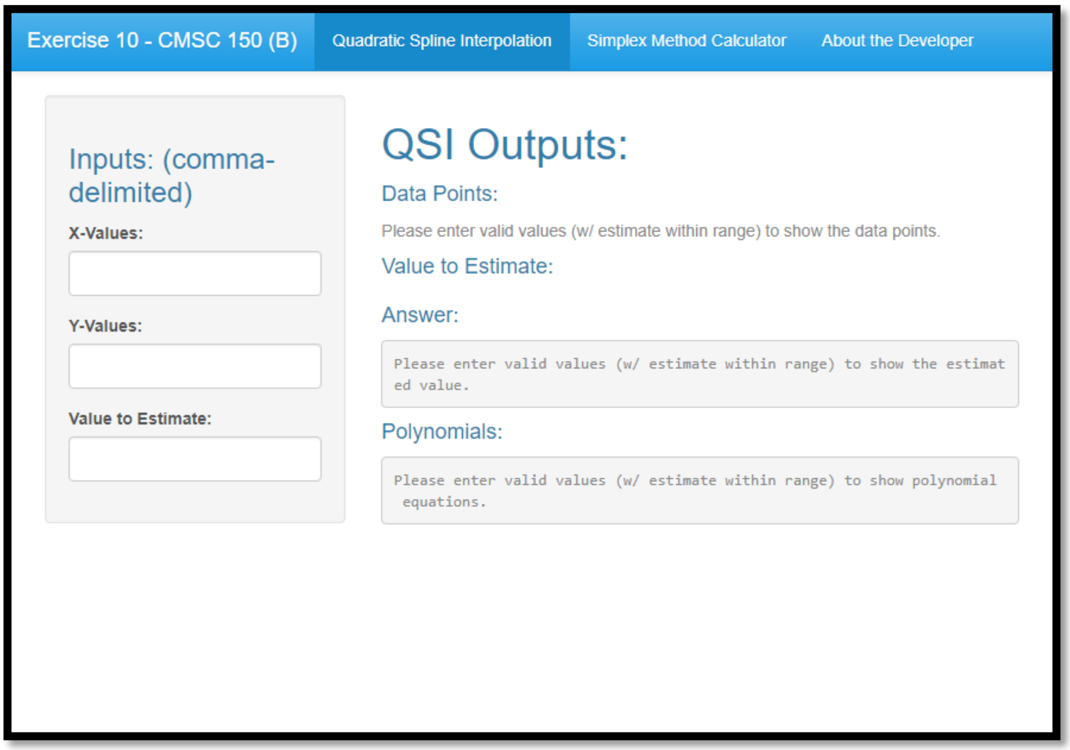
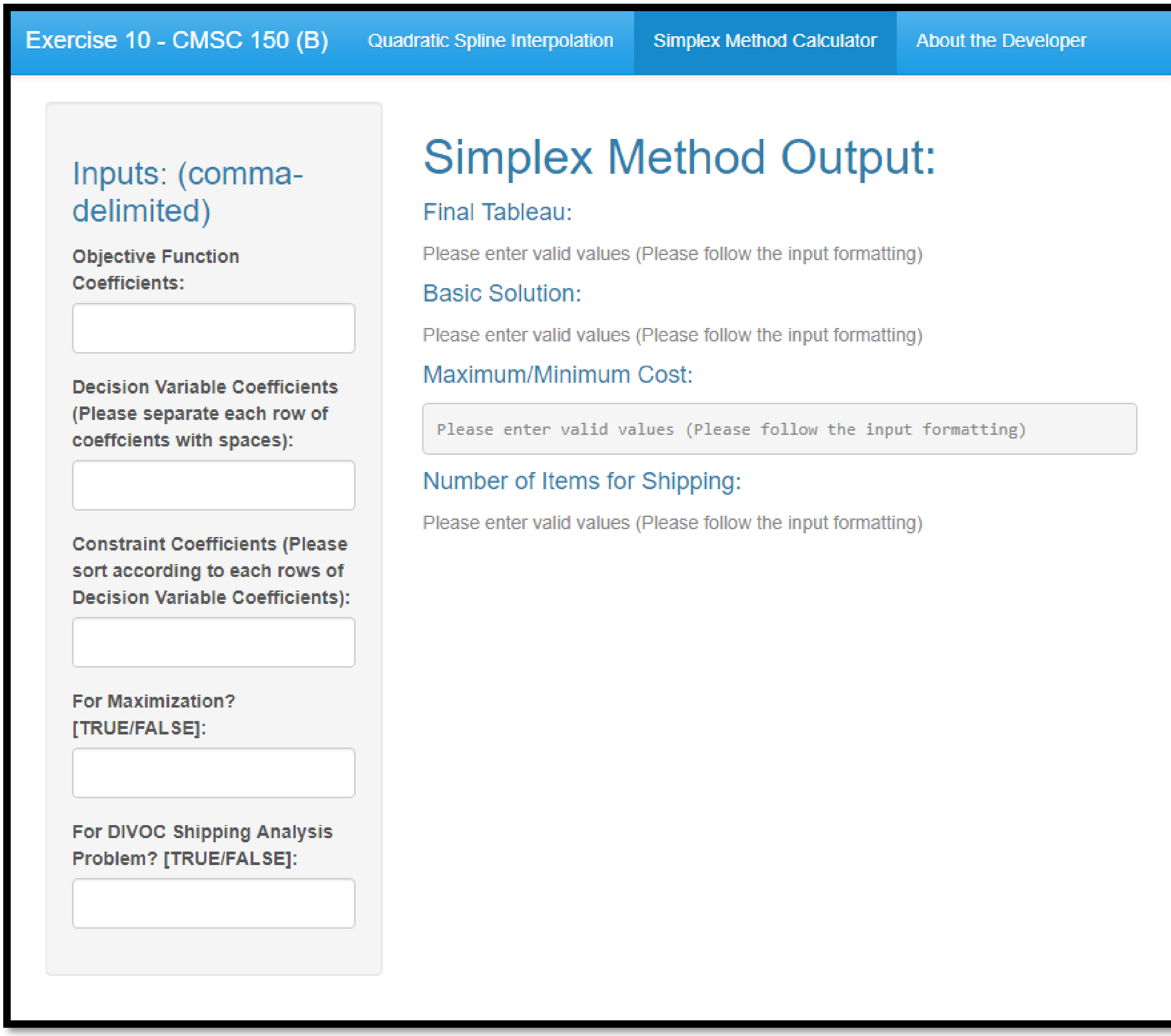
Exercise 10: Integration (User Manual)

Welcome to the User Guide/Manual for Exercise 10, integrating Exercise 8 (Quadratic Spline Interpolation) and Exercise 9 (Simplex Method). This manual consists of the steps to use the web application for the user's needs. Please read them carefully to make sure to get the expected results.

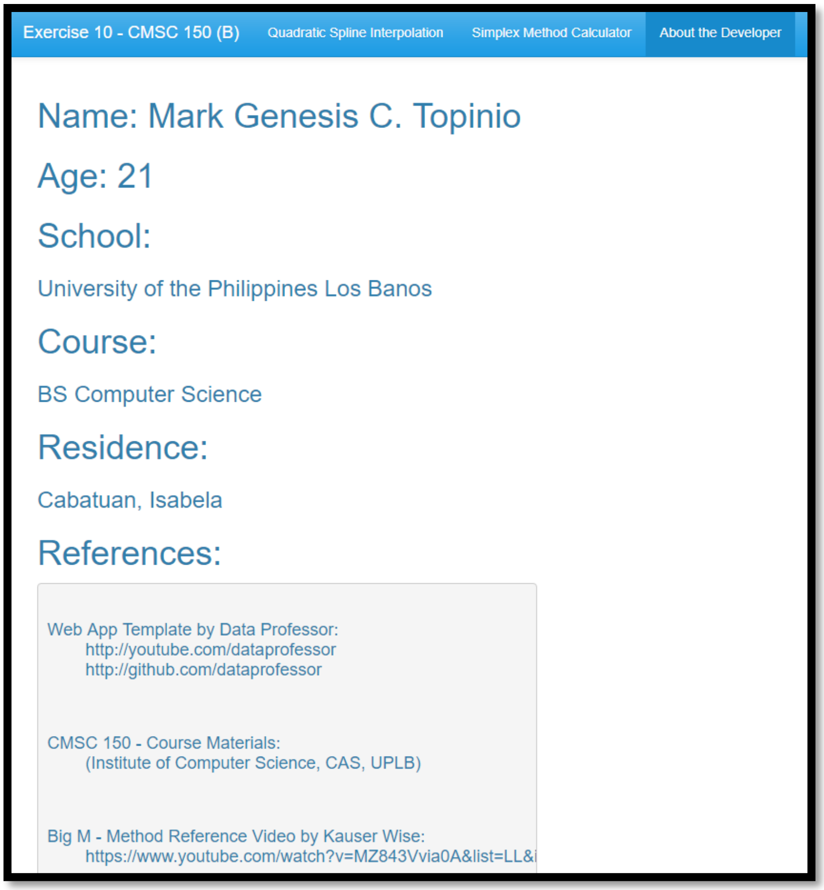
What does the web application look like?



When running the application via RStudio, you'll first see the navigation bar for the Quadratic Spline Interpolation Calculator. Navigate through the tabs to see each section.



The following navigation bar is for the Simplex Method Calculator.



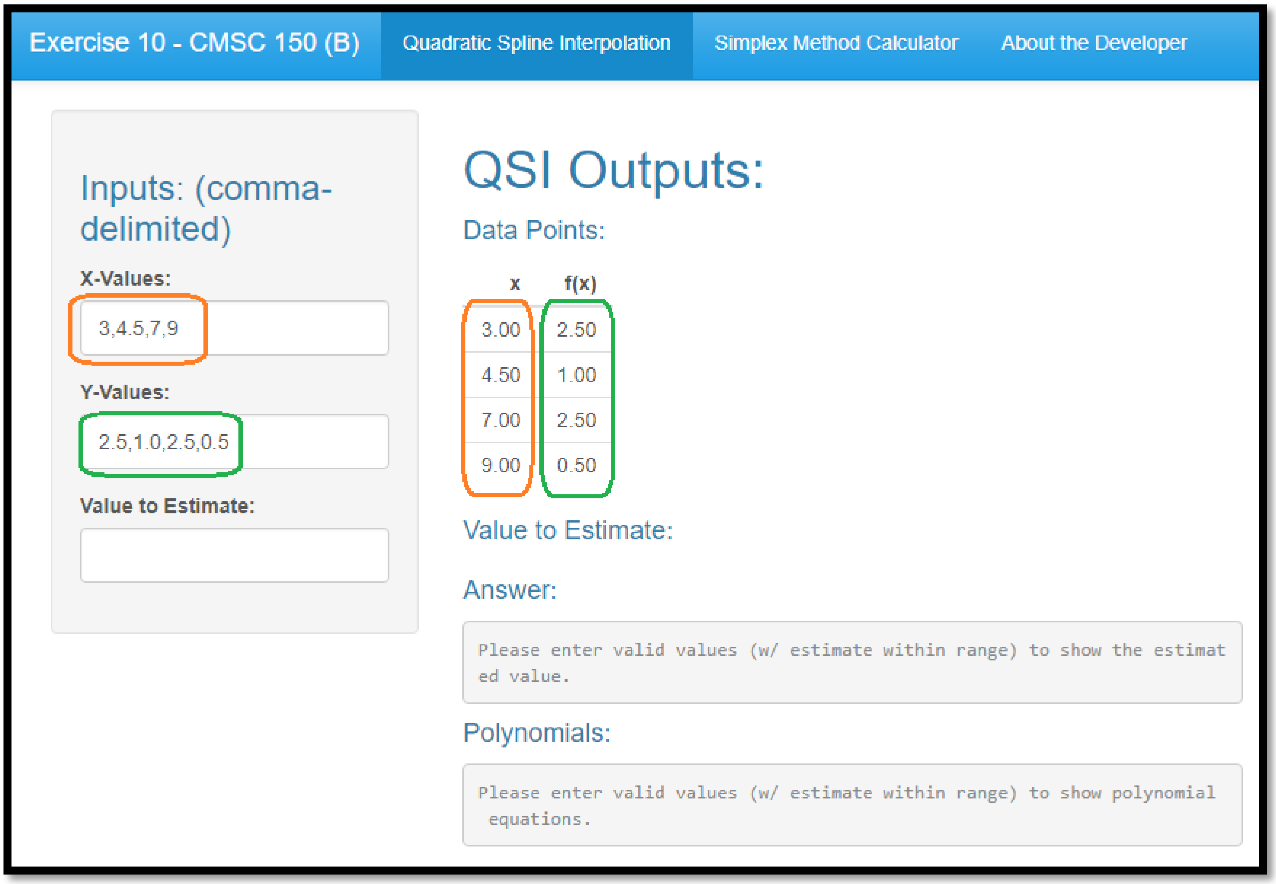
The last navigation bar contains the description of the web application developer and some references.

How to use the Quadratic Spline Interpolation Calculator

The Quadratic Spline Interpolation Calculator's objective is to derive a **second-order polynomial** for each interval between the given data points.

How to Use:

Step 1: Data Points

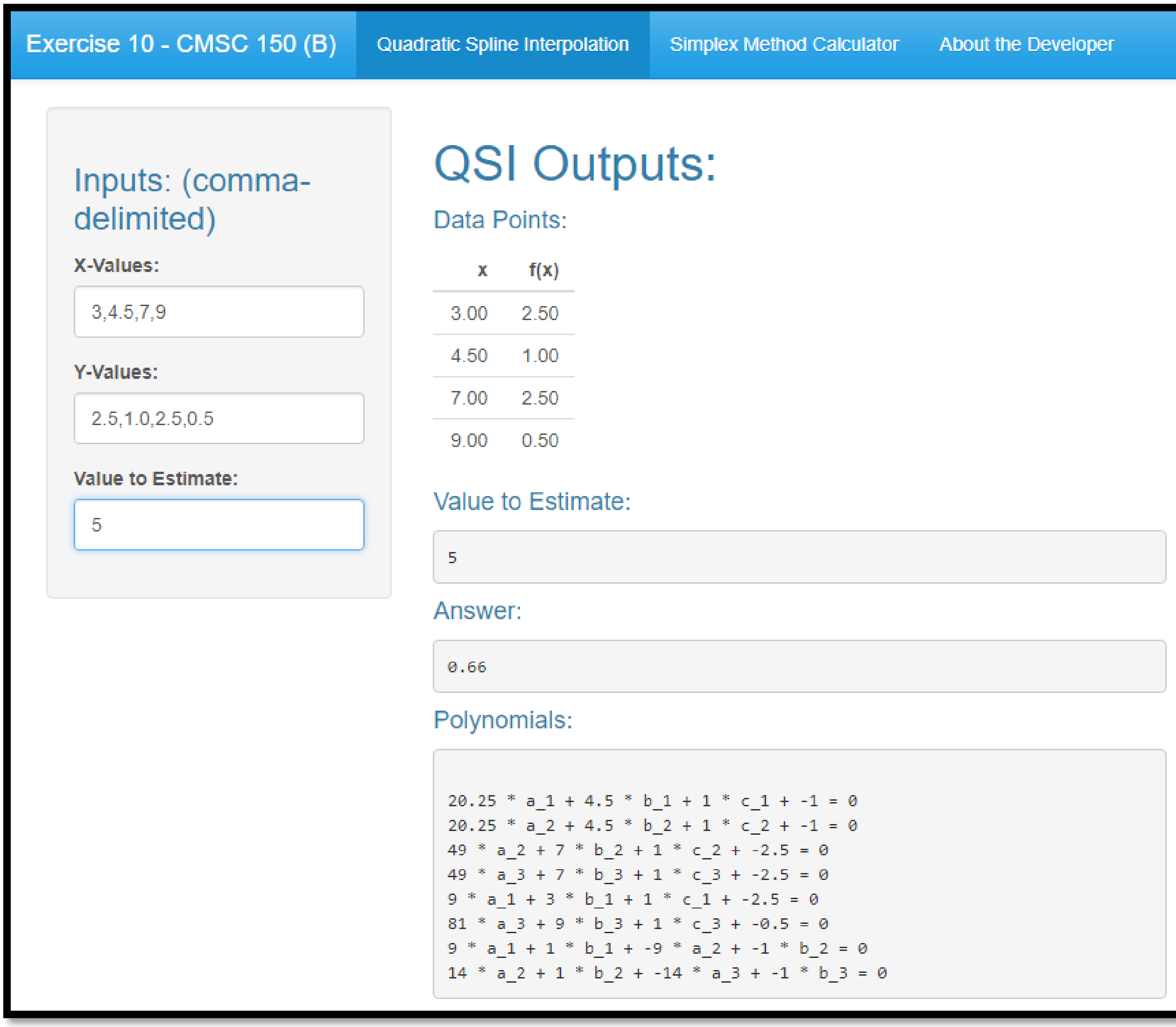


The X-Values and Y-Values (**or f(x)**) are comma-delimited, which means that you need to separate your values with **commas**. Also, please don't enter any special characters or letters from these input bars because it only accepts numeric values. Moreover, **the length of your X and Y values must be equal**. The indexing of your X-Values also corresponds to the indexing of your Y-Values. For example, if your **first input** for the X-Values is **3**, its **f(x)** should also be in your **first input** for the Y-Values.

Step 2: Value to Estimate

The input for this section is straightforward. You only need to enter **one** numeric value as input. Again, don't enter any special characters or letters. Also, the value to estimate should be within the range of your **X-Values**. Otherwise, you won't get your answer and polynomials.

Expected Outcome (QSI)



The calculator displays your inputs and the expected output on the right-hand side. If you have entered valid data points, the calculator will show you a tableau of your data points and your value to estimate. Aside from the expected answer, the calculator will also show the anticipated polynomial equations based on your inputs. Note that the formatting for the polynomial equations is not standard because they're **all equated to zero.**

Simplex Method

The Simplex Method Calculator works for Maximization and Minimization cases (excluding the mixed-constraint instances). Furthermore, it also solves the **Exercise 9 problem: Assessing the Value of Supply Chain Management Optimizing Shipments.**

How to use the Simplex Method Calculator

Maximization Case:

For this case, let's have an example to understand how the input formatting works for this calculator. Please note that the indexing of entered values is **essential**. Also, special characters and letters are not allowed (except for the Boolean inputs). The input formatting relies on the syntax in Linear Programming.

Example Problem:

Problem statement: Suppose that a gas processing plant receives a fixed amount of raw gas each week. The raw gas is processed into two grades of heating gas: regular and premium quality. These grades of gas are in high demand (that is, they are guaranteed to sell) and yield different profits to the company. However, their production involves both time and on-storage constraints. For example, only one of the grades can be produced at a time, and the facility is open for only 80 hours/week. Further, there is a limited on-site storage for each of the products. All these factors are listed below.

Resource (Unit)	**Product**		**Resource Availability**
	Regular	**Premium**	
Raw gas (m3/ton)	7	11	77 m^3/wk
Production time (hr/ton)	10	8	80 hr/wk
Storage (ton)	9	6	
Profit (price/ton)	150	175	

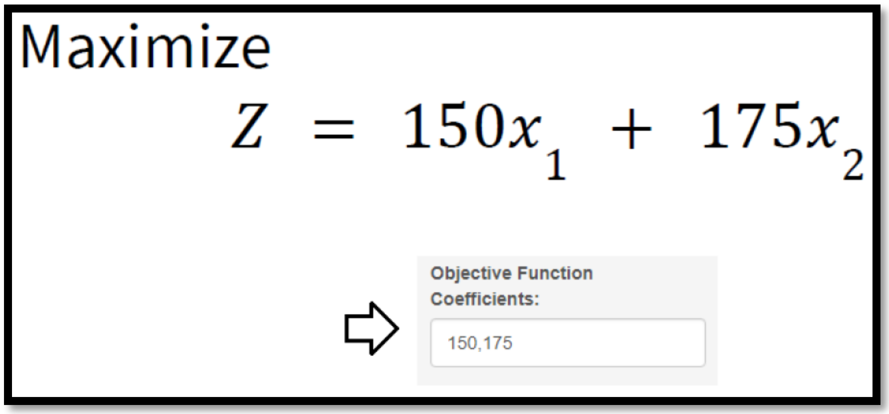
Maximize

$$Z = 150x_1 + 175x_2$$

subject to

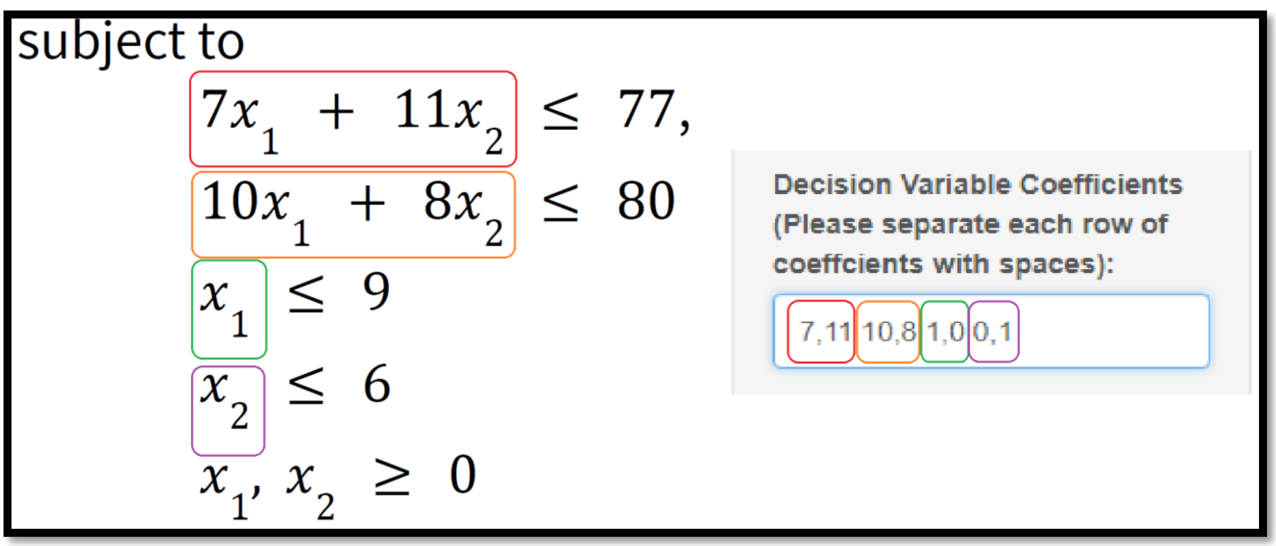
$$7x_1 + 11x_2 \leq 77,$$
$$10x_1 + 8x_2 \leq 80$$
$$x_1 \leq 9$$
$$x_2 \leq 6$$
$$x_1, x_2 \geq 0$$

Step 1: Objective Function Coefficients



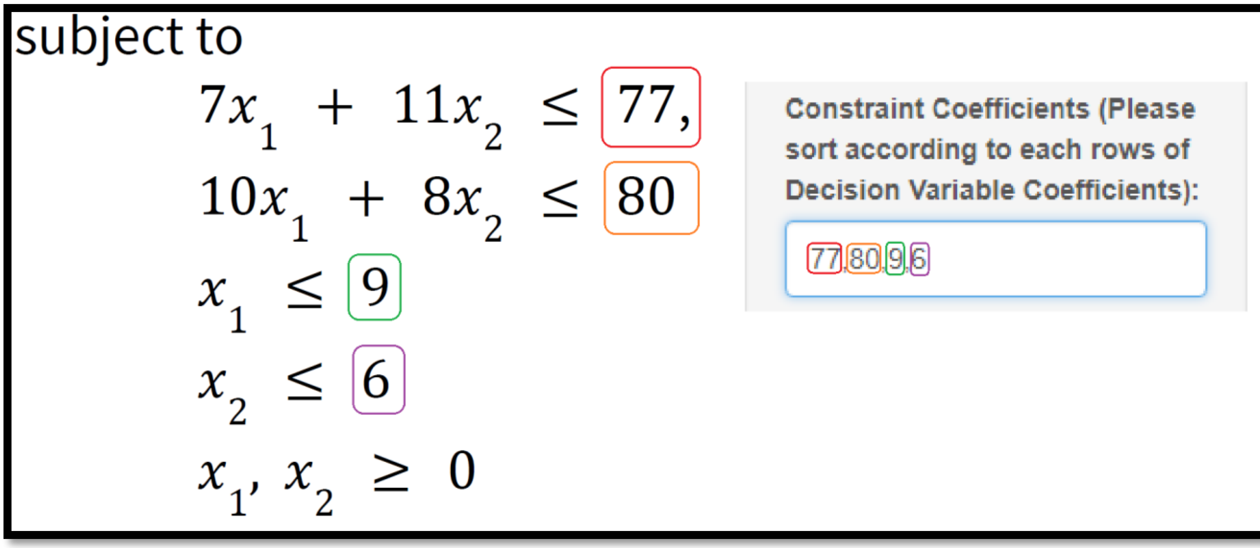
For this input, enter the coefficients for the Objective Function for the problem separated by commas.

Step 2: Decision Variable Coefficients



Please note that the coefficients for this input are multiplied by the decision variables based on your problem. For each constraint equation, separate the decision variables' coefficients **with spaces**. Commas separate each coefficient from each line, and each line consists **must have the same number of coefficients**. Please see the picture for reference.

Step 3: Constraint Coefficients

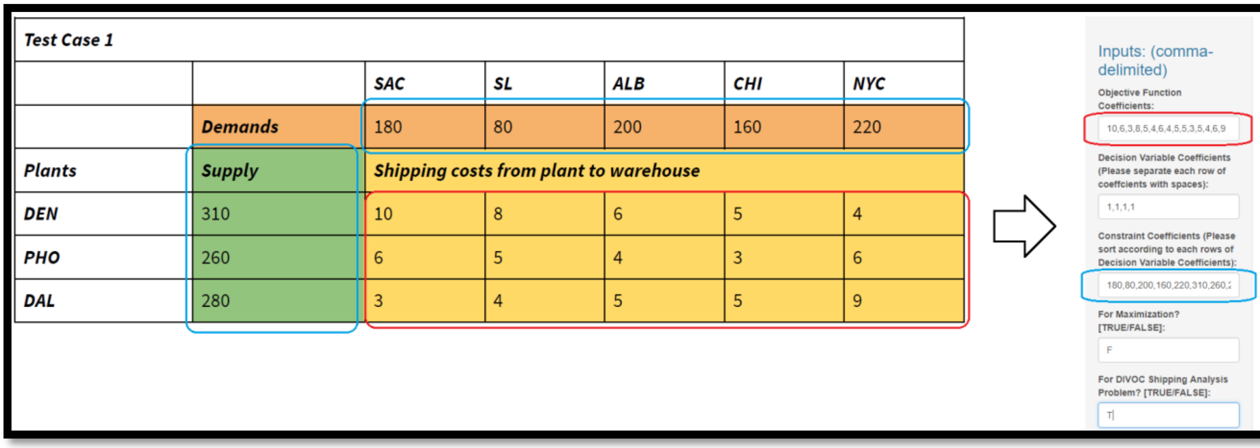


Like the Objective Function Coefficients, each numeric value must be separated by commas. The indexing of your Constraint Coefficients corresponds to the indices of your decision variable coefficients that are separated with spaces. Please see the picture for reference.

Step 4: For Maximization?

The input is straightforward. Only enter a Boolean value (e.g., TRUE, FALSE). You can also enter **T** or **F**. If TRUE, the inequality symbols for the constraint equations are **greater than or equal,** and the calculator will employ the Simplex Method based on your given inputs. If entered FALSE, the inequality symbols for the constraint equations are **less than or equal.** Thus, the calculator will employ the Dual Method for the Minimization case, which transposes the matrix of your inputs and treats it as a Maximization case.

Step 5: For DIVOC Shipping Analysis Problem?



Test Case 1						
		SAC	SL	ALB	CHI	NYC
	Demands	180	80	200	160	220
Plants	Supply	Shipping costs from plant to warehouse				
DEN	310	10	8	6	5	4
PHO	260	6	5	4	3	6
DAL	280	3	4	5	5	9

This input only requires you to enter a Boolean value. If TRUE, the calculator will solve the **Exercise 9 problem: Assessing the Value of Supply Chain Management Optimizing Shipments**. Please note that this section follows a specific tableau for this type of problem. Thus, the user's total number of Objective Constraints must be **15**, while the total number of Constraint Coefficients must be **8 (5 Demand Coefficients + 3 Supply Coefficients, respectively)**. If there is a feasible solution, the calculator will also show the labelled matrix showing the number of items shipped from a plant (**Denver, Phoenix, and Dallas**) to a warehouse (**Sacramento, Salt Lake City, Albuquerque, Chicago, and New York City**). If entered TRUE, **you can enter any placeholder values** for the **Decision Variable Constraints** because the problem only focuses on the Objective Function and Constraints. Also, the default optimum value is the minimum cost. **Please zoom into the picture for reference**.

Minimization Case:

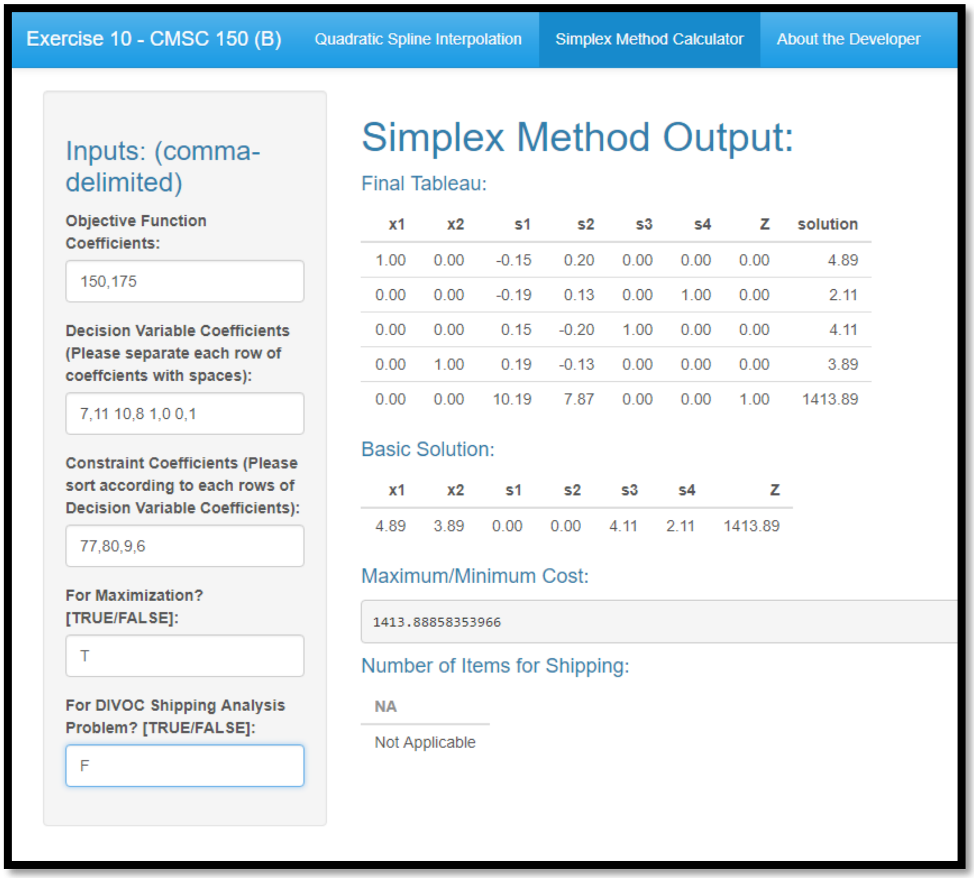
The input formatting for the Minimization case is the same as the Maximization case. The only difference is that the input for the **“For Maximization?”** section must be **FALSE**. Please note that the initial Linear Programming for Maximization and Minimization is the same when using the calculator. **However, the inequalities are different.** After employing the Dual Method, the Minimization problem will be treated as a Maximization case.

Expected Outcomes (Simplex Method)

On the right-hand side, the calculator displays the following:

- **Final Tableau**: the matrix of the final tableau after employing the Simplex Method
- **Basic solution**: the matrix of the final basic solution after employing the Simplex Method
- **Maximum/Minimum Cost**: the maximum or minimum value of the computation.
- **Number of Items for Shipping**: the matrix of the number of items shipped from a plant to a warehouse (For Exercise 9 problem only). The rows represent the plants, and the columns are the warehouse.

Expected Outcome from the Maximization Example



Exercise 10 - CMSC 150 (B) | Quadratic Spline Interpolation | Simplex Method Calculator | About the Developer

Inputs: (comma-delimited)

Objective Function Coefficients:

150,175

Decision Variable Coefficients (Please separate each row of coeffcients with spaces):

7,11 10,8 1,0 0,1

Constraint Coefficients (Please sort according to each rows of Decision Variable Coefficients):

77,80,9,6

For Maximization? [TRUE/FALSE]:

T

For DIVOC Shipping Analysis Problem? [TRUE/FALSE]:

F

Simplex Method Output:

Final Tableau:

x1	x2	s1	s2	s3	s4	Z	solution
1.00	0.00	-0.15	0.20	0.00	0.00	0.00	4.89
0.00	0.00	-0.19	0.13	0.00	1.00	0.00	2.11
0.00	0.00	0.15	-0.20	1.00	0.00	0.00	4.11
0.00	1.00	0.19	-0.13	0.00	0.00	0.00	3.89
0.00	0.00	10.19	7.87	0.00	0.00	1.00	1413.89

Basic Solution:

x1	x2	s1	s2	s3	s4	Z
4.89	3.89	0.00	0.00	4.11	2.11	1413.89

Maximum/Minimum Cost:

1413.88858353966

Number of Items for Shipping:

NA
Not Applicable

Expected Outcome from a Minimization Example

Minimize

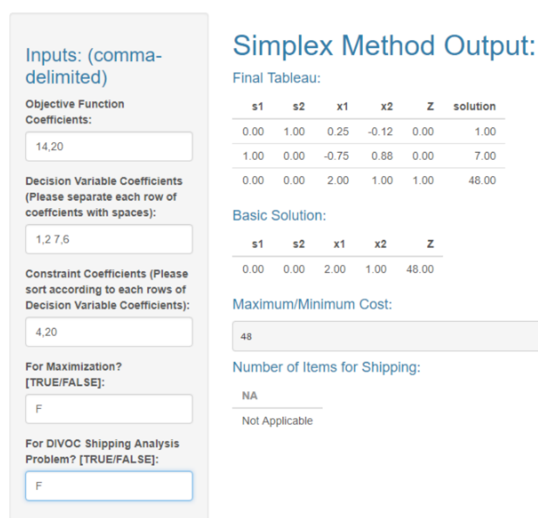
$$Z = 14x_1 + 20x_2$$

subject to

$$x_1 + 2x_2 \geq 4$$

$$7x_1 + 6x_2 \geq 20$$

$$x_1, x_2 \geq 0$$



Inputs: (comma-delimited)

Objective Function Coefficients:

14,20

Decision Variable Coefficients (Please separate each row of coeffcients with spaces):

1,2 7,6

Constraint Coefficients (Please sort according to each rows of Decision Variable Coefficients):

4,20

For Maximization? [TRUE/FALSE]:

F

For DIVOC Shipping Analysis Problem? [TRUE/FALSE]:

F

Simplex Method Output:

Final Tableau:

s1	s2	x1	x2	Z	solution
0.00	1.00	0.25	-0.12	0.00	1.00
1.00	0.00	-0.75	0.88	0.00	7.00
0.00	0.00	2.00	1.00	1.00	48.00

Basic Solution:

s1	s2	x1	x2	Z
0.00	0.00	2.00	1.00	48.00

Maximum/Minimum Cost:

48

Number of Items for Shipping:

NA
Not Applicable