, south, midwest, west\}$)
F_i : $Fixed\ cost\ to\ produce\ air\ conditioners\ from\ city\ i$
V_{ij} : $Per\ unit\ shipping\ cost\ for\ the\ units\ shipped\ from\ city\ i\ to\ region\ j$
C : $Production\ capacity, 150000$
D_j : $Demand\ in\ region\ j$
$A_{13} \& A_{23} = 50000, Min\ products\ that\ should\ be\ shipped\ from\ NY\ and\ Atlanta\ to\ Midwest$

Decision Variables:

x_i : *Decision on whether producing product in city* i

y_{ij} : *Units shipped from city* i *to region* j

Objective:

$$Minimize\ total\ \ cost = \sum_{i=1}^{4}(x_i * F_i) + \sum_{j=1}^{4}\sum_{i=1}^{4}(y_{ij} * V_{ij})$$

Constraints:

$$\sum_{i=1}^{4} y_{ij} \geq D_j \ \ ; For\ j \in \{1,2,3,4\} \qquad (1)\ Demand\ Constraint$$

$$x_i \in \{0,1\} \qquad (2)\ Binary\ Constraint$$

$$\sum_{j=1}^{4} y_{ij} \leq C * x_i \quad ; For\ i \in \{1,2,3,4\} \qquad (3)\ Capacity\ constraint$$

$$y_{13} \geq A_{13}\ \&\ y_{23} \geq A_{23} \qquad (4)\ Min\ units\ from\ NY\ to\ Midwest\ \&\ Atlanta\ to\ Midwest$$

In constraint 3, if we don't multiply the decision variable x_i on R.H.S of the constraint, as it is a minimization problem, our optimal solution will make sure that there is no Annual fixed cost by consider all the binary decisions as Zero (0)

Excel Implementation: Please find the attached spreadsheet for solution.

43[RA].xlsx

Location [Easting house]: IP-CH6-Q57

Prepared By: Ramesh Alla

Air conditioner data

Unit production and shipping costs

From\To	East	South	Midwest	West
NY	$206	$225	$230	$290
Atlanta	$225	$206	$221	$270
Chicago	$230	$221	$208	$262
LA	$290	$270	$262	$215
Demand	100,000	150,000	110,000	90,000

Annual Fixed Cost	17700000
Unit Production & Shipping Cost	99220000
Total Cost	**116,920,000**

	Annual fixed costs	Decision to produce	Production Capacity
NY	$6,000,000	**1**	150,000
Atlanta	$5,500,000	**1**	150,000
Chicago	$5,800,000	**0**	150,000
LA	$6,200,000	**1**	150,000

Constraint	**Midwest**
NY	*50,000*
Atlanta	*50,000*

From\To	**East**	**South**	**Midwest**	**West**			
NY	100,000	0	50,000	-	150,000	<=	150,000
Atlanta	-	100,000	50,000	-	150,000	<=	150,000
Chicago	-	-	-	-	-	<=	-
LA	-	50,000	10,000	90,000	150,000	<=	150,000
	100,000	150,000	110,000	90,000			
	>=	>=	>=	>=			
	100,000	150,000	110,000	90,000			

Inputs

Decision variables

Calculated Variables

Constraints

Objective