**PHASE 1**Provide answers to the questions in Part A. Include a summary of the steps  
taken to obtain answers. Provide essential components for a solution for Part B with  
a spreadsheet implementation.

**PART A**

**Problem**Vance and Melissa are particularly interested in the realignment of the Staunton, Richmond,  
Warrenton, and Tappahannock regional offices, and thus have provided data only for those  
regional offices and the stores that should be collectively assigned to them. They tell Sasha  
that they are interested in an assignment of each of these stores to one of the four given  
regional offices, and that this assignment should minimize cost. After speaking with them at  
some length, you and Sasha are able to determine that by “cost,” they really mean travel cost.  
Travel cost has two primary components: a mileage component, and a salary component.  
The mileage component includes gasoline and wear and tear on vehicles. This cost is captured  
in the state mileage rate, which is currently $0.585 per mile. The salary component reflects  
the amount of salary being paid to employees while driving. Essentially, hours that an  
employee spends in transit between the regional office and the store are hours that cannot  
be devoted to substantive work for all stores. Vance and Melissa indicate that most of their  
employees are paid roughly $26 per hour.  
Vance and Melissa wonder what would happen if each store were simply assigned to the  
closest regional office (based on mileage). What is the cost of this assignment? Is it feasible?

**Step-by-Step Calculation:**

**1. Closest Regional Office Assignment**

Using the distances provided in the file, determine the closest regional office to each store **based on mileage**. For each store, note the distance to this closest office.

**2. Cost Calculation**

**Mileage Component:**

Multiply the distance from each store to its closest office by the state mileage rate ($0.585 per mile) to find the mileage cost.

**Salary Component:**

Multiply the travel time(given in the data) by the hourly wage ($26 per hour) to calculate the salary cost for each trip.

The total travel cost for each store assignment is the sum of the mileage cost and the salary cost

The travel cost for each store is given by the formula:

**3. Sum Total Cost:**

Add up the individual travel costs for each store to get the total travel cost for the initial closest-office assignment.

**4.** **Feasibility Check**:

Compare the total required hours for each regional office (sum of service hours for stores assigned to it) against the available work hours in that office, as provided in the data.

If any office’s assigned hours exceed its available hours, this assignment is infeasible; otherwise, it is feasible.

**5. Example Calculation**

Steps:  
Albemarle\_County store for Staunton office

1. Distance = 37 miles

2. Mileage Cost = 37×0.585=21.65 dollars

3. Travel Time = 0.66 hours

4. Salary Cost = 0.66×26=17.16 dollars

5. Total Travel Cost = 21.65+17.16=38.81 dollars

Repeat this calculation for each store, and then sum up all stores’ annual travel costs to get the **total travel cost** for the initial assignment.

**6. Results  
Assignment of stores based on minimum distance to the office.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Staunton** | **Warrenton** | **Richmond** | **Tappahannock** |
| Albemarle County | City of Fredericksburg | Charles City County | Caroline County |
| Amherst County | Culpeper County | Chesterfield County | Essex County |
| Augusta County | Greene County | City of Richmond | Fauquier County |
| Buckingham County | Madison County | Cumberland County | King and Queen County |
| Fluvanna County | Orange County | Dinwiddie County | King George County |
| Nelson County | Page County | Goochland County | King William County |
| Rockbridge County | Prince William County | Hanover County | Mathews County |
| Rockingham County | Rappahannock County | Henrico County | Westmoreland County |
|  | Shenandoah County | Hopewell County | York County |
|  | Spotsylvania County | James City County |  |
|  | Stafford County | Louisa County |  |
|  | Warren County | New Kent County |  |
|  |  | Powhatan County |  |
|  |  | Prince George County |  |

The initial assignment with a total travel cost of **$1,736.74** is not feasible because it does not meet the capacity constraints for each regional office. Although assigning each store to its closest regional office minimizes travel cost, it results in some offices being assigned more hours than their available capacity.

This over-assignment means that certain regional offices do not have enough work hours to meet the service demands of the stores assigned to them, making the solution impractical under the current staffing levels. Therefore, a different approach is needed to balance the workload across offices while also minimizing travel costs.

**PART B**

**1. Problem**

Create a model that will find the lowest cost assignment of all stores to a regional office that  
respects area availability in each office. What is this assignment? How does it differ from  
the assignment in Part A? How is it the same?

**2. Objective in Words**

**Decide** the assignment of each store to a regional office **so that** the total travel cost is minimized, subject to the following **constraints**:

**a) Capacity Constraints**: The total hours required by all stores assigned to each regional office must not exceed the available employee hours at that office.

**b) Assignment Constraints**: Each store must be assigned to exactly one regional office.

**c) Nonnegativity and Binary Constraints**: The assignment variable for each store to a regional office must be binary, meaning a store is either assigned (1) or not assigned (0) to a specific office.

**3. Data Definition**

**Data**

|  |  |  |  |
| --- | --- | --- | --- |
| **Staunton** | **Warrenton** | **Richmond** | **Tappahannock** |
| Amherst County | Buckingham County | Chesterfield County | Augusta County |
| Charles City County | Caroline County | City of Richmond | Shenandoah County |
| City of Fredericksburg | Essex County |  | Spotsylvania County |
| Culpeper County | Fluvanna County |  | Stafford County |
| Cumberland County | Hanover County |  | York County |
| Dinwiddie County | Nelson County |  |  |
| Fauquier County | New Kent County |  |  |
| Goochland County | Page County |  |  |
| Greene County | Powhatan County |  |  |
| Henrico County | Warren County |  |  |
| Hopewell County | Westmoreland County |  |  |
| James City County |  |  |  |
| King and Queen County |  |  |  |
| King George County |  |  |  |
| King William County |  |  |  |
| Louisa County |  |  |  |
| Madison County |  |  |  |
| Mathews County |  |  |  |
| Orange County |  |  |  |
| Prince George County |  |  |  |
| Prince William County |  |  |  |
| Rappahannock County |  |  |  |
| Rockbridge County |  |  |  |
| Rockingham County |  |  |  |

**4. Variable Definition – Decision variable**

**5. Algebraic Formulation**

**6. Implementation**[**realignment\_data\_group\_4.xlsx**](https://1drv.ms/x/c/5ec65275fd2fbbb4/EWnpM4cJzbxIrxJ1NGwe81cBkoi5VI4i3Hj5S3vUIaZlXw?e=oabrhf)

**7. Results**The optimal solution is that we should minimize the total travel cost to **$96,955.50** This value represents the combined expenses of mileage and salary costs for the trips required by each store to their assigned regional offices.

**How does the assignment in Part B differ from the assignment in Part A?**

**Feasibility**: Part B's solution is feasible, meaning it respects the capacity constraints at each regional office. Part A's solution, while aiming for minimum travel distance, might not be feasible due to over-allocation at certain offices.

**Optimization**: Part B optimizes not only for minimum travel distance but also for overall cost efficiency, considering factors like capacity constraints and potential trade-offs between travel distance and office capacity.

**Reassignments**: Part B involves reassignments of some stores to different regional offices compared to Part A to ensure feasibility and optimize overall cost.

**How is it the same?**

**Coverage**: Both solutions ensure that every store is assigned to a single regional office, providing complete coverage.

**Proximity**: Both solutions prioritize assigning stores to their nearest regional office whenever possible, as this often leads to lower travel costs.

**Objective**: Both solutions aim to minimize total travel costs, although Part B considers additional constraints and optimization considerations.